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ADVANCES IN SUSTAINABLE DEVELOPMENT RESEARCH

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INTRODUCTION

The series Advances in Sustainable Development Research includes the Book of Abstracts and selected Papers of the 23rd Congress of the International Sustainable Development Research Society ISDRS held in Bogotá-Colombia in the School of Management at Universidad de los Andes in June 2017.

The abstracts and papers that were selected had a complete peer review process. They show the richness in interdisciplinary approaches, theories, models and applied research presented in the different streams and tracks designed for the conference.

This is an important contribution to the discussion of the state of the art in the different dimensions of sustainable development. This is a conference that offers an academic space known for its interdisciplinary approach as well as a space for academics and practitioners. Here, the reader will find a broad approach including different visions, theoretical orientations to sustainable development as well as a richness in research methodologies from quantitative to qualitative.

Inclusive sustainable development was the main theme of the conference. By inclusiveness, we understand the objective of creating a more equitable society by ensuring wider access and opportunities across social groups, regions and economic sectors as well as reducing the high income disparities that occur today. How to achieve the objective of inclusiveness is a matter of intense discussion and concern as the movement behind the sustainable development goals shows. Governments, private enterprises and communities must play an important role on this process. We believe that Universities must also be engaged in this societal purpose.

This Book of abstracts and proceedings clearly contribute to that important aim.

Sincerely,

Eduardo Wills Herrera
Academic Chair of 23rd ISDRS Conference
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Capacity to associate, subjective well-being and perceptions of insecurity: three key variables to understand sustainability in conflictive rural Colombia.

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Abstract

Sustainability is a multidimensional concept that includes environmental, social, economic and cultural dimensions. We propose in this study that the concept of sustainability is closely related to the quality of life of a community. Under this view, the economic, social and environmental systems that support the community should provide a healthy, meaningful and productive life for all the actual and future members of that community. Some of the basic issues that must be considered in relation to quality of life as sustainability include security, the quality of social relationships (social capital) and satisfaction with life as a whole. In this study, we approach the dimension of security as perceptions of insecurity, an individual variable that processes social conflict and violent environments in the minds and emotions of individuals and communities. We also link social capital as the capacity to associate, trust, reciprocity and belonging to social networks. The relationship between these variables is explored in a rural context that has been affected by a long social conflict, and whose intensity has substantially decreased in the last years. We explore also, the relations of perceptions of quality of life and social capital at different levels, using the second phase of a survey from 1680 rural producers in Colombia. The main findings of the empirical analysis show a positive relation of social capital on sustainability measured as perceptions of well-being. At the same time, perceptions of insecurity have a negative effect on both sustainability and social capital. We found regional differences in the impact of these variables. These results allow policy-makers to strengthen rural sustainability programs and encourage effective processes of post-conflict development.

Key words: sustainability, social capital, perceptions of insecurity, rural conflict.

1. Introduction

Sustainability is a multidimensional concept that includes environmental, social, economic and cultural dimensions. We understand social development as the increase of individual and social well-being. Under this view, the economic, social and environmental systems that support the community should provide a healthy, meaningful and a productive life for all the current and future members of that community.

In this paper, we explore the relation of well-being, sustainability and social capital from the point of view of rural producers in Colombia. We state that the concept of sustainability is closely related to the measure of quality of life of an individual and a community. With that purpose in mind, we propose subjective well-being- SWB- as a proxy of social sustainability. In particular, we relate this concept with quality of life which includes the dimensions of security and the strength of social relationships.

In the last years, a new literature is emerging proposing definitions of sustainability as a measurement of quality of life of communities and subjective well-being (Wills, 2015; De Vries, 2009). SWB is the cognitive and affective evaluation that individuals do in relation to their satisfaction with life as a whole. In particular, SWB explores the self-evaluations of individuals of how satisfied they are with their lives. This can include both positive and negative evaluations.

In the first quarter of 2017, after many years seeking for a Peace agreement, Colombia reached the end of a long conflict with one of the oldest guerrillas in the world. Colombia´s conflict has been characterized for being hard and persistent in the rural area. On average, the terrorism rate per 100.000 inhabitants, measured by the number of terrorist attacks, is higher in the rural than in the urban area in Colombia, which may lead to feelings of mistrust, insecurity, lack of support and cooperation, also it affects confidence on public institutions. Thus, we are interested in understand the social dynamics in the rural regions in Colombia and its impact on individual’s decisions and perceptions.

Social capital can be considered as the set of values and norms shared by a community, manifested through cooperation, reciprocity and trust. It can be understood as the “glue that holds societies together and without which there can be no economic growth or human well-being” (Serageldin 2000). Social capital in this context “refers to the set of resources that inheres in those relations and the structure of those relationships (Putman, 2015). In this way, we can identify three dimensions of social capital, cooperation, reciprocity and trust.

Conflict has been known to be a strong barrier in the accumulation of any type of capital, due to its negative effects on investment, violence and destruction of human and physical capital. The accumulation of capital is an important determinant in a country´s development. Evidence shows that not only the accumulation of capital contributes to the development of a country or region, but also human and social capital has an important role. Knack and Keefer (1997) find that trust has a positive impact on economic growth. In the same way, Cuartas (2016) argues that the inequality and poverty have a negative correlation with social capital. La Porta et al, also shows that the increase of the country -level trust has a positive effect regarding the efficiency of public institutions and also reduces corruption.

Does social capital have a different behavior at a macro (regional and local levels) and at a micro level (individual level)? How is it influenced by individual perceptions of insecurity? On the other hand, how do perceptions of insecurity influence subjective wellbeing and how does social capital moderate this relationship? These are the main questions that are addressed in this paper. To answer these questions, we used the information from the Unidades Productivas survey to propose a measure of Social Capital, perception variables and as well as to measure subjective wellbeing.

In this paper we explore how perceptions of insecurity of rural producers vary along individual, local and regional variables. I addition, we analyze the determinants of social capital at the individual and regional level. In this way, we show how social capital (understood as capacity to associate-social networks-, reciprocity and trust) influence the different levels of subjective well-being. In sum, we are particularly interested in understand how social capital and perception of insecurity are related to satisfaction with life as a whole. We consider that this approach is an important contribution in the literature since sustainability traditionally has been only studied from an environmental point of view.

The main results that we obtained are as follows. Social capital and insecurity perceptions have opposite effects on subjective wellbeing. In particular, insecurity perceptions have a negative effect on both measurements. In addition, social capital has multiple dimensions that can be studied individually. Our results suggest that the demographic variables of rural producers and the different perceptions of insecurity have a different effect on the two distinct measures of social capital that we used in this study; a-) as trust and reciprocity and b-) voluntary affiliation to social networks. We found that subjective insecurity has mixed effects on social capital variables. Second, our results show that the different types of land property have a small statistical effect on social capital. Finally, we found important variations in the level of social capital regarding the type of region that was considered.

The rest of the paper is organized as follows. First, we realize a review of the literature on social capital and subjective wellbeing, in particular its definition and possible determinants. Consequently, we describe the data used in the empirical approach and, in the next section we describe the methods used in the empirical approach. In the fifth section, we discuss the results of the empirical study. Finally, we address some conclusions and public policy implications.

2. Literature review: Subjective Wellbeing, as indicator of sustainability, perceptions of insecurity, Social Capital and its implications.

In 2015, the Universidad de los Andes and the Departamento Nacional de Planeación- DNP collected information of a set of variables through the Unidades Productivas survey as a second phase of the project Seguridad y Asociatividad rural of 2007. This project attempted to understand the dimensions of social capital related to violence, insecurity perceptions, and the capacity of producers to associate and create economic associations in conflict affected areas in Colombia. In this first stage, the aim was also to understand how these aspects relate.

To answer if social capital has a different behavior at a micro and at a macro level, we use this data to estimate a group of statistical models to answer the questions proposed. We include multilevel statistical models to explore not only individual variables but also variables at the municipal and regional level. We also refine our measure of social capital distinguishing between two different dimensions of it: i-) trust and reciprocity in the relationship formed by social producers and contribution to social networks that are formed at the local and regional level in order to strengthen social ties and interact with public policies and state agencies. In particular, we follow the multidimensional approach of social capital in Wills et al. (2013) and in Peña (2016), which identify trust, cooperation and reciprocity as its three main components.

The perception indexes refer to 4 dimensions of subjective insecurity as explored by (Orozco, Forero, & Wills, 2013). Similarly, we construct two subjective wellbeing indexes, at the personal and community level. A subjective wellbeing index has been proposed and constructed taking into account 7 parameters related to satisfaction of personal life (Cummings in (Orozco, Forero, & Wills, 2013)) that has been evaluated in Australia, Colombia and Spain. This is also an important contribution since the literature of subjective wellbeing has been mainly based at the individual level and has not clearly explored how these perceptions are influenced by communitarian contact and interaction. Last, we propose two social capital indexes, one that describes trust and reciprocity and the other that give a measure of the existent networks. We use data at individual and regional level to explore the relation of social capital with insecurity, demographic characteristics, and wellbeing. We explore also the regional differences of the measure of social capital.

Durston (2002) gathers various definitions of social capital and proposes three dimensions identified as part of the social structure and relationships. These dimensions are expressed in forms of attitudes of trust, cooperation and reciprocity. The latter can be identified as capital since it can be accumulated over time and combined with other forms of capital can increase other forms of capital, like human and produced capital (Coleman in Bebbington and Perreault 2002 and Durston 2002). Thus, the dimensions of social capital describe the relationships and social institutions where they are embedded. For this reason, we decided to embrace this definition because it encloses the others, and better describe the social capital present in the data we used for our analysis.

Trust is the first dimension taken into account. It reflects the vulnerability of an individual on the expected behavior of another person with whom he/she has relation (Durston, 2002). It derives from repetition of social exchange, better explained by game theory, where each player determines its strategies based on past encounters. In other words, players take into account previous decisions and the opponent's past decisions. Like in the prisoners' dilemma if there is more than one encounter, the best strategy of neighbors is to cooperate, in this case neighbors have incentives to behave reliably to maintain the trust acquired.

Second, reciprocity plays an important role in maintaining and developing relationships. Reciprocity is part of the actions that can be rewarded directly or indirectly at any point in time. It implies, that resources, as time, or labor are available to another person. Third, cooperation is also a result of repeated encounters that can be traduced in the search of common objectives. It can be reflected in the construction and formation of social associations or other forms of participation. Putman, concludes that the reinforcement of these dimensions, strengthen social relations and nurture social capital in a community. Finally, Durston concludes that we can define social capital in terms of individuals and as a collective asset. Nevertheless, others conclude that social capital is more an individual asset embedded in social interactions (Magnani & Struffi, 2009).

Various studies had analyzed social capital in rural areas (Bebbington & Perreault, 1999) (Magnani & Struffi, 2009) (Durston, 2002) (Orozco, Forero, & Wills, 2013) (Sorensen, 2000). Rural communities have characteristics that allow us to study social capital more closely. Rural communities are conformed by groups of people that have close ties and share values and norms. Because they are small and sometimes isolated social units, their traditions and views are more similar than in urban areas where there is more dissociation. Durston, defines rural communities as entities conformed by households that exploit natural resources.

Social Capital is strongly related to the construction of subjective wellbeing. Wellbeing has been related with measures of development. Given the actual environmental conditions it is necessary to encourage a sustainable development to preserve communities. Subjective wellbeing can be understood as an indicator of "how the individual evaluates the overall quality of his or her life" (Pena-López, Sánchez, & Membiela, 2016). We introduce the idea of quality of life from a subjective perspective, as subjective wellbeing, the cognitive and affective evaluation that individuals do in relation to their satisfaction of life as a whole. Subjective wellbeing was proposed as an alternative to measure social development. Satisfaction with life as a whole or subjective wellbeing (Diener, 2003) can be explained by satisfaction of the individuals with particular dimensions of life. This variable is a subjective appraisal which includes a cognitive and an affective dimension (Wills, 2009). SWB is a multidimensional that encompasses individual, social and environmental domains (Wills et al. 2009).

Individuals measure their SWB in a number of different ways (Kim-Prieto, 2005) rating their satisfaction with different life domains (particularly the quality of social relationships and security,) in a bottom-up procedure (Cummins 1996; Brief et al. 1993). Diener (1985) proposes satisfaction of life as a whole is a five items scale. Moreover, Cummins et al (2003) propose a Personal Wellbeing Index that take into account 7 domains; i) satisfaction with health, ii) personal relationships, iii) safety, iv) standard of living, v) achieving goals, vi) community connectedness, and vii) future security. Wills (2009) takes into account these domains to build a Personal Wellbeing Index in Colombia and includes the spiritual domain.

Bebbington and Perreault also link social capital to sustainability. In a study case in the highland of Ecuador, they understand sustainability in two dimensions. One, as access to different forms of capital and as the process of formation and strengthening of social capital as a vehicle to access to other forms of capital (produced, human, and natural Capital). They follow a rural community that had little or no access to means of production. The intervention of national policies and the work of NGOs started a process that boosted the formation and accumulation of social capital. As a result, community associations were born, networks where consolidated, and this allowed the community to renegotiate political power. After 40 years, the dynamics of the region changed. The area went from being controlled by hacienda landowners who made the political and economic decisions of the region to being governed by the local and indigenous communities. In addition, after the process of social capital construction, land use was intensified; a high percentage of population now has access to natural capital and to education. In other words, the region became a model of development, with high levels of cooperation and strengthening of social networks and relationships (Bebbington and Perreault).

Insecurity perceptions in turn are related to feelings and cognitions of wellbeing (SWB) via the quality of the social relationships between the members of rural communities that have been affected by a prolonged state of social and armed conflict. In this way, SWB is influenced by these perceptions, since it reflects the lack of control the environment. These perceptions are linked with feelings of loss. Under some conditions, as violent environments, an adaptation process may occur; people can develop strategies to maintain SWB despite of the environment. Insecurity perceptions have a local character (Barker and Crawford, 2006) and can be divided in different dimensions related to personal feelings of insecurity, economic insecurity and communitarian insecurity. In turn, these dimensions vary according to the contextual changes that have occurred in rural areas of Colombia where objective indicators of violence have declined considerably in time in the process to a post-conflict society at the same time that economic uncertainties and insecurities for the population of these areas has increased.

Objective insecurity is measured as the frequency and intensity of crimes and violence. Authors as Sen (1999) and Mahbub-ul Haqs (1999) introduce the concept of security in the human development discourse, with the aim to humanize this concept and to integrate the definitions at different levels. Mahbub-ul Haqs (1999) redefine the concept of security to take into account “the capacity and abilities of individuals and communities to control their environments and secure basic conditions for a good life”. In this way, the concept introduces subjective traits, since it takes into account the way that individuals internalize the threats (personal, political, economic and wellbeing threats). In this way, the objective measures of insecurity differ from the subjective measures of it.

In an early work, (Orozco, Forero, & Wills, 2013) analyzed the behavior of subjective wellbeing of rural producers in conflict affected regions in Colombia. They found a significant relation among insecurity perceptions, subjective wellbeing and social capital. Their findings show that insecurity perceptions have a negative effect on subjective wellbeing. In contrast, social capital has a positive effect on subjective wellbeing and it reduces the negative impact that insecurity perceptions have. They found also little or no correlation between subjective insecurity and objective insecurity measured as the number of murders in 2005.

This paper contributes to the existing literature of social capital at micro and macro level. It suggests a way to study sustainability through personal wellbeing and social capital. We propose different dimensions of social capital and a way to measure it. We implement, factor analysis to measure the correlation of the variables of social capital, and conclude that the dimensions of trust and reciprocity are strongly correlated, while the networks' dimension of social capital constitutes measure by itself. We used the correlated variables to construct proxies through the methodology of item response theory given the nature of the variables. The empirical research helps to understand the relations of individual and municipality characteristics of social capital, subjective wellbeing and subjective insecurity. In addition, it gives a glance of the evolution of the impact of conflict in the areas studied and allows exploring opportunities that help accumulate social capital in a community. This constitutes an interesting contribution to the literature since it clarifies how variable at different levels of analysis interact and how the different components of social capital are differently related to individual, local and regional variables and how they differently influence the relationship between perceptions of insecurity and social capital. In addition, we construct a set of indexes that measure perception, social capital and wellbeing.

2. Data and Methods

The dataset we utilize in this paper was constructed from different sources that included socioeconomic, geographic, crime, and perception variables. These data came from five sources. First, we use the Unidades Productivas survey that was part of the second stage project Seguridad y Asociatividad rural, carried out by the Universidad de los Andes and the Departamento Nacional de Planeación in 2015.

The survey was collected in eight zones in Colombia, taking into account 56 municipalities, 3 areas of each municipality. The areas were randomly selected and have heterogeneous security conditions. However, the regions selected have a conflict heritage or were affected by conflict. The survey contains personal information of a sample of 1680 participants in 7 municipalities per area and in each area 10 producers were surveyed. In particular, the 8 regions are Antioquia, Huila, Magdalena Medio, Meta, Montes de María, Nariño, Tolima, and Norte de Santander. The survey also included questions of insecurity, cooperation and wellbeing perceptions from the area where the participants live. In particular, the participants were owners or managers of units of land from (in) the rural area of these regions where they develop their productive activities.

The Unidades Productivas survey is divided in 14 modules of questions related to land production and tenancy, commerce of agricultural products, security perception, networks, subjective wellbeing, assets and demographic characteristics. The questions related to land production; assets, networks, and commerce have a binary response. The questions related to perception were measured either in a binary or in a Likert Scale. The binary responses describe yes or no questions. The Likert Scale is used to describe attitudes or opinions. This scale is an ordinal measure that describes levels of agreement or disagreement. The former questions were used to construct perception indexes used in our estimations.

Second, our survey data was complemented with the panel data of Centro de Estudios sobre Desarrollo Económico. This is a panel at the municipality level that contains socioeconomic, geographic and demographic information in Colombia. In particular, it includes education rates, per capita incomes, and conflict and violence rates. Third, we use the insecurity panel data of the

Departamento Administrativo Nacional de Estadística that contains crime variables from 1995 to 2015, such as homicides, kidnappings, robberies, and extortions in Colombian municipalities. Fourth, we include to our data, a set of variables of the of land tenancy from the Censo Nacional Agropecuario from the year 2014 that contains statistic information related to the rural area in Colombia. Finally, we use the data of the Colombian road system provided by the Sistema de Información Geográfica para la Planeación y el Ordenamiento Territorial that records and produces spatial and geographic information at different levels.

Table 1 and Table 2 show the descriptive statistics of the principal variables used in the estimations. We find that 65% of the participants were male and the most common level of education in women and men in the regions where the survey took place was primary school. In addition, more than a half of the participants earn less than the minimum wage in 2015 and most of them have lived their lifetimes in the area where they were surveyed. The 8 areas where the survey was applied are regions that were affected by violence and conflict. Table 2 also shows the descriptive statistics of the crime/violence variables per 100,000 habitants. We find that, from1985 to 2014 the type of violence more frequent was homicides with an average of 21 homicides per 100,000 habitants, and the region most affected was Meta with an average of 6.0 homicides per 100,000 habitants. Table 3 shows the descriptive statistics of the variables we construct from the survey responses.

Table 1 Demographic Characteristics of the surveyed

	Category	Frequency	Percentage
Level of education	None	305	18.15%
	Primary School	967	57.56%
	Secondary School	339	20.18%
	Technical Education	34	2.02%
	University	35	2.08%
Income	< $644,350	883	52.56%
	$ 644,35	497	29.58%
	[$644,350, $1.5 millions)	253	15.06%
	[$1.5 million, $4.5 millions)	43	2.56%
	<4.5 millions	4	0.24%
Gender	Masculine	1,076	64.05%
	Feminine	601	35.77%
	Other	3	0.18%
Time of residence	(0, 1 year)	85	5.06%
	[1,5 years)	194	11.55%
	< 5 years	650	38.69%
	Lifetime	751	44.70%

Table 2 Descriptive statistics of the variables of interest

Variable	Obs.	Mean	Std. Dev.	Min	Max
Age	1680	47.44	14.65	18	93
Number of children	1680	3.22	2.38	0	13
Associability	1680	2.56	2.00	0	16
Distance to nearest town	1225	51.74	51.82	3	420

Km of roads	1680	269.93	306.09	32	1,784.88
Population density	1680	42.47	44.21	0	236.89
Size of the productive unit	1680	35.96	214.56	0.00005	6,400
Homicides	1665	20.69	52.35	0	1,222.11
Robs	1665	13.11	36.58	0	522.41
Kidnapping	1665	1.32	6.33	0	118.31
Extortion	1665	2.24	8.13	0	105.76
Terrorism	1665	3.04	17.11	0	339.05

Table 3 Descriptive statistics of the indexes

Variable	Obs.	Mean	Std. Dev.	Min	Max
Personal insecurity index	1680	0.6082472	0.3334849	0.0036235	0.9477386
Economic insecurity index	1680	0.122632	0.2147835	0.000108	0.8387873
Community insecurity index	1680	0.5860548	0.2853175	0.0248186	0.9039785
Inner circle insecurity index	1680	0.5577657	0.2648111	0.0073683	0.8329413
Trust and reciprocity social capital index	1680	0.0336858	0.0429898	0.0013226	0.4627675
Networks social capital index	1680	0.4708815	0.1500477	0.0389042	0.6625535
Community subjective wellbeing index	1680	0.0067826	0.0269081	0	0.6414062
Personal subjective wellbeing index	1680	0.0126912	0.0451946	0.0000772	0.9651071

The empirical strategy used to answer our questions of interest was developed in two stages. First, as in Pena-Lopez et al and Ciliers et al (2016), we used a statistical approach to construct a set of latent variables that, from now on, we are going to call indexes. The first step to build our indexes was to use factor analysis. We wanted to study the correlation among the perception variables in order to group those that were more likely to relate. Factor analysis is a statistical technique used to group a large number of variables into a smaller set of correlated variables.

In addition, the perception variables responses are measured in an ordinal scale and factor analysis assumes that the variables are continuous. For this reason, we use the item response estimation theory, IRT. IRT measures categorical responses through latent variables. The IRT uses statistical models to find the relationship between item responses and a latent variable. Given the methodology described above we create 8 indexes; 4 insecurity indexes, 2 social capital indexes, and 2 subjective wellbeing indexes.

Second, we used the regression analysis to explain the relation of our variables of interest. We applied 3 methods of estimation. For the variables at the individual level, as in the first stage of the project, we used ordinary least squares (OLS) with cross-sectional data. In addition, the nature of the data allowed us to explore the relations of the variables at different levels. For that reason, to explore the variance of the data at the regional level, we introduced a multilevel analysis; in particular, we estimated hierarchical models.

We estimate an OLS regression where the personal and community SWB indexes depend on the individual characteristics, the measurements of social capital and the perceptions of insecurity of the sample as in equation 1, where X is the vector of individual variables, and W the vector of insecurity perceptions.

$$SWB_c = \beta_0 + X_i\beta 1 + \beta_2 W_j + \varepsilon_i \ (1a)$$

$$SWB_p = \beta_0 + X_i\beta 1 + \beta_2 W_j + \varepsilon_i \ (1b)$$

Second, we explored the relation of the individual variables and the perception of insecurity on the social capital. In this case, the dependents variables were the social capital indexes. Equation 2 shows the estimation model.

$$SK_1 = \beta_0 + X_i\beta 1 + \beta_2 W_j + \varepsilon_i \ (2a)$$

$$SK_1 = \beta_0 + X_i\beta 1 + \beta_2 W_j + \varepsilon_i \ (2b)$$

To evaluate the relation of the regional variables and social capital we estimate equation 3, where Z is the vector of land tenancy, and C is the vector of control variables.

$$SK_1 = \alpha_0 + Z_i\alpha_1 + C_i\alpha_3 + \varepsilon_i \ (3a)$$

$$SK_2 = \alpha_0 + Z_i\alpha_1 + C_i\alpha_3 + \varepsilon_i \ (3b)$$

The multilevel regressions allow analysis of data with different patterns of variability, and with a hierarchical structure, for example, workers nested in firms and firms nested in industries. In this case, we have rural producers in municipalities and municipalities arranged in different regions, where there is variability between producers and also between regions. “This technique allows identifying contextual effects that have an effect on the relationships sought through the hypothesis. If the responses of individuals in the same group are similar to those of other individuals in the same group, there is a contextual effect.” (Orozco, Forero, & Wills, 2013).

To explore the existence of regional differences due to social capital in the insecurity perceptions, equation 4 shows the multilevel model at the regional level and the variables related; insecurity contains the 4 insecurity indexes of insecurity perceptions, the vector of demographic characteristics and social capital variables.

$$Insecurity_{ij} = \beta_{0j} + \beta_{1j}X_{1ij} + \beta_2 X_{2ij} + \cdots + \beta_n X_{nij} + \varepsilon_{ij} \ (4)$$

$$\beta_{0j} = \gamma_{00} + \mu_{0j}$$

$$\beta_{1j} = \gamma_{10} + \mu_{1j}$$

$X_{1ij} \ldots X_{nij}$ = Social Capital index

$X_{2ij} \dots X_{nij}$ = controls

3. Results

Our results on SWB are presented in Table 5. As it was found in the first stage of the project Unidades Productivas, insecurity perceptions have a negative effect on SWB. Here we introduce a second dimension of SWB at the community level. In particular, the personal and inner circle insecurity indexes reduce the personal SWB in 0.0141 and 0.0385 standard deviations. We found that, in the second stage of the project the economic and the community insecurity indexes have no explanatory capacity on the personal SWB. Additionally, the time of residence in the municipality has a negative impact on the personal SWB against the base outcome (less than a year). Predictably, the individuals with lower income have lower personal SWB against the base outcome (less than the minimum wage). Consistent with the first stage of the project, personal SWB is higher for the individuals with a higher social capital index of trust and reciprocity. However, the variable of social capital index of networks has no explanatory capacity on the dependent variable.

For the community SWB index the impact of the variables differ slightly. Individuals with lower income have lower community SWB against the base outcome (less than the minimum wage). We find that the individuals with higher community, personal and inner circle insecurity index have a lower community SWB index. In particular, an increase in 1 standard deviation of the insecurities index, reduce the community SWB in 0.00784, 0.0121 and 0.0727 standard deviations respectively. The social capital index of reciprocity and trust increase the community SWB index in 0.0727 standard deviations. Pena-Lopez et al. found similar results for Spain, where variables as income and education have a weak or no impact on SWB. Nevertheless, we have to take into account the effect of conflict on perceived wellbeing, for that reason we included the insecurity indexes. Cilliers et al. (2016) found that despite the efforts of reconciliation after conflict it has a negative effect on individual wellbeing.

Table 4 OLS Subjective Wellbeing, social capital and insecurity perceptions

Dependent variable: Subjective wellbeing		
Observations	1,225	1,225
Prob>chi2	0	0
R-squared	0.127	0.084
Independent variables and controls	**Personal Subjective Wellbeing**	**Community Subjective Wellbeing**
Age	-0.000196	-0.000349
	(0.000537)	(0.000344)
Age^2	3.39e-07	1.53e-06
	(5.34e-06)	(3.42e-06)
Gender: Women	-0.00114	-0.00239
	(0.00294)	(0.00188)
Gender: Other	-0.0261	0.00169
	(0.0468)	(0.0300)
Time of residence: [1,5) years	-0.0162**	-0.000623
	(0.00763)	(0.00489)
Time of residence >5 years	-0.0132*	-0.00250
	(0.00690)	(0.00442)
Time of residence: Lifetime	-0.0159**	-0.00434
	(0.00677)	(0.00433)
Children in the family	0.000283	0.000297
	(0.000678)	(0.000434)

Income: Minimum wage 2015	-0.00867***	-0.00535**
	(0.00326)	(0.00209)
Income: (Minimum wage 2015, $ 1.5 million COP)	-0.00884*	-0.00594*
	(0.00479)	(0.00307)
Income: [$ 1.5 million COP, $4.5 million COP)	-0.0126	-0.00867
	(0.0111)	(0.00710)
Income > $ 4.5 million COP	0.0334	0.00721
	(0.0481)	(0.0308)
Distance in time to the nearest town	-1.60e-05	-1.36e-05
	(2.69e-05)	(1.72e-05)
Level of Education: Primary school	-0.00269	-0.000210
	(0.00385)	(0.00247)
Level of Education: Secondary School	-0.00665	0.00389
	(0.00491)	(0.00314)
Level of Education: Technical education	-0.0187*	-0.00262
	(0.0107)	(0.00686)
Level of Education: University	-0.00576	-0.000451
	(0.0111)	(0.00711)
Marital status: married	0.00141	0.00109
	(0.00438)	(0.00280)
Marital status: widowed	0.00301	-5.85e-06
	(0.00733)	(0.00470)
Marital status: divorced	-0.00833	-0.00463
	(0.00948)	(0.00607)
Marital status: domestic partner	-0.00310	-0.000396
	(0.00420)	(0.00269)
Community insecurity index	-0.00577	-0.00814**
	(0.00550)	(0.00352)
Economic insecurity index	-0.00337	-0.00236
	(0.00827)	(0.00529)
Personal insecurity index	-0.0141***	-0.00784**
	(0.00486)	(0.00311)
Inner circle insecurity index	-0.0385***	-0.0121***
	(0.00629)	(0.00402)
Social capital: reciprocity- trust	0.119***	0.0727***
	(0.0333)	(0.0213)
Social capital: networks	0.00196	0.000550
	(0.0101)	(0.00647)
Constant	0.0731***	0.0394***
	(0.0155)	(0.00992)

Robust standard errors in parentheses
***p<0.01, **p<0.05, *p<0.1

Now we examine the effects of the individual level variables on social capital. Accumulation of human capital is a vehicle to accumulate social capital as found in Glaeser et al, so we used variables such as level of education and income to explore the effect on social capital; we also included other individual level variables and other controls. Table 6 shows the effect of the individual level variables on each dimension of the measures of social capital. We find that, with respect with the base outcome (male), the individuals identified with other gender have lower index of social capital of reciprocity and trust.

Individuals with a level of income of minimum wage have lower of social capital of reciprocity and trust with respect of the base outcome of income (less than the minimum wage). In contrast, individuals with higher level of income have a higher level of social capital index of reciprocity and trust. Education is significant only in some levels, and has low explanatory capacity. We find a significant effect of insecurity perceptions, the higher the index of insecurity perception, the lower the social capital index. Thus, higher perception of insecurity lowers social capital.

Controls of demographic characteristics as distance to the nearest town and connectivity measured through the km of roads have a positive and negative relation with social capital respectively. When the individual lives closer to the municipality has a lower social capital index, because he is more likely to develop sentiments of trust and reciprocity among its nearest neighbors. However, higher connectivity among neighbors facilitates social capital construction. We find difference in the variables that are significant in the network social index model. First, women and individuals identified with other gender have a lower index of the network social capital. The longest an individual has lived in the community the lower the social capital of networks is, due to the past encounters in the community that can lower the incentives to establish and maintain networks. As found in La Due & Huckfeldt (1998) “higher income individuals are more likely to have larger networks”, but we cannot conclude that individuals with low income do not develop this kind of relationships. Also, we find that, with higher population density, the higher social capital index. With more population per square kilometer is more likely to build networks. In addition, we find that there is a small positive effect of the number of km. of roads on the network’s social capital. The effects of insecurity indexes differ with the ones found on the social capital of reciprocity and trust. Insecurity has a positive effect on networks’ social capital. Mainly, the personal and the inner circle insecurity indexes increase social capital, if individuals feel that is more threatened the more the incentives to form networks.

These results are consistent with the theory. La Due & Huckfeldt (1998) explore the effect of individual level variables on social capital, in particular, in social capital that facilitates political engagement. They found that income and education have a positive effect on the size of the network and frequency of participation. Moreover, Glaeser et al, find a negative relation with of physical distance with social capital. Attanasio et al. (2015) find a positive effect of a conditional cash transfer program on social capital in a deprive area of Colombia. The authors used an impact evaluation to evaluate the effects of Familias en Acción on social capital, and through an experimental set up they measure the levels of trust, reciprocity and networking. In particular, the program of Familias en Acción induced the construction of trust and networks in the neighborhoods where the families had access to the program. The change in social capital was due through the mandatory meetings, where mothers met to share knowledge about health, education and the program in general. They found that the neighborhood first treated had higher levels of cooperation and trust.

Table 5 OLS individual level variables and social capital

Dependent variable: Social capital		
Observations	1,225	1,225
Prob>chi2	0	0
R-squared	0.102	0.135
Independent variables and controls	**Reciprocity-Trust**	**Networks**
Age	0.000116	0.000803
	(0.000409)	(0.00156)
Age^2	-1.28e-06	1.12e-06
	(4.18e-06)	(1.53e-05)

Gender: Female	-0.00333	-0.0233***
	(0.00233)	(0.00827)
Gender: Other	-0.0189***	-0.277***
	(0.00455)	(0.0151)
Time of residence: [1,5) years	0.00152	-0.0633***
	(0.00509)	(0.0228)
Time of residence >5 years	0.00706	-0.0882***
	(0.00486)	(0.0200)
Time of residence: Lifetime	0.00507	-0.0721***
	(0.00462)	(0.0196)
Children in the family	-5.52e-05	-0.00138
	(0.000558)	(0.00175)
Income: Minimum wage 2015	-0.00508*	-0.00405
	(0.00267)	(0.00950)
Income: (Minimum wage 2015, $ 1.5 million COP)	-0.00154	-0.0192
	(0.00463)	(0.0146)
Income: [$ 1.5 million COP, $4.5 million COP)	-0.0106	-0.00884
	(0.0114)	(0.0363)
Income > $ 4.5 million COP	0.0157**	0.121***
	(0.00667)	(0.0380)
Distance in time to the nearest town	-4.37e-05**	4.13e-05
	(2.01e-05)	(8.61e-05)
Level of Education: Primary school	0.00364	-0.0113
	(0.00285)	(0.0103)
Level of Education: Secondary School	0.00886**	-0.00962
	(0.00434)	(0.0140)
Level of Education: Technical education	0.0212	-0.0567*
	(0.0141)	(0.0303)
Level of Education: University	-0.00850*	-0.000395
	(0.00506)	(0.0338)
Population density	-2.59e-05	0.000143*
	(2.32e-05)	(8.64e-05)
Km of roads	9.40e-06**	7.51e-05***
	(4.05e-06)	(1.38e-05)
Community insecurity index	-0.0238***	0.000433
	(0.00501)	(0.0154)
Economic insecurity index	-0.0161**	-0.0160
	(0.00747)	(0.0258)
Personal insecurity index	0.00466	0.0502***
	(0.00402)	(0.0141)
Inner circle insecurity index	-0.0280***	0.0916***
	(0.00575)	(0.0181)
Constant	0.0554***	0.441***
	(0.0115)	(0.0436)

Robust standard errors in parentheses
***p<0.01, **p<0.05, *p<0.1

Third, we explore the relation of regional variables and land tenure on social capital. The variables of land tenure have mixed effects. In general, the collective land tenure variables have a negative effect on reciprocity and trust, nevertheless the impact is small. Also, we find that higher average age in the municipality, higher social capital regarding reciprocity and trust. Land tenure has a higher explanatory capacity on social capital regarding social networks. Both, collective and individual land tenure variables have a positive effect on networks. For example, an increase in 1 hectare of sharecropping increases the social capital index in 0.000308 standard deviations. In addition, a higher road density and a higher literacy index in the municipality increase this same index. A higher average age in the municipality, lower the social capital index regarding networks, ergo younger individuals are more engaged in conforming associations. Moreover, the size of the property has a positive but small effect on the dependent variable.

The results for the two-level models are presented in Table 8 and Table 9. We find that the aggregate individual insecurity perceptions differ among regions. We find higher dispersion of the data regarding the economic insecurity index. We identify demographic variables that identify these differences. We find a significant effect of social capital on insecurity perceptions. In particular, higher social capital, decreases insecurity perception. In the first level, income, population, size of property, number of homicides, literacy rates, and age has explanatory capacity on the insecurity indexes.

Table 6 OLS Regional variables and social capital

Dependent variable: Social capital		
Observations	1,680	1,680
Prob>chi2	0	0
R-squared	0.030	0.093
Independent variables and controls	**Reciprocity-Trust**	**Networks**
Land tenure with property rights	1.04e-06	2.56e-05*
	(3.78e-06)	(1.34e-05)
Land tenure: rent	-1.09e-06	0.000205***
	(1.36e-05)	(4.80e-05)
Land tenure: sharecropping	-4.02e-05	0.000308***
	(3.33e-05)	(8.72e-05)
Land tenure: usufruct	-6.80e-05	8.98e-05
	(4.49e-05)	(0.000167)
Land tenure: lending	0.000419**	-0.00130*
	(0.000197)	(0.000725)
Land tenure: without property rights	-3.24e-06	0.000671***
	(6.80e-05)	(0.000185)
Land tenure: Collective ownership	-5.82e-05***	0.000173***
	(1.29e-05)	(6.17e-05)
Land tenure: Communal property	0.000537**	3.58e-05
	(0.000220)	(0.000679)
Land tenure: other	0.000190***	0.000100
	(4.83e-05)	(0.000144)
Land tenure: mixed property (legal entity and natural person)	-8.30e-05***	0.000230**
	(2.45e-05)	(9.74e-05)
Population density	-8.76e-05***	-9.44e-05
	(3.23e-05)	(0.000111)
Road density	0.000477	0.0412***
	(0.00196)	(0.00815)
Municipal income	-2.37e-08	-1.61e-07
	(7.27e-08)	(2.25e-07)
Literacy rate 2015	-0.000205	0.00180***

	(0.000153)	(0.000600)
Age(average)	0.00589***	-0.0168***
	(0.00135)	(0.00484)
Size of the property	-3.67e-06	4.35e-05***
	(2.50e-06)	(1.28e-05)
Constant	-0.241***	1.170***
	(0.0630)	(0.227)

Robust standard errors in parentheses
***p<0.01, **p<0.05, *p<0.1

Table 8 Multilevel analysis, insecurity, reciprocity and trust

Dependent variable: Insecurity indexes

Observations	1,680	1,680	1,680	1,680
Number of groups	8	8	8	8
Prob>chi2	0	0	0	0
Independent variables and controls	**Community insecurity index**	**Economic insecurity index**	**Personal insecurity index**	**Inner insecurity index**
Fixed effects				
Social capital: Reciprocity-Trust	-1.347***	-0.515***	-1.038***	-1.373***
	(0.140)	(0.112)	(0.160)	(0.136)
Average income	2.47e-05***	8.37e-06***	-3.77e-05**	-2.94e-05***
	(6.56e-06)	(2.28e-06)	(1.48e-05)	(7.19e-06)
Average km of roads	-0.000600	0.000560***	0.00319***	0.00221***
	(0.000433)	(0.000150)	(0.000973)	(0.000474)
Average population	-4.73e-05***	-1.41e-05***	-1.48e-05	5.14e-06
	(7.09e-06)	(2.44e-06)	(1.60e-05)	(7.77e-06)
Average size of the property	0.00535***	-0.000337	-0.00185	-0.00315*
	(0.00171)	(0.000592)	(0.00384)	(0.00187)
Average number of homicides	-0.0244***	-0.0119***	-0.00562	0.00371
	(0.00453)	(0.00158)	(0.0102)	(0.00496)
Average literacy	0.0310***	-0.00939***	-0.0110	-0.0129*
	(0.00630)	(0.00217)	(0.0142)	(0.00691)
Average age	-0.00504***	-0.00261*	-0.00233	-0.00140
	(0.00188)	(0.00150)	(0.00214)	(0.00182)
Constant	1.245***	0.564***	1.279***	0.812***
	(0.145)	(0.0817)	(0.276)	(0.152)
Random effects				
Var(Constant)	0.0013774	0.0000139	0.0080694	0.0017307
Var(Residual)	0.0596579	0.0384974	0.0772185	0.0563993

Robust standard errors in parentheses
***p<0.01, **p<0.05, *p<0.1

Table 9 Multilevel analysis, insecurity, and networks

Dependent variable: Insecurity indexes				
Observations	1,680	1,680	1,680	1,680
Number of groups	8	8	8	8
Prob>chi2	0	0	0	0
Independent variables and controls	**Community insecurity index**	**Economic insecurity index**	**Personal insecurity index**	**Inner insecurity index**
Fixed effects				
Social capital: Networks	-0.0324	0.0305	-0.00273	0.112***
	(0.0448)	(0.0349)	(0.0504)	(0.0436)
Average income	2.39e-05***	8.94e-06***	-3.78e-05***	-2.72e-05***
	(5.86e-06)	(2.86e-06)	(1.41e-05)	(5.83e-06)
Average km of roads	0.0322***	-0.00904***	-0.0101	-0.0121**
	(0.00556)	(0.00264)	(0.0135)	(0.00553)
Average population	-0.000472	0.000579***	0.00327***	0.00224***
	(0.000383)	(0.000184)	(0.000928)	(0.000381)
Average size of the property	-4.83e-05***	-1.49e-05***	-1.58e-05	2.66e-06
	(6.27e-06)	(2.99e-06)	(1.52e-05)	(6.24e-06)
Average number of homicides	0.00484***	-0.000531	-0.00224	-0.00366**
	(0.00151)	(0.000717)	(0.00366)	(0.00150)
Average literacy	-0.0232***	-0.0118***	-0.00488	0.00373
	(0.00401)	(0.00193)	(0.00971)	(0.00399)
Average age	-0.00551***	-0.00289*	-0.00279	-0.00234
	(0.00193)	(0.00152)	(0.00217)	(0.00188)
Constant	1.212***	0.542***	1.251***	0.753***
	(0.136)	(0.0865)	(0.265)	(0.134)
Random effects				
Var(Constant)	0.0009926	0.0001067	0.0072851	0.0009957
Var(Residual)	0.0629903	0.0388848	0.0792066	0.0597016

Robust standard errors in parentheses
***p<0.01, **p<0.05, *p<0.1

5. Conclusions

The intensity of the conflict has declined in Colombia in the past few years, as so people have changed their perspectives, expectations and relationships. The main purpose of this study is to analyze sustainability through social constructed variables in this case subjective wellbeing and social capital. Subjective wellbeing is a proxy of sustainability that abstracts the perception of the conditions and characteristics of the environment. We also take into account social capital and insecurity perceptions as important variables that mediate the measure of subjective wellbeing. Our social capital variable is based on the perceptions of trust, reciprocity and association. We construct the indexes used to measure these variables from the Unidades Productivas survey from 2015.

We use an empirical approach to evaluate the impact of individual and regional level variables on subjective wellbeing and social capital. We find that social capital has a positive effect on subjective wellbeing, but subjective insecurity reduces the perception of wellbeing. This confirms the theory that social capital mediates the impact of conflict on perceptions of wellbeing. In addition, we find that insecurity perceptions have a negative effect on both subjective wellbeing and social capital. Individual characteristics have low explanatory capacity on our variables of interest. We use demographics and land tenure variables to make a global description of the variables that impact social capital and the way that it models sustainability. By using a multilevel analysis, we conclude that the perceptions of insecurity vary among regions, due by the differences in social capital and demographic characteristics.

Our results can strengthen public policy in areas affected by conflict. These results can be used to guide public policy and rural development programs in areas affected by armed conflict. It is necessary to take into account regional differences for the implementation and the development of this type of policies to obtain positive results, and thus avoid loss of economic and human resources. There is evidence that the strengthening of social capital and the possibility of improving subjective well-being have a positive impact on the development of rural regions. It is important to take into account these measures of perception of insecurity, wellbeing and social capital as components of sustainability to not only improve environmental conditions but also to work on improving individual perceptions to build a sustainable environment and future, overcoming the barriers imposed by conflict, violence and insecurity.

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Protected Areas Under Weak Institutions: Evidence from Colombia*

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Abstract

This paper assesses the effects of protected areas in Colombia using high-resolution forest loss imagery for the period 2001-2012. We combine two empirical strategies to identify causal effects: Regression discontinuity for protected areas created before 2001 (long-term effects) and difference-in-differences for areas create after 2001 (short-term effects). Results indicate that both natural protected areas (national and regional) and collective lands (Indigenous Reserves and Afro-Colombian lands) have significantly contributed to reducing forest loss. While the short-term effects tend to be larger in remote areas, in the long-term protected areas perform consistently better in densely populated areas and near roads. Given the predominance of illicit activities such as coca crops and gold mining in remote areas, we interpret our findings as suggestive evidence that protected areas are more effective when authorities are able to uphold the rule of law.

Keywords: Protected areas, deforestation, regression discontinuity
JEL Classification: Q20, Q28, Q58

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1 Introduction

Almost half of the Colombian continental territory is covered by natural protected areas and collective lands. In fact, there are approximately 160,000 km^2 of natural protected areas, of which 86% are national, and the remaining 16% are regional or managed by civil society. As part of the Paris Climate Agreement (COP21), the country engaged to further extend the natural protected areas by 25.000 km^2 before 2019. Collective lands, on the other hand, include 323,000 km^2 of Indigenous Reserves and 56,000 km^2 of Afro-Colombian lands. While this is not their main function, collective lands are legally restricted to sustainable activities, which makes them a key instrument of environmental policy.

Despite the extension of the protected areas, Colombian deforestation rates are high and continue growing. Official statistics indicate that the country lost 52,342 km^2 of forest between 1990 and 2015, equivalent to 8% of the baseline coverage (IDEAM, 2011; IDEAM, 2016). Kim et al. (2015) recent estimates suggest that the deforestation rate is growing from 1,300 km^2/year in 1990-2000 to 3.630 km^2/year in 2000-2010. Official reports and specialized literature have consistently shown that the main causes of deforestation are the expansion of the agricultural frontier, logging and mining, and coca crops (IDEAM, 2016; UNODC (2016a)). Most of these activities are only possible because of weak institutions, that translate into the inability of national and local authorities to enforce the law. Consistently, there is evidence that while conflict fuels deforestation through the expansion of illicit crops and mining in remote areas (Dávalos et al., 2011; Fergusson et al., 2014), land titling and enforcement policies do reduce coca cultivations (Muñoz-Mora et al., 2014; Mejía et al., 2015).

The increasing deforestation in protected areas is particularly alarming. Official reports indicate that, only in 2015, the National Natural Parks System lost 56,9 km^2 of forest, most of which due to the expansion of illegal crops and mining (IDEAM, 2016). These activities are also affecting collective lands. According to UNODC (2016a), in 2015, 40% of the illicit crops were located in Natural National Parks, Indigenous Reserves and Afro-Colombian lands. This is consistent with

Armenteras et al. (2009), who finds a significant correlation between deforestation and illicit crops in protected areas. Likewise, 45% of the illegal alluvial gold mining takes place in Afro-Colombian lands (UNODC, 2016b). These statistics cast doubts on the effectiveness of protected areas. While it seems reasonable to believe that the incidence of deforestation is smaller in protected areas than in the rest of the territory, there is no causal evidence to support this claim.

This paper addressed this question by estimating the extent to which natural protected areas (national and regional) and collective lands (Indigenous Reserves and Afro-Colombian lands) reduce forest loss. Our analysis is based on high-resolution annual forest loss imagery from 2001 to 2012 and official cartography of protected areas in Colombia. We propose two complementary identifications strategies that provide causal estimates of the effect of protected areas. First, we use Regression Discontinuity (RD) methods to estimate the effect of protected areas created before 2001 on the on the accumulated 2001-2012 forest loss. Second, we use Difference-in-Differences (DD) models for protected areas created after 2001. While the DD estimates reflect the short-term effects of protected areas, the RD estimates can be interpreted as long-term effects.

Our main results indicate that natural protected areas and collective lands have significantly contributed to reducing forest loss. Our long-term estimates find that national natural protected areas and indigenous reserves, most of which were created before 2001, reduce deforestation by -0.020 and -0.013 $ha/km^2/year$, respectively. Similarly, regional natural protected areas, civil society reserves and Afro-Colombian lands have negative and significant effects short-term effects that oscillate between -0.041 and -0.057 $ha/km^2/year$. These estimates are robust to different specifications and bandwidths, and placebo regressions confirm that the effects are concentrated around the true limits of the protected areas.

We also assess the role of human settlements on the effectiveness of protected areas by estimating heterogeneous effects by population density (measured with night lights clusters) and distance to roads. While the short-term effects tend to be larger in remote areas, in the long-term, protected areas are more effective in densely populated areas and near roads. These results suggest that even though settlements

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increase pressure on ecosystems, in a context of abundant illicit activities, protected areas are more effective when authorities are able to uphold the rule of law.

The paper contribution to the literature on the effectiveness of protected areas is twofold. On the one hand, we innovate in the identification strategy by introducing RD methods to estimate the long-term effect of protected areas. While most of the previous cross-section estimations corrected for observed heterogeneity (Andam et al., 2008; Joppa and Pfaff, 2011; Nelson and Chomitz, 2011), this is, to the best of our knowledge, the first paper to also account for unobserved heterogeneity in long-term estimates. As a complementary analysis, we use DD models to assess the short-term effects of protected areas created more recently. The combined results, along with numerous robustness checks, provide compelling evidence confirming that protected areas effectively reduce deforestation, forest fires, and fragmentation (Nepstad et al., 2006; Andam et al., 2008; Adeney et al., 2009; Armenteras et al., 2009; Nelson and Chomitz, 2011; Blankespoor et al., 2017; Sims, 2014). We also propose a two-step correction for the compound treatments bias. As our results show, this is particularly relevant when there are numerous contiguous protected areas.

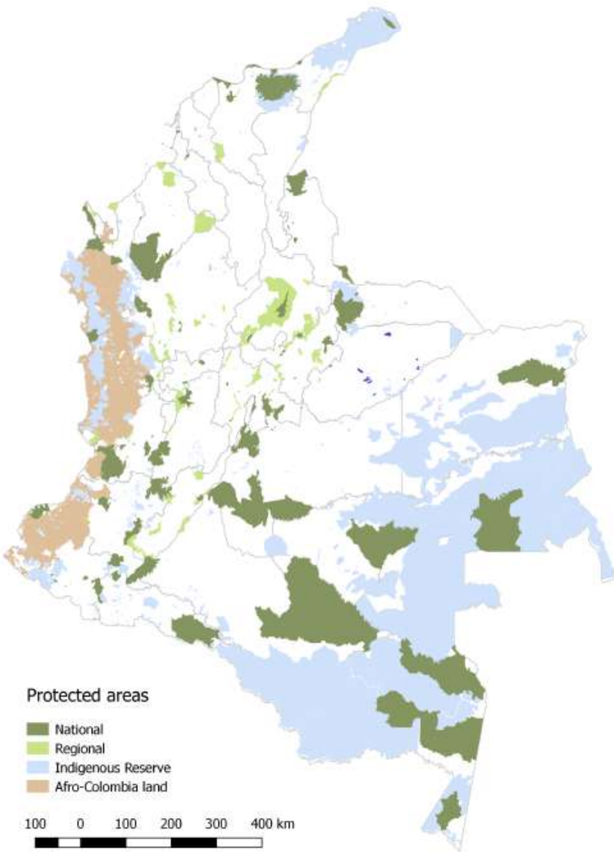
On the other hand, we provide new evidence on the heterogeneous effects of protected areas. While previous evidence on strict and mixed-use protected areas was mostly based on national natural protected areas and indigenous reserves (Nepstad et al., 2006; Adeney et al., 2009; Armenteras et al., 2009; Nelson and Chomitz, 2011; Porter-Bolland et al., 2012), we also estimate the effects for regional natural protected areas and Afro-Colombian lands. Our results show that the estimated effects vary considerably depending on the type of protected area and the time-frame. Furthermore, we assess the role of human settlements, finding that, in the long-run protected areas benefit from the capacity to enforce the law. These results are consistent with previous studies highlighting the relationship between conflict and state fragility and the proliferation of illicit activities and deforestation (Dávalos et al., 2011; Fergusson et al., 2014; Muñoz-Mora et al., 2014; Mejía et al., 2015).

The remaining of the paper is organized as follows. Section 2 describe the natural protected areas and the collective lands, emphasizing on their role in the environmental policy and the main threats they face. Sections 3 and 4 present the data and the empirical strategy. The main results, presented in section 5, are divided into three parts: long-term and short effects, and heterogeneous effects by population density and roads. The last section concludes.

2 Protected Areas as Environmental Policy

There are two main types of protected areas in Colombia: natural protected areas and collective lands. Natural protected areas, covering near 165,000 km^2, are national or regional, depending on the jurisdiction. There are also Civil Society Natural Reserves that are relatively new but are rapidly expanding. Collective lands include approximately 323,000 km^2 of indigenous reserves and 56,000 km^2 of Afro-Colombian Lands. Most of the national protected areas and indigenous reserves are located in the amazonian region (southeast), and most of the Afro-Colombian Lands are located in the Pacific (western) Coast (Figure 1). While most of the national natural protected areas and indigenous reserves were created during the 70's and 80's, regional natural protected areas and Afro-Colombian Lands are more recent (Figure 2). As will be seen in the following subsections, this is the result of the progressive development of the institutional and legal framework regarding environment and ethnic minority policy.

Figure 1
Continental Protected Areas (2015)



Source: Own calculations based on WDPA and IGAC.

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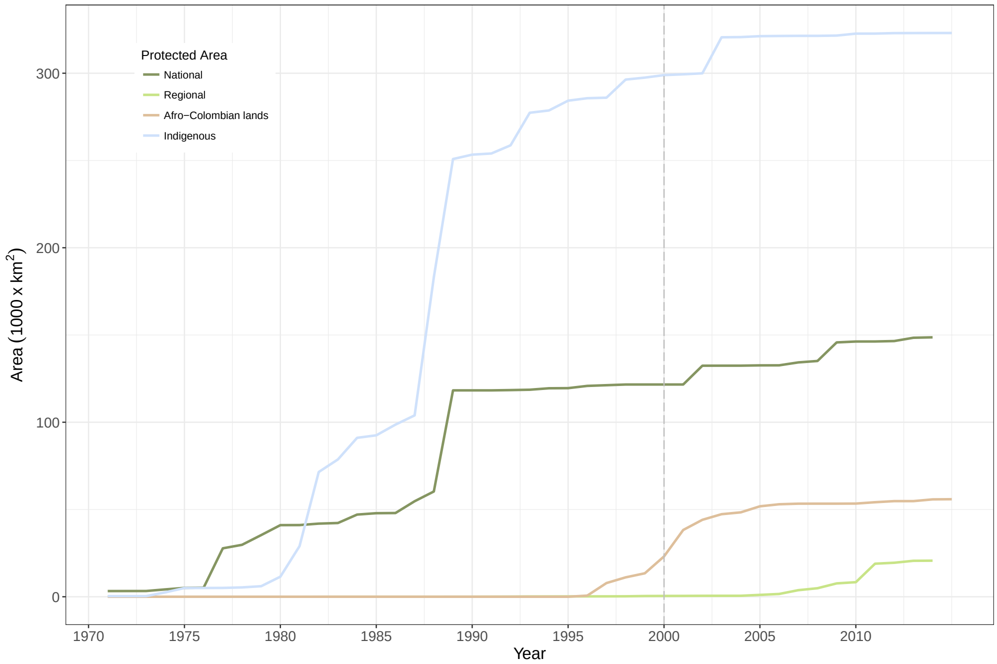
Figure 2
Expansion of Protected Areas (1940-2015)



Source: Own calculations based on WDPA and IGAC.

2.1 Natural Protected Areas

While there have been numerous environmental protection laws since the colonial period, the first natural protected area dates from 1948, when the Biological Reserve of *La Macarena* was created.[1] In 1959, the National Government takes a step forward by declaring seven Forest Reserves covering 652,803 km^2, equivalent to 57,2% of the continental land. Since then, national authorities has been in charge of setting aside areas for protective purposes, regulating forestry, and subtracting lands for economic activities and urban expansion. One of the first set-aside areas became the *Cueva de los Guácharos* National Park in 1960, first of its kind in Colombia. The National Institute for Renewable Natural Resources

[1] *La Macarena* was then expanded and transformed into National Park in 1971.

and Environment (INDERENA) was created in 1968 as the national environmental agency in charge of environmental policy and sustainable development. Following the 1972 United Nations Conference on the Human Environment, the Government established environment as a public good in 1973 and created the National Natural Parks System in 1974. It is under this legal framework that most of the existing National Parks were created during the 1980's (Figure 2).

The 1991 Constitution and subsequent legislation restructured the environmental institutional framework by creating the Ministry of Environment and Sustainable Development and the specialized agency Natural National Parks of Colombia. The reform also assigned the Regional Autonomous Corporations (CAR), decentralized environmental authorities, the delimitation and management of regional natural protected areas, and the enforcement of environmental licenses. The National System of Protected Areas (SINAP), created in 1994, includes 165,829 km^2 of protected areas, of which 87% are national, 12.4% are regional and 0.4% are Civil Society Natural Reserves.[2]

There are two key differences between national and regional protected areas. First, while national protected areas restrict most economic activities, with the exception of conservation, education, and research, most of the regional protected areas allow sustainable activities that include non-intensive agriculture, farming and mining. Second, national protected areas are by Constitution imprescriptible, inalienable and indefeasible and therefore cannot be revoked. With the exception of Regional Natural Parks, it is legally possible to subtract land from all regional protected areas.

2.2 Collective Lands

Colombian ethnic minorities are particularly diverse and dispersed throughout the country (Laurent, 2007). On the one hand, there are approximately 87 indigenous

[2]National protected areas include Unique Natural Area, National Natural Park, National Forest Reserve, Natural Reserve, Fauna and Flora Sanctuary, Park Way, and the UNESCO Biosphere Reserve and World Heritage Site. Regional protected areas include Recreation Area, Soil Conservation District, Integrated Management District, Regional Natural Park and Regional Forest Reserve. The extension of each type of protected area is presented in Panel A of Table A.1 of the Appendix.

groups, representing 3.4% of the total population, which have inhabited the region since the precolonial era. These groups have different languages and cultural heritage and do not necessarily relate to each other. While the two states with most indigenous, La Guajira and Cauca, account for less than 40% of the indigenous population, there are indigenous reserves in almost every state. The Afro-Colombians, on the other hand, account for 10.6% of the population and are more geographically concentrated in the Pacific and Caribbean coasts. Their settlement pattern is closely related to the slave traffic routes and the gold mining activities during the colonial period. The Pacific region, where most of the Afro-Colombian Lands are located, is nowadays mostly populated by former slaves, freed by emancipation and bought manumission, whose main economic activity is still based on mining, logging and agriculture (Sharp, 1976; Leal and Restrepo, 2003).

Indigenous reserves were created during the colonial period as a way of concentrating and somehow protecting the native workforce. The institution was then inherited by the Colombian government, which continued establishing indigenous reserves during the XIX and XX century. However, most of the original settlements were never classified as such and rights could be revoked, which led to systematic displacement throughout this period (Gros, 1988; Jackson, 2002). It was not until the late XX century that the institutional and legal framework translated into more effective protection. In particular, the 1991 Constitution declared Colombia as a multilingual and multicultural nation and accorded collective rights to minority groups. indigenous reserves land titles became imprescriptible, inalienable and indefeasible, and their organizations gained political participation and administrative and judiciary autonomy. The Law 70 of 1993 granted similar rights to Afro-Colombian from traditional settlements in the Pacific region.

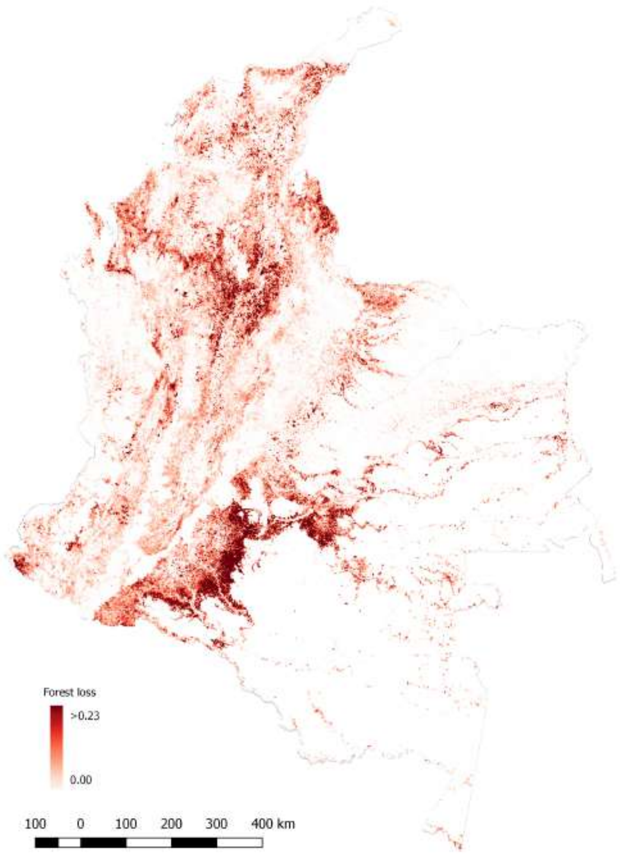
Even though this is not their main purpose, collective lands are also intended to protect and preserve the environment. In fact, The Laws 70 of 1993 and 60 of 1994 required indigenous reserves and Afro-Colombian lands economic activities to be environmentally sustainable, and in accordance with their traditional practices. The environment in collective lands, however, is particularly threatened by illicit activities. In fact, coca crops have rapidly expanded in indigenous reserves and Afro-Colombian lands (Armenteras et al., 2009,UNODC, 2016a), and so have illegal logging and gold mining takes place in Afro-Colombian lands (UNODC, 2016b). This is partly due to the incapacity of local authorities to monitor economic activities in remote areas and restrict illicit crops and heavy machinery in alluvial mining (Velez, 2011).

One key element that natural protected areas and collective lands have in common is that their limits are given by biological, geographical and historical factors. In fact, environmental authorities usually rely on expert assessment to identify areas which are key to the preservation of particular endemic species or ecosystems (Fandiño and Van Wyndaarden, 2005; Andrade, 2009). For instance, the *Cueva de los Guácharos* National Park was created in 1960 to preserve the Guácharos (*Steatornis caripensis*) habitat and facilitate bird migration. Likewise, minority groups applying for collective ownership titles need to prove ethnic origins and historic ties to the land. It is worth noting, however, that the delimitation can also involve discretionary choices. In fact, it is not uncommon to use state limits or rivers as borders, even though they do not reflect major changes in the landscape. As will be seen in section 4, this has practical implications for the identification strategy.

3 Data

Our main results are based on detailed geographic information on forest loss and protected areas. Regressions also control for population density, and physical and chemical characteristics of the land, for which we collect information from different sources. This section briefly describes them and provide some descriptive statistics of deforestation in protected areas.

Figure 3
Accumulated Deforestation (2001-2012)



Source: Own calculations based on Hansen et al. (2013).
Note: The 2001-2012 total deforestation is aggregated at a spatial resolution of 1 km^2 and expressed in $ha/km^2/year$.

Our annual deforestation measure is based on Hansen et al. (2013)'s 2001-2012 forest loss imagery.[3] In order to match the spatial resolution of other data sources, we aggregated the deforestation measure to $\approx$1 km^2, obtaining a continuous variable

[3]Data for 2013-2014 is also available, however, images are not entirely comparable due to methodological changes, which is why we focus on the 2001-2012 period.

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expressed in ha/km^2. During this period, the country lost over 30,000 km^2 of forest (see Figure 3). While most of the deforestation in the Amazon region is due to the expansion of the agricultural frontier and the presence of illicit crops, Antioquia, Bolíivar (north-central region) and the Pacific Coast have also witnessed a sharp increase in illegal alluvial gold mining (IDEAM, 2011; IDEAM, 2016; UNODC, 2016a; UNODC, 2016b).

Protected areas are delimited using two data sources: World Database on Protected Areas (WDPA) for natural protected areas, and the Colombian Geographic Information System for Planning (SIGOT) for indigenous reserves and Afro-Colombian Lands. Descriptive statistics of deforestation in protected areas are presented in Table 1. Between 2001 and 2012, most of the deforestation in protected areas took place in national and regional natural protected areas, with 96.3 and 53.4 $km^2/year$, respectively. The deforestation in collective lands is smaller but still significant, with 25 $km^2/year$ in indigenous reserves and 11.4 $km^2/year$ in Afro-Colombian lands. In relative terms, national natural protected areas are the best preserved, followed by regional natural protected areas and indigenous reserves, with deforestation rates that oscillate between 0.0005 and 0.0066 $ha/km^2/year$. Afro-Colombian lands and Civil Society Natural Reserves have the highest forest loss rate, with 0.0181 and 0.3209 $ha/km^2/year$, respectively.

Table 1
Annual deforestation in protected areas
(2001-2012)

	Annual Deforestation	
	Total (km^2)	*Rate* (ha/km^2)
A. Natural Protected Areas		
National	96.295	0.0005
Regional	53.385	0.0024
Civil Society Natural Reserves	1.229	0.3209
B. Collective Lands		
Indigenous Reserve	24.954	0.0066
Afro-Colombian Land	11.381	0.0181

Source: Own calculations based on WDPA, IGAC and Hansen et al. (2013).

We measure population density using nightlights imagery from the National Oceanic and Atmospheric Administration (NOAA). Specifically, we calculate the year-2000 clusters of high-intensity night lights to identify densely populated areas.[4] We also identify cells located less than 5 km from the roads using the 2005 official cartography of the Colombian National Department of Statistics (DANE). As expected, there is a very high spatial correlation between population density and roads (Figure A.1 of the Appendix). It is worth noting, however, that the road measure has two limitations. First, there are some isolated communities, particularly in the Amazon region and the Pacific Coast, that are not served by roads. In such cases, night lights provide a more accurate measure of human settlements. Second, road cartography is only available since 2005, and therefore measures based on roads might be endogenously determined.

As additional controls, we include basic geographic characteristics at the cell level including altitude, slope, and roughness, calculated using the Digital Elevation Model (DEM) (Danielson and Gesch, 2011). Soil nutrient availability is taken from the Food and Agricultural Organization (FAO) soil quality measurements and baseline average precipitations are calculated using the *WorldClim* 1960-2000 spatial interpolation (Hijmans et al., 2005).

4 Empirical Strategy

A growing body of literature has studied the causal effect of protected areas on deforestation. The main empirical challenge lies in the fact that protected areas are not randomly delimited. In fact, the limits are usually given by biological, geographic and even historic factors, and therefore we should expect observed and unobserved differences between treated and control cells to bias traditional estimates. To address this potential endogeneity problem Joppa and Pfaff (2011)

[4]Night lights have been extensively used in the literature as a proxy for population and economic density (Henderson et al., 2012; Michalopoulos and Papaioannou, 2013, 2014; Min, 2015). Doll et al. (2000) and Small et al. (2011) show that nightlights can detect populations up to 150 inhabitants and sparsely populated areas. Clusters are calculated using a clump algorithm based on queen distance with 8 nearest neighbors.

and Nelson and Chomitz (2011) use matching methods, that balance the sample on observed characteristics but could still be biased by unobserved characteristics. More recently, Blankespoor et al. (2017) and Shah and Baylis (2015) use annual deforestation data to estimate DD methods that control for both observed and non-observed characteristics. The main limitation of this approach is that it can only assess protected areas that were recently created.

We propose using RD methods to estimate the long-term effect of protected areas. The key idea is that as we approach the protected area limits, the differences between cells on both sides of the boundary tend to vanish. The main advantage of this approach is that it allows estimating the local effects of protected areas created *before* forest loss is measured -usually a majority- while controlling for both observed and unobserved characteristics. We also propose a two-step correction for compound treatments that restrict the control group to cells that are not part of any other protected area. This is, to the extent of our knowledge, the first paper to use these methods to assess the effect of protected areas. As a complementary analysis, we estimate the short-term effect of recently created protected areas using DD models that exploit the time and space variation. The remaining of this section describes the definition of the treatment and control groups and the compound treatments correction and presents the estimation methods: RD for the long-term and DD for the short-term.

4.1 Treatment and Control Groups and Compound Treatments Correction

Our first classification is based on location and period. For a particular type of protected area and a given year, continental cells within an existing protected area are assigned to treatment group, and those outside to control. For simplicity, we exclude marine protected areas and protected areas under 1 km^2. This leaves us with 287 natural protected areas, 550 indigenous reserves, and 106 Afro-Colombian lands. We further restrict the sample to comparable cells located nearby the protected area boundaries. To this purpose, we calculate the minimum distance between the cells' centroids and the boundaries. When protected areas are contiguous to international

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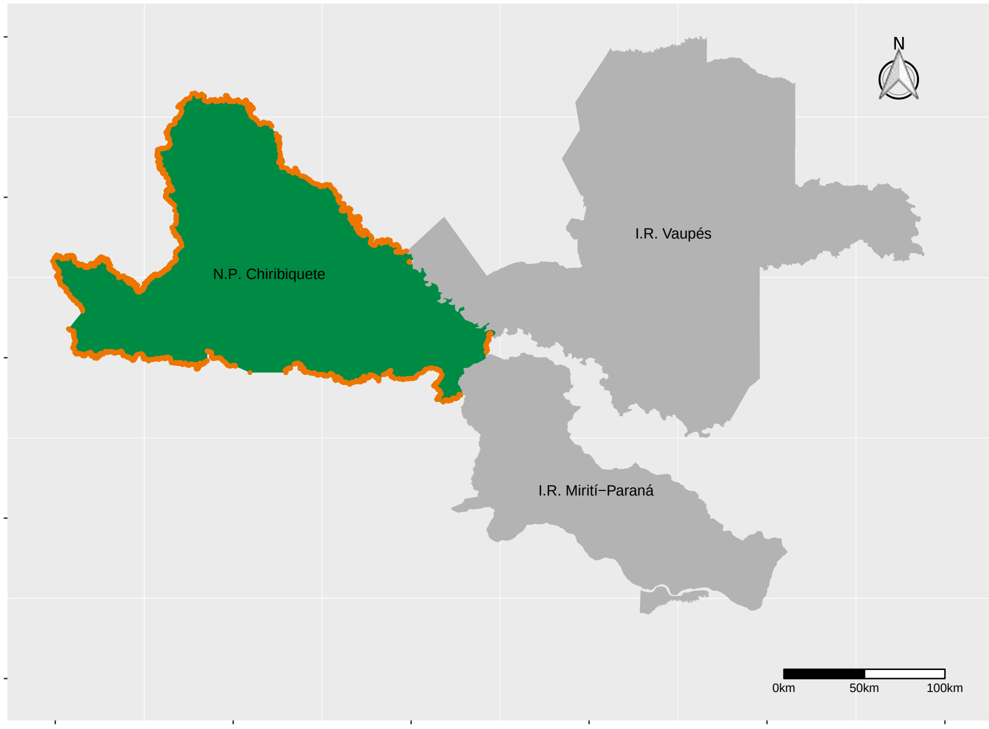
borders and coastline, these segments are excluded from the boundary.

Figure 4
Contiguous Protected Areas Correction



Source: Own calculations based on WDPA and IGAC.
Note: NP: National Park, IR: Indigenous Reserve. The valid boundary is presented in orange (thick border). Point density depends on the polygon complexity.

There are many protected areas that are contiguous to each other, especially in the Amazon and Pacific regions. This translates into compound treatments that can seriously bias the estimates. In fact, it is possible that cells that are considered control for one type of protected area are treated for another type (Keele and Titiunik, 2015). To correct this problem, we propose a simple two-step approach. First, we identify boundaries which are close (<1km) to *valid* control cells, i.e. cells in the continental territory that are not part of any other protected area. Second, we recalculate the minimum distance with respect to the new *valid* boundaries. Figure

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4 illustrates the correction. In order to define the treatment and control groups for the Chiribiquete National Park (green), we exclude the segments where the National Park is contiguous to indigenous reserves, calculate the valid boundary, and keep the cells located within the selected bandwidth.

Table 2 presents some descriptive statistics of deforestation rate and the physical and chemical characteristics by type of protected area and treatment status for a 5km fixed bandwidth. As can be seen, in most cases deforestation rates are significantly lower in the treatment cells. The results presented in the next section confirm that these differences are mostly due to protected areas. It is also worth noting that treatment and control groups are not always balanced in observed characteristics. This is consistent with the fact that protected areas are not exogenously delimited. In order to address the potential selection bias, RD regressions control for physical and chemical characteristics of the land and protected area fixed effect. DD models also account for unobserved heterogeneity by including cell fixed-effects and protected area specific time trends. The fact that results are similar across specifications indicate that selection bias is not a critical issue in our local estimations.

Table 2
Descriptive Statistics *(Continues)*

	Control		Treatment		Difference
	Mean	S.E.	Mean	S.D	p-value
A. National					
Deforestation ($ha/km^2/year$)	0.214	0.475	0.135	0.434	0.001
Population density	0.171	0.377	0.063	0.242	0.000
Roads ($< 5km$)	0.424	0.494	0.239	0.426	0.000
Elevation (m)	1305.110	1183.921	1404.441	1299.599	0.102
Slope (*degrees*)	0.073	0.077	0.076	0.083	0.444
Ruggedness	178.576	188.787	187.713	200.429	0.457
Precipitation (mm)	186.869	55.783	189.151	53.019	0.397
Soil nutrient availability	2.671	0.667	2.757	0.606	0.031
Forest cover in 2000 (ha/km^2)	69.232	31.190	75.311	31.121	0.003
Observations	50,980		45,190		
B. Regional					
Deforestation($ha/km^2/year$)	0.253	0.430	0.205	0.449	0.087
Population density	0.440	0.496	0.232	0.422	0.000
Roads ($< 5km$)	0.791	0.407	0.612	0.487	0.000
Elevation (m)	1585.277	1092.327	1742.207	1205.792	0.152
Slope (*degrees*)	0.084	0.073	0.100	0.079	0.027
Ruggedness	207.758	174.926	246.610	190.407	0.026
Precipitation (mm)	162.519	48.607	161.806	49.343	0.860
Soil nutrient availability	2.423	0.756	2.578	0.705	0.013
Forest cover in 2000 (ha/km^2)	51.565	28.706	61.449	30.319	0.000
Observations	41.915		21.420		
C. Civil Society Natural Reserves					
Deforestation($ha/km^2/year$)	0.159	0.297	0.179	0.428	0.838
Population density	0.304	0.460	0.242	0.428	0.437
Roads ($< 5km$)	0.729	0.444	0.499	0.500	0.095
Elevation (m)	1140.358	1250.027	1928.957	1273.893	0.018
Slope (*degrees*)	0.058	0.078	0.108	0.089	0.004
Ruggedness	146.231	193.244	264.495	214.375	0.005
Precipitación (mm)	162.324	42.530	166.418	38.712	0.685
Soil nutrient availability	2.515	0.798	2.391	0.694	0.440
Forest cover in 2000 (ha/km^2)	35.707	29.200	62.983	30.162	0.000
Observations	4.184		1.183		
D. Indigenous Reserves					
Deforestation ($ha/km^2/year$)	0.231	0.455	0.107	0.311	0.000
Population density	0.107	0.309	0.022	0.147	0.000
Roads ($< 5km$)	0.439	0.496	0.215	0.411	0.000
Elevation (m)	553.792	741.805	372.110	588.480	0.000
Slope (*degrees*)	0.031	0.054	0.023	0.049	0.000
Ruggedness	75.608	131.147	56.845	120.140	0.000
Precipitation (mm)	219.122	67.192	228.226	67.426	0.071
Soil nutrient availability	2.655	0.678	2.715	0.681	0.226
Forest cover in 2000 (ha/km^2)	65.719	34.800	75.538	34.499	0.000
Observations	92.654		59.463		

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Table 2
Descriptive Statistics

	Control		Treatment		Difference
	Mean	S.D.	Mean	S.D	p-value
E. Afro-Colombian Lands					
Deforestation ($ha/km^2/year$)	0,333	0,688	0,171	0,392	0,001
Population density	0,086	0,280	0,049	0,216	0,013
Roads ($< 5km$)	0,335	0,472	0,259	0,438	0,082
Elevation (m)	590,869	810,220	373,658	635,912	0,000
Slope (*degrees*)	0,046	0,063	0,032	0,052	0,001
Ruggedness	111,639	152,545	76,535	126,360	0,001
Precipitation (mm)	310,291	120,590	372,568	135,516	0,000
Soil nutrient availability	1,904	0,850	2,082	0,815	0,006
Forest cover in 2000 (ha/km^2)	84,345	19,729	91,637	11,866	0,000
Observations	10.780		13.759		

Source: Own calculations based on Hansen et al. (2013). WDPA, IGAC, NOAA, FAO and Hijmans et al. (2005).
Note: Calculations are based on treatment and control cells within 5 km of the valid boundary. Deforestation is defined as the annual forest loss between 2001 and 2012. Population density is a dummy variable indicating if a cell is inside a clump of night luminosity at the baseline year (2000). Roads is a dummy variable identifying cells within the 5 km of a 2005 road. The remaining control variables are described in section 3. The last column presents the *p-value* of a group mean difference test.

4.2 Long-term: Regression Discontinuity

The motivation behind using RD methods is twofold. On the one hand, treatment and control cells located near and around the protected area boundaries are more likely to be comparable, which attenuates the potential selection bias in local estimations. This is particularly true for protected area limits based on discretionary choices such as state borders or rivers. On the other hand, the granularity of the remote sensing data provides a large number of observations, allowing for robust inference. The running variable is the distance to the closest boundary, which is set to be positive for treatment cells and negative for control so that the cutoff is zero for all areas. This analysis focuses on protected areas created before 2001, and their effect on the annual average deforestation between 2001-2012. In order to avoid compound treatments, we discard potential control cells that are classified as protected area at any point in time.

We use the Calonico et al. (2014) RD sharp design model, that first selects the optimal bandwidth, balancing the asymptotic bias and the variance of the estimator,

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and then estimate the effect using local-polynomial non-parametric regressions. The estimated effect is given by the conditional mean difference between treatment and control cells:

$$\tau = \mathbf{E}[Y_{i(T=1)} - Y_{i(T=0)} \mid X = \bar{x}] \tag{1}$$

Conditional means are estimated with triangular kernel-weighted polynomials.[5] Regression include as control variables for baseline forest cover, altitude, slope, roughness, soil nutrient availability, and precipitations. Regressions also control for protected area fixed effects, which account for unobserved heterogeneity.[6] Errors are computed using cluster-robust nearest neighbor variance estimation.

4.3 Short-term: Difference-in-Differences

For protected areas created after 2001 we exploit the time variation to estimate DD models that compare treatment and control cells, before and after the protected area is created. We test for bandwidths ranging from 1 to 15km. The main regression takes the form:

$$Y_{it} = \gamma T_{it} + \mu_i + \tau_t + \eta_a * t + \epsilon_{it} \tag{2}$$

Where the dependent variable (y_{it}) is the annual deforestation and T_{it} is a categorical variable that is one if cell i is within a protected area in year t, and zero otherwise. Regressions control for cell (μ_i) and time (τ_t) fixed effects that account for observed and unobserved characteristics of the land and common shocks, as well as protected area specific time trends ($\eta_a * t$). The models are estimated with ordinary least squares (OLS) and errors are clusterized at the protected area level.

[5]The regression function is estimated with a first order polynomial and the bias of the regression with a second order polynomial. Overall, our results are robust to different specifications.

[6]Covariate-adjusted RD estimates are consistent and improve efficiency (Calonico et al., 2016). Control cells are assigned to the nearest protected area.

5 Results

The main results of the paper are presented in three sections. The first two correspond to the long-term and short-term effects, and their respective robustness checks. The third section assesses the role of human settlements, measure by population density and roads. Our estimated coefficients are comparable to the extent that they are all expressed in $ha/km^2/year$ and can be interpreted as local effect of protection. However, most of the national natural protected areas and indigenous reserves were created before 2001 (Figure 2). This implies that short-term results are driven by relatively few protected areas and should not allow to infer about the population of protected areas. The opposite happens to Afro-Colombian lands, regional natural protected areas and civil society natural reserves that were for the most created after 2001. In this case, long-term estimates should be interpreted with caution.

5.1 Long-term (Areas created before 2001)

Our main long-term results, based on the Calonico et al. (2014) estimates with optimal bandwidths, are presented in Table 3. We find negative and significant effects for national protected areas and indigenous reserves. The estimated effect of national protected areas is -0.02 ha/km^2/year, equivalent to a 9.1% avoided forest loss when compared to the control group. Multiplying the estimated coefficient by the surface of the treated area in the optimal bandwidth we find that national protected avoided the deforestation of 839,2 ha per year. Since we are only considering cells within the local bandwidths, this should be interpreted as a lower bound of the overall effect of these protected areas. The effect of indigenous reserves is slightly smaller, with an estimated coefficient of -0.013, equivalent to a 6.3% avoided forest loss or 452,2 ha per year in the optimal bandwidth. These findings are consistent with Armenteras et al. (2009), the only existing study for Colombia, who find significantly larger effects for national natural protected areas than for indigenous reserves. Our results also indicate that there are negative and significant effects for regional protected areas created before 2001 (-0.028

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ha/km^2/year), and no effect for Afro-Colombian lands. It is important to note, however, that these results only reflect the effect of the few regional protected areas and Afro-Colombian lands created before 2001.

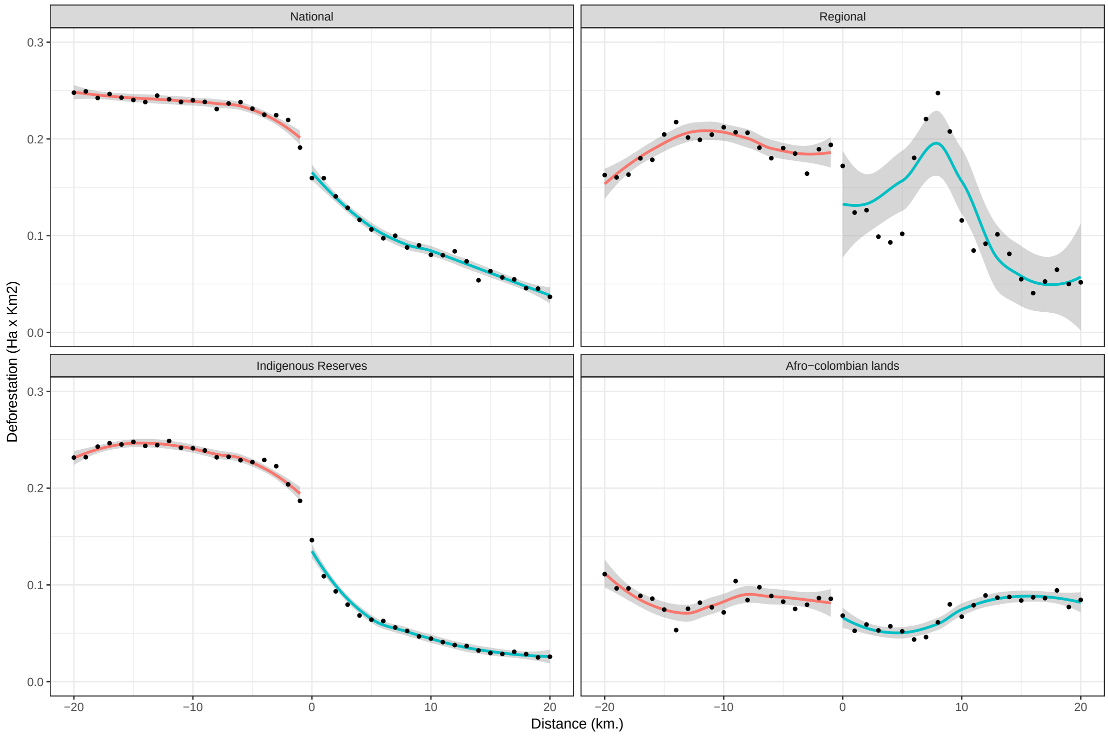
Table 3
Long-term Effects of Protected Areas on Deforestatation

	Natural Protected Areas		Collective Lands	
	National (1)	Regional (2)	Indigenous Reserves (3)	Afro-Colombian (4))
Treatment	$-0.020***$	$-0.028**$	$-0.013**$	-0.008
	(0.006)	(0.013)	(0.006)	(0.013)
Optimal Bandwidth (km)	5.429	14.035	3.231	8.637
Control Group Mean(y)	0.219	0.197	0.207	0.086
Observations	92,178	16,034	81,682	5,789

Source: Own calculations based on Hansen et al. (2013), WDPA, IGAC, NOAA, FAO and Hijmans et al. (2005).
Note: * is signicant at 10%, ** at 5%, and *** at 1% level. Deforestation is expressed in $ha/km^2/year$. Each column correspond to separate Calonico et al. (2014) RD estimates with optimal bandwidth and robust bias-correction. All regressions control for population density and the geographic and climate variables described in the Section 3. We present the results based on a first order local-polynomial for bias correction and estimation, however results are robust to different specifications of the model. Standard errors in parenthesis are based on a nearest neighbor variance estimator.

These findings are illustrated in Figure 5 with the RD plots for the different types of protected areas. The left panels clearly show that the RD estimates for national natural protected areas and indigenous reserves are driven by a sharp jump in deforestation around the protected area limits. This is not the case of regional protected areas and Afro-Colombian lands, for which the difference is less steep and not necessarily statistically significant.

Figure 5
Long-term Effects of Protected Areas on Deforestatation



Source: Own calculations based on WDPA, IGAC and Hansen et al. (2013). Note: Observations are binned with 1km intervals and smoothed using triangular kernels. Shaded areas represent the 95% confidence interval.

In order to check the sensibility of our results to changes in the bandwidth, we estimate the Calonico et al. (2014) bias corrected model using bandwidths from 1 to 15 km in Figure 6. As can be seen, the effects are consistently negative and significant for national protected areas and indigenous reserves, but not for regional protected areas and Afro-Colombia lands, where the estimated coefficients only reject the null hypothesis for bandwidths larger than 10km.

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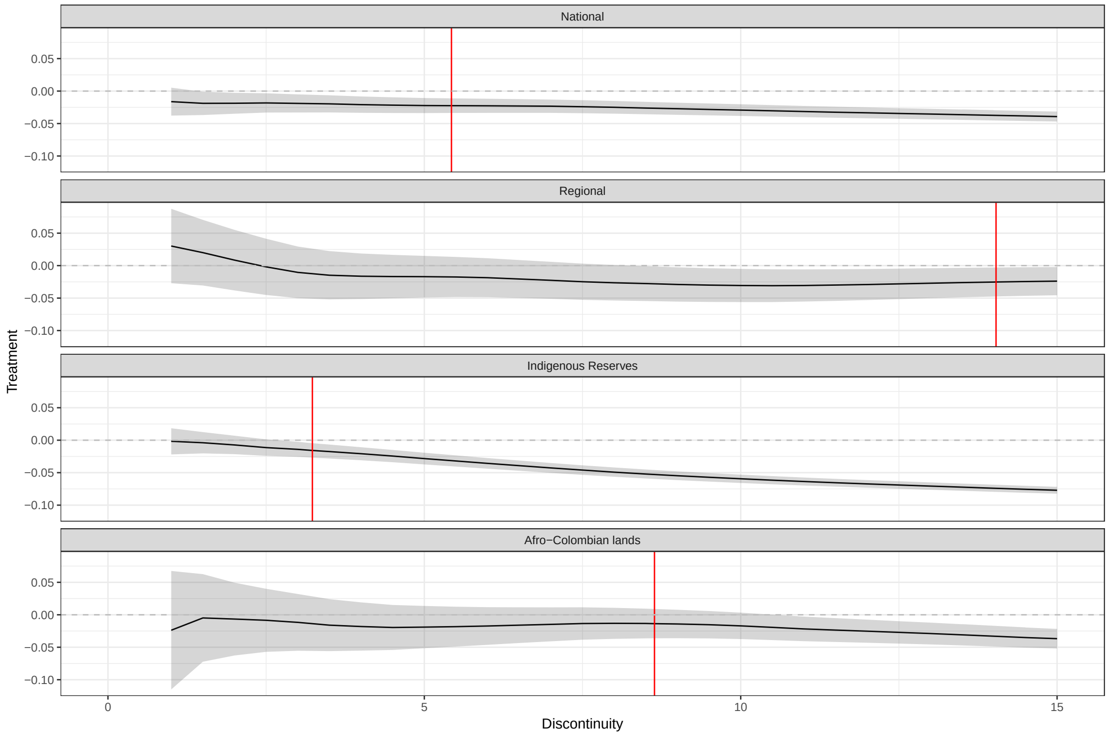
Figure 6
Long-Term Effects: Bandwidth Sensibility



Source: Own calculations based on Hansen et al. (2013), WDPA, IGAC, NOAA, FAO and Hijmans et al. (2005).
Note: Each graph corresponds to DD estimate for bandwidths between 1 and 15 km with increments of 500 meters. All regressions control for population density and the geographic and climate variables described in the Section 3. We present the results based on a first order local-polynomial for bias correction and estimation, however, results are robust to different specifications of the model. Errors are robust to heteroscedasticity and optimal bandwidth is shown in red.

We also estimate two alternative specifications of the model in Table A.2 of the Appendix. In Panel A we drop the control variables finding fairly similar results, with the sole exception of regional protected areas, where the estimated coefficient is no longer significant. Panel B omits the compound treatments correction described in section 4.1. The estimated effects are relatively similar, although larger in magnitude, confirming that including all potential control cells can bias the estimates.

Our last robustness check uses placebo threshold, drawn as artificial limits

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parallel to the original ones. We should expect the estimated effects to vanish as the placebo thresholds move away from the true limits of the protected areas. Figure A.2 of the Appendix presents the estimated effects with fixed bandwidth of 5km and placebo limits moving as far as 10km on both sides of the original limit.[7] The negative and significant effects are concentrated nearby the true limits, and converge to zero as they move away, confirming that protected area do account for most of the local variation in deforestation.

5.2 Short-term (Areas created after 2001)

The DD short-term estimates, based on a fixed bandwidth of 5km, are presented in Table 4. We find negative and significant effects for all natural protected areas and Afro-Colombian lands, with estimated coefficients oscillating between -0.029 and -0.057 ha/km^2/year, slightly larger than the ones found in the long-run. indigenous reserves are the exception, with positive and significant effects, indicating that deforestation increased within the park limits. Remember, however, that only few of the indigenous reserves were created after 2001 and therefore results should be interpreted with caution. In this case, most of the positive effect can be explained by the fast expansion of illegal coca crops and gold mining in one particular Indigenous Reserve, *Selva de Matavén*, which accounts for nearly 90% of the treated cells MJD and UNODC (2015).

[7] We opt for a fixed bandwidth in order to have comparable results across samples.

Table 4
Short-term Effects of Protected Areas on Deforestatation

	Natural Protected Areas			Collective Lands	
	Nacional (1)	Regional (2)	Civil Society (3)	Indigenous Reserve (4)	Afro-Colombian (5)
Treatment	-0.029***	-0.041***	-0.057***	0.058***	-0.049***
	(0.005)	(0.005)	(0.019)	(0.010)	(0.012)
Bandwidth (km)	5.000	5.000	5.000	5.000	5.000
Control Group Mean(y)	0.146	0.259	0.169	0.301	0.386
Observations	94,824	640,716	64,404	90,492	176,436

Source: Own calculations based on Hansen et al. (2013), WDPA and IGAC.
Note: * is signicant at 10%, ** at 5%, and *** at 1% level. Deforestation is expressed in $ha/km^2/year$. Each column correspond to separate DD estimate with a 5km bandwidth. All regressions control for cell and year fixed effects and protected area specific time trends. Errors in parenthesis are clustered at the protected area level.

The robustness checks are analogous to those of the long-term results. The sensibility analysis, presented in Figure 7, shows that all of our estimates are robust to bandwidth selection. Results are also similar without the compound treatment correction (Table A.3 of the Appendix). Moreover, the placebo threshold estimates confirm that the significant effects tend to be concentrated around the true limits of the protected areas (A.3 of the Appendix). The only exception are the national natural protected areas, for which the estimated effects are larger for artificial limits located inside protected areas. This reflects that the National Parks created after 2001 are particularly threaten by deforestation in the border areas.

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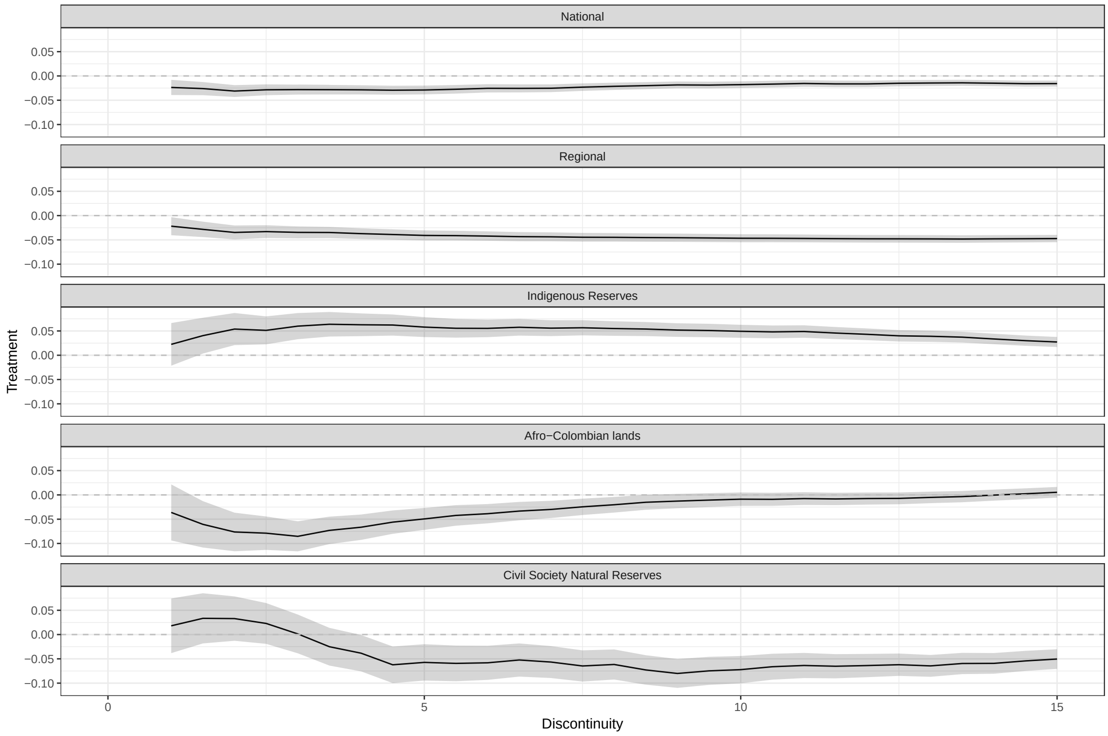
Figure 7
Short-Term Effects: Bandwidth Sensibility



Source: Own calculations based on Hansen et al. (2013), WDPA, IGAC, NOAA, FAO and Hijmans et al. (2005).
Note: Each graph corresponds to DD estimate for bandwidths between 1 and 15km with increments of 500 meters. All regressions control for cell and year fixed effects and protected area specific time trends. Errors are clustered at the protected area level.

5.3 The Role of Human Settlements

The effectiveness of protected areas may vary depending on the context. While there is abundant evidence on the impact of roads and economic activity on deforestation (i.e. Chomitz and Gray, 1996; Nelson and Hellerstein, 1997; Pfaff, 1999; Perz et al., 2008; Pfaff et al., 2007; Laurance et al., 2009; Alix-Garcia et al., 2013; Hargrave and Kis-Katos, 2013), little is known about how these factors determine the effectiveness of protected areas. There are two opposing mechanisms through which settlements can affect the affects protected areas. On the one hand, cities and roads increase pressure on ecosystems. Beyond the land allocated to urban development, the proximity to growing markets also stimulates the expansion of the agriculture and mining. On the other hand, the presence of human settlements reduces the cost of enforcing the law, and more specifically the environmental regulations. This is particularly true in the presence of high-profit illicit activities, such as coca crops and gold mining.

In order to assess whether human settlements represent a threat or an opportunity in this context, we estimate the heterogeneous effects of protected areas by population density, measured using high-resolution nightlight imagery. Specifically, we create a dummy variable that is one if the cell centroid is located within a year-2000 nightlight cluster, and zero otherwise (Figure A.1 of the Appendix). As a complementary analysis, we estimated the heterogeneous effects by the proximity to roads, using that dummy variable that is one if the cell centroid is located less than 5km from a road in the year 2005, and zero otherwise. However, these results should be interpreted with caution as roads are measured in 2005 and could therefore be endogenously determined by the protected area limits. The DD estimates use interacted models and the RD are based on separate regressions.[8]

The long-term heterogeneous effects indicate that protected areas are more effective near human settlements (Table 5). In fact, the estimated coefficients are consistently larger in densely populated areas and near roads, and also more statistically significant. For instance, the effect of national natural protected areas shifts from -0.018 ha/km^2/*year* in remote areas to -0.039 ha/km^2/*year* in high-density areas. Likewise, the effect is -0.032 ha/km^2/*year* near roads and -0.021 ha/km^2/*year* away from them. The differences are even larger in regional natural protected areas and indigenous reserves. As for Afro-Colombian lands, we find similar results with our night lights density measure but not with roads. In fact, the estimated effects are negative and significant in areas not served by roads, and positive (although insignificant) near roads. Notice however that the Pacific region,

[8]The main reason to use separate regressions in the RD models is that heterogeneous effects are only identified if the covariate of interest does not vary across treatment and control groups (Calonico et al., 2016), which is not the case in this context.

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where most of the Afro-Colombia lands are located, has a very low road density and therefore this is not a good proxy for human settlements in this case.

It is worth noting that the control group average deforestation is similar across samples, indicating that in most cases there is no additional pressure on ecosystems in densely populated areas or near roads. Even when these differences exist, we find that in the long-run protected areas benefit from the proximity of human settlements. Given the evidence of illegal crops and mining in remote areas, these results suggest that the enforcement mechanism is dominant, and therefore the effectiveness of protected areas depends on the capacity of authorities to act.

Table 5
Long-term Effects By Population Density and Roads

	Natural Protected Areas		Collective Lands	
	National (1)	Regional (2)	Indigenous Reserves (3)	Afro-Colombian (4))
A. Population Density				
Low Density	−0.018**	0.001	-0.014**	−0.011
	(0.006)	(0.028)	(0.006)	(0.017)
Optimal Bandwidth (km)	6.159	14.365	3.295	6.192
Control Group Mean(y)	0.224	0.106	0.197	0.076
Observations	89,371	3,628	77,999	3,237
High Density	−0.039***	−0.036**	−0.058***	−0.048*
	(0.015)	(0.017)	(0.019)	(0.030)
Optimal Bandwidth (km)	3.573	10.248	10.773	8.645
Control Group Mean(y)	0.218	0.107	0.215	0.078
Observations	7,996	8,998	16,528	431
B. Roads				
No ($> 5km$)	−0.021***	0.098	−0.019***	−0.032***
	(0.007)	(0.124)	(0.005)	(0.011)
Optimal Bandwidth (km)	8.350	8.277	5.782	14.087
Control Group Mean(y)	0.180	0.123	0.130	0.050
Observations	86,434	374	95,349	9,769
Yes ($< 5km$)	−0.032***	−0.033**	−0.027**	0.018
	(0.010)	(0.014)	(0.011)	(0.022)
Optimal Bandwidth (km)	4.910	12.663	3.820	7.865
Control Group Mean(y)	0.186	0.147	0.127	0.060
Observations	29,028	13,526	32,723	1,062

Source: Own calculations based on Hansen et al. (2013), WDPA, IGAC, NOAA, FAO and Hijmans et al. (2005).
Note: * is signicant at 10%, ** at 5%, and *** at 1% level.Deforestation is expressed in $ha/km^2/year$. Each column correspond to separate Calonico et al. (2014) RD estimates with optimal bandwidth and robust bias-correction. All regressions control for population density and the geographic and climate variables described in the Section 3. We present the results based on a first order local-polynomial for bias correction and estimation, however results are robust to different specifications of the model. Standard errors in parenthesis are based on a nearest neighbor variance estimator.

In the short-run, the effect of protected areas tends to be smaller near human settlements (Table 6). For instance, regional natural protected areas reduce deforestation by -0.057 ha/km^2/*year* in areas with low-density or no road, as opposed to -0.018 ha/km^2/*year* in high-density areas, and -0.027 ha/km^2/*year* near roads. Similar results are found for national and civil society natural protected areas and Afro-Colombian lands, even though the differences between groups are not always statistically significant. indigenous reserves have positive effects oscillating between 0.060 and 0.072 ha/km^2/*year* in remote areas, and no significant effects in densely populated areas. This is consistent with the fact that most of the deforestation registered in the *Selva de Matavén* Indigenous Reserve is related to illicit activities MJD and UNODC (2015). These short-term results could be reflecting the time it takes to develop the institutional capacity to enforce environmental regulations in new protected areas. In the meanwhile, the effect of human pressure on ecosystems is dominant.

Table 6
Short-term Effects By Population Density and Roads

	Natural Protected Areas			Collective Lands	
	Nacional (1)	Regional (2)	Civil Society (3)	Indigenous Reserve (4)	Afro-Colombian (5)
A. Population Density					
Low Density	-0.029***	-0.057***	-0.077***	0.060***	-0.054***
	(0.005)	(0.006)	(0.023)	(0.011)	(0.012)
High Density	-0.026**	0.018	0.007	0.033	0.131***
	(0.012)	(0.012)	(0.023)	(0.027)	(0.037)
p-value (Low=High)	0.796	0.000	0.008	0.353	0.000
Control Group Mean(y)	0.146	0.259	0.169	0.301	0.386
Observations	94,824	640,716	64,404	90,492	176,436
B. Roads					
No (> 5*km*)	-0.031***	-0.057***	-0.091**	0.072***	-0.061***
	(0.005)	(0.008)	(0.037)	(0.011)	(0.012)
Yes (< 5*km*)	-0.021***	-0.027***	-0.031***	-0.032	-0.017
	(0.006)	(0.007)	(0.012)	(0.028)	(0.019)
p-value (No=Yes)	0.089	0.002	0.102	0.000	0.019
Control Group Mean(y)	0.146	0.259	0.169	0.301	0.386
Observations	94,824	640,704	64,392	90,492	176,364

Source: Own calculations based on Hansen et al. (2013), WDPA and IGAC.
Note: * is signicant at 10%, ** at 5%, and *** at 1% level. Deforestation is expressed in $ha/km^2/year$. Each panel correspond to separate DD estimate with a 5km bandwidth. The heterogeneous effects are estimated interacting the dummy variable for each group with the treatment indicator. All regressions control for cell and year fixed effects and protected area specific time trends. Errors in parenthesis are clustered at the protected area level.

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6 Conclusions

We assess the effect of Colombian natural protected areas and collective lands on deforestation using two methods: regression discontinuity for protected areas created before 2001 (long-term effects) and difference-in-differences for areas create after 2001 (short-term effects). Results indicate that natural protected areas and collective lands reduce forest loss, with negative and significant effects oscillating between -0.013 and -0.057 $ha/km^2/year$. These findings are in line with most of the specialized literature in that protected areas significantly contribute to preserve the forest (Nepstad et al., 2006; Andam et al., 2008; Adeney et al., 2009; Armenteras et al., 2009; Nelson and Chomitz, 2011; Blankespoor et al., 2017; Sims, 2014). We also provide evidence that the effect vary depending on type of protected area and the time-frame. In particular, our results are consistent with Armenteras et al. (2009), the only existing study for Colombia, who also find that national natural protected areas have larger effects than indigenous reserves.

We also study the role of human settlements by estimating the heterogeneous effects of protected areas by population density and distance to roads. While the short-run effects tend to be larger in remote areas, our long-term estimates show that protected areas perform better in densely populated areas and near roads. Given the predominance of illicit activities in remote areas, we interpret these findings as suggestive evidence that protected areas are more effective when authorities are able to uphold the rule of law. This is consistent with recent studies showing that conflict increase deforestation via the expansion of illicit activities (Dávalos et al., 2011; Fergusson et al., 2014), whereas stronger property rights and enforcement policies tend to reduce coca crops (Muñoz-Mora et al., 2014; Mejía et al., 2015). These findings highlight the importance of institutions, and particularly the capacity to enforce environmental policies in remote areas. Recent efforts towards implementing regional economic development plans, and simultaneously strengthening the early-warning systems and environmental crime task-forces seem to go in the right direction. Future research should further study these policies.

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Appendix

Table A.1
Continental Protected Areas (2000 and 2015)

		2000		2015	
		Number	Surface (km^2)	Number	Surface (km^2)
A. Natural Protected Areas					
National	Unique Natural Area	1	6,5	1	6,5
	National Natural Park	33	88.504,5	43	110.455,2
	National Forest Reserve	56	6.082,3	56	6.082,3
	Natural Reserve	2	19.989,8	2	19.989,8
	Fauna and Flora Sanctuary	8	641,0	10	787,5
	Park Way	1	601,6	1	601,6
	Biosphere Reserve	1	5.578,3	1	5.578,3
	World Heritage Site	1	829,5	2	10.518,7
Regional	Recreation Area	0	.	10	8,0
	Soil Conservation District	0	.	9	439,2
	Integrated Management District	9	253,9	57	14.374,4
	Regional Natural Park	0	.	36	4.726,2
	Regional Forest Reserve	30	207,2	86	1.135,9
Civil Society Natural Reserves		0	.	292	815,6
B. Collective Lands					
Indigenous Reserve		525	298.921,8	712	323.049,7
Afro-Colombian Land		56	23.106,2	184	55.898,9

Source: Own calculations based on WPDA and IGAC.

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Table A.2
Long-term Effects of Protected Areas on Deforestatation
(Alternative Specifications)

	Natural Protected Areas		Collective Lands	
	National (1)	Regional (2)	Indigenous Reserves (3)	Afro-Colombian (4))
A. Without Control Variables				
Treatment	−0.024 * **	−0.017	−0.012 * *	−0.020
	(0.006)	(0.014)	(0.006)	(0.012)
Optimal Bandwidth (km)	5.695	12.519	3.338	10.838
Control group Mean(y)	0.220	0.194	0.208	0.085
Observations	96,992	14,076	84,911	8,399
B. Without Compound Treatments Correction				
Treatment	−0.016 * *	−0.034 * *	−0.031 * **	−0.026 * **
	(0.005)	(0.015)	(0.004)	(0.004)
Optimal Bandwidth (km)	4.513	9.719	2.065	7.372
Control Group Mean(y)	0.198	0.196	0.174	0.055
Observations	108,144	10,669	105,453	28,195

Source: Own calculations based on Hansen et al. (2013), WDPA, IGAC, NOAA, FAO and Hijmans et al. (2005).
Note: * is signicant at 10%, ** at 5%, and *** at 1% level. Deforestation is expressed in $ha/km^2/year$. Each column correspond to separate Calonico et al. (2014) RD estimates with optimal bandwidth and robust bias-correction. All regressions control for population density and the geographic and climate variables described in the Section 3. We present the results based on a first order local-polynomial for bias correction and estimation, however results are robust to different specifications of the model. Standard errors in parenthesis are based on a nearest neighbor variance estimator.

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Table A.3
Short-term Effects of Protected Areas on Deforestatation
(Alternative Specifications)

	Natural Protected Areas			Collective Lands	
	Nacional	Regional	Civil Society	Indigenous Reserve	Afro-Colombian
	(1)	(2)	(3)	(4)	(5)
A. Without Compound Treatments Correction					
Treatment	-0.011***	-0.025***	-0.056***	0.044***	0.011
	(0.002)	(0.005)	(0.019)	(0.008)	(0.008)
Bandwidth (km)	5.000	5.000	5.000	5.000	5.000
Control Group Mean(y)	0.075	0.262	0.173	0.242	0.268
Observations	198,552	612,072	66,240	120,132	307,572

Source: Own calculations based on Hansen et al. (2013), WDPA and IGAC.
Note: * is signicant at 10%, ** at 5%, and *** at 1% level. Deforestation is expressed in $ha/km^2/year$. Each column correspond to separate DD estimate with a 5km bandwidth. All regressions control for cell and year fixed effects and protected area specific time trends. Errors in parenthesis are clustered at the protected area level.

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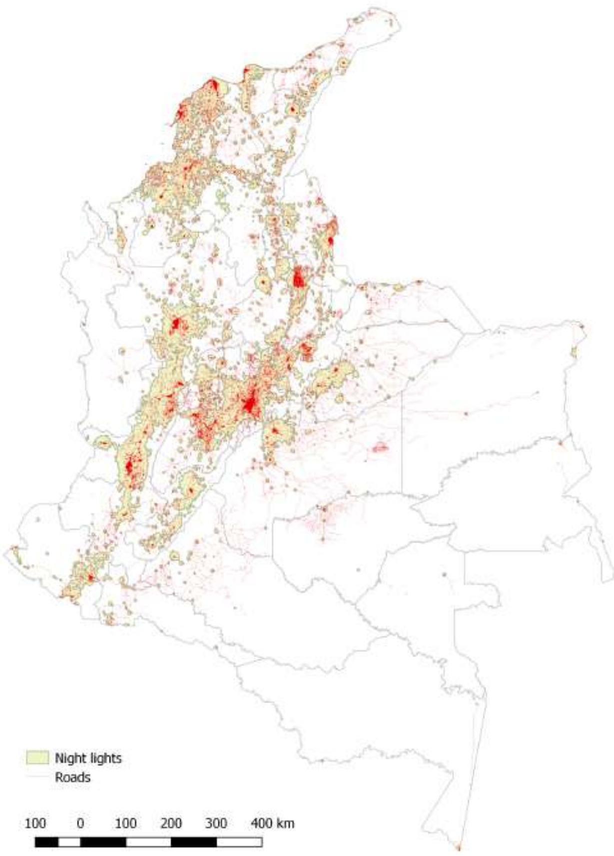
Figure A.1
Nightligh clusters and Roads



Source: Own calculations based on NOAA, MGN and SIGOT.
Note: Nightlight clusters, in yellow, are calculated with the year-2000 night light data using a clump algorithm based on queen distance with 8 nearest neighbors. Road network, in red, correspond to the year-2005 reported in official cartography.

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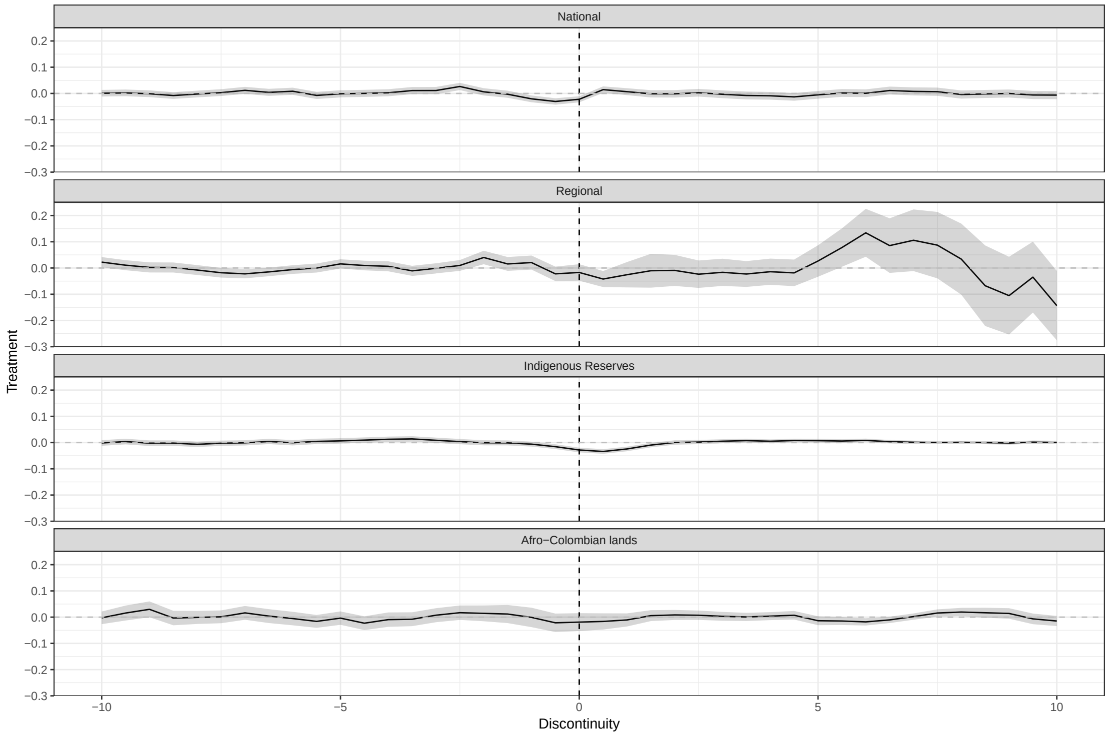
Figure A.2
Placebo Threshold Test for Long-Term Effects



Source: Own calculations based on Hansen et al. (2013), WDPA, IGAC, NOAA, FAO and Hijmans et al. (2005).
Note: Graphics show treatment estimator for artificial limits of protected areas parallel to the original ones. Pacebo limits move as far as 10km from the original ones, with an increment of 500m. Estimations are based on the Calonico et al. (2014) robust RD estimators with a fixed bandwidth of 5 km. Shaded areas correspond to confidence intervals at 95%.

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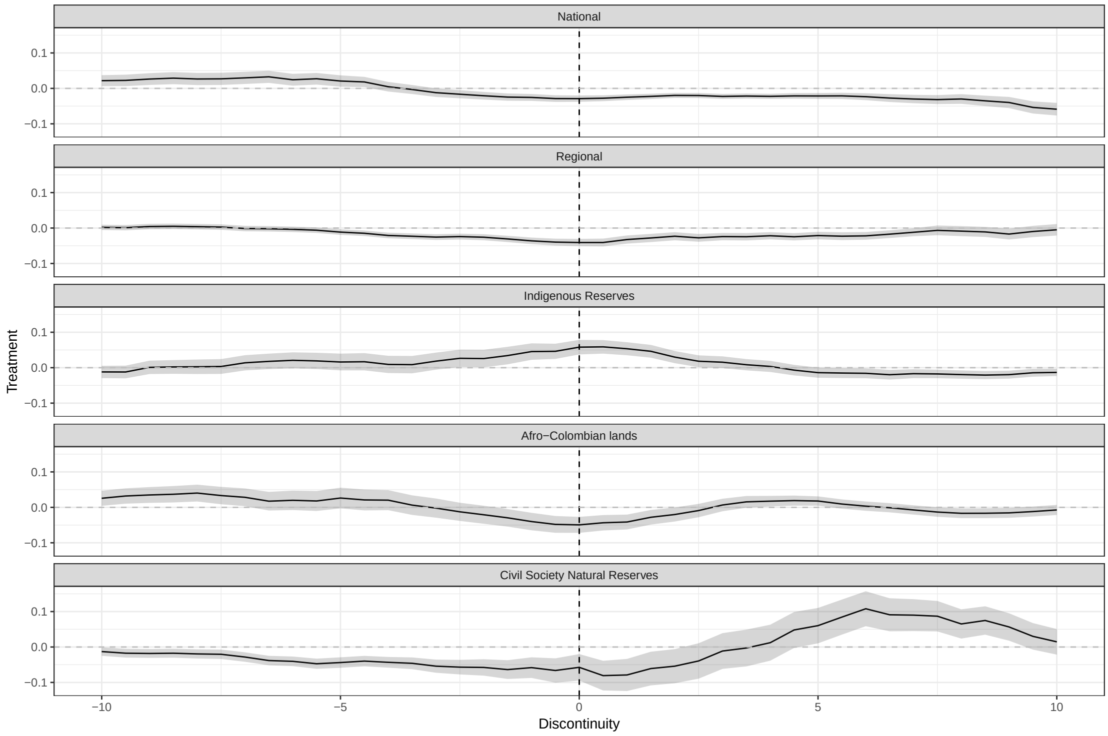
Figure A.3
Placebo Threshold Test for Short-Term Effects



Source: Own calculations based on Hansen et al. (2013), WDPA and IGAC.
Note: Graphics show treatment estimator for artificial limits of protected areas parallel to the original ones. Pacebo limits move as far as 10km from the original ones, with an increment of 500m. Estimations are based on the Calonico et al. (2014) robust RD estimators with a fixed bandwidth of 5 km. Shaded areas correspond to confidence intervals at 95%.

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Study on the results of the co-creation process of the governance framework for the Tourism, Peace and Coexistence Program: public, private and community strategy for post-conflict sustainable development

"Peace and tourism is what we have been doing in the rural territories, it was the engine in the middle of despair, conflict and inequality"

Josefina Klinger - leader of ecotourism in Colombia

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Abstract

This article shows how through co-creation or collaborative creation of governance frameworks that link the public, private and community sectors, tourism can be an instrument for the well-being of those who have lived in areas affected by the armed conflict in Colombia, where populations face exclusion, marginalisation and precarious living conditions. This article examines four reference cases specifically that share similar characteristics: the presence of armed conflict and tourism potential, which have shown that tourism is an effective tool to change informal survival dynamics by implementing economic practices that make social equity possible-- and in these cases, through ecotourism, promote environmental sustainability. A study of several related studies is made and the previous and subsequent values of some of the related indicators are compared for each case, whereupon conclusions are drawn as a starting point for new studies that will deepen and advance these studies. In this sense, this article challenges the status quo to make a shift towards open governance models, based on co-creation, with a focus on diversity and territorial development and that promote the creation of well-being.

Keywords: Tourism, Sustainable Development, Peace and Coexistence.

1. Introduction

Colombia, a country in the north of the continent of South America, is currently in a post-conflict era with two guerrilla groups in Latin America. This era is prefaced by the signing of the peace agreement with the FARC (Revolutionary Armed Forces of Colombia) and the first stages of talks with the ELN (National Liberation Army). The end of the conflict has resulted in agreements that must be implemented so that the ceasefire and reintegration of the guerrillas into civilian life is efficient, and, also generates a sustainable well-being in the territories. This implementation entails challenges, as expressed by Fabrizio Hochschild (2017) through the journal Humanum Colombia; The first is that peace must be territorial: "the challenge of post-conflict requires that regions really take the reins of peacebuilding, and that these efforts be guided and supported by Bogota and the international community" (Hochschild, 2017). Another is related to the implementation mechanisms: "it is fundamental that we think of institutional capacities at the local level, including governors and mayors, to carry out the measures that are agreed upon and ensure that their implementation inspires confidence in citizenship through A transparent and responsible act "(Hochschild, 2017). Both challenges involve designing innovative Frameworks which include multilevel and inter-institutional cooperation-- with a focus on territories.

This article deals with the relevance of the pluralistic and participatory arrangements that arise from co-creation initiatives for the development of public policies that promote post-conflict development strategies. It presents evidence on the creation of alternative conditions for understanding and collaborative work among the members of the tourism chain, including: community members, local public institutions, and the Vice Ministry of Tourism, who have built a sustainable tourism strategy through a model of innovative governance. This initiative was concentrated in four regions with high potential for tourism and peace: La Macarena in the Meta Department; Sibundoy Valley and Mocoa in the Putumayo Department; Camino Teyuna in the District of Santa Marta; And the Gulf of Urabá in Chocó and Antioquia Departments.

The main hypothesis is that these territories can replace the illegal industries--including the arms trade-- with tourism as an option for sustainable development. Meaning that economic growth, equitable and socially participatory and with environmental sustainability are taken into consideration in a highly coordinated multilevel governance framework. In this scenario, the reconfiguration of governance Frameworks is critical. According to Pérez, Wills and Bravo, in their book on Innovation Strategy for Territorial Peace Governance, "the objective of territorial development and innovation for peace should be a central idea in the public policies to be applied after signing of the peace accords. It is necessary and urgent that we promote an innovative process that foments territorial social cohesion, which is currently lacking in these territories, given that, as it is said 'peace will be in the territories, or it will not be', given that the poverty and marginalisation seen in different territories is a result of the prolonged armed conflict in the country" (Wills Herrera, Perez Yruela, & Bravo Moran, 2015).

2. Methodology

Qualitative and quantitative methodologies were combined to perform this analysis, including:

• Literary review: Permits the validation of the central points of discussion and the conclusions referred to in this document, through cross referencing with scientific texts.

• Semi-structured interviews: conversations were held with stakeholders at national and local levels.

• Direct observation in the field: field visits were carried out to observe the implementation process of the Tourism, Peace and Coexistence Governance Framework in selected municipalities.

• Co-creation: primary methodology. In the co-creation effort, multiple stakeholders come together to develop new practices that traditionally would have emerged only in a bureaucratic, top-down process. Change, moreover, occurs not just at the level of an organisation, but also across an entire value chain (Goullart & Hallet, 2015). Co-creation starts from the experience of each actor and strives to discover new modes of interaction that will improve the experience for all actors simultaneously. That process often leads to a restructuring of roles: Recipients of services become service providers, and vice versa. In the public sector, adoption of the co-creation method is a fairly recent development.

Table 1: The path of cooperation for the Tourism, Peace and Coexistence Governance Model

Step	**Description**	**Process carried out**
Identify target communities	The first step of any co-creative initiative is to select communities and sub-communities whose members will take part in that effort (Goullart & Hallet, 2015).	Community leaders, members of the value chain, local and national public institutions were mapped for each territory
Build engagement platforms	The second step is to provide targeted communities with physical or virtual platforms where community members can engage with each other (Goullart & Hallet, 2015).	A National Committee for Tourism, Peace and Coexistence was formed to coordinate between territories and is the nucleus of the Governance Framework.
Foster interactions among stakeholders	The second step is to provide targeted communities with physical or virtual platforms where community members can engage with each other (Goullart & Hallet, 2015).	With the National Committee for Tourism, Peace and Coexistence, an action plan was created which included the cocreation of frameworks to govern each territory in agreement with their follow up process and involvement.
Enable new experiences	The fourth step involves ensuring that new interactions lead to valuable experiences for all stakeholders—experiences that intrinsically improve the quality of their lives (Goullart & Hallet, 2015).	The set of indicators that collectively monitor progress in each territory on tourism, peace and coexistence were co-created.

Assess new value	The fifth and last step of co-creation is to verify that the sponsoring organization has generated new value—measurable economic value, in particular—as a result of its effort. (Goullart & Hallet, 2015)	The sponsoring entity, the Vice Ministry of Tourism of the Ministry of Commerce, Industry and Tourism in Colombia, will create new processes in four more territories in Colombia with similar conditions with the co-creation methodology and pilot.

3. Results

Tourism, Peace and Coexistence Framework Indicators: The first result of this process is the co-creation of an indicator framework (**Table 2)** that allows monitoring for effectiveness of the program in each of the following dimensions:

1. Social equity
2. Environmental sustainability
3. Positioning of each destination as a tourism, peace and coexistence region
4. Satisfaction of tourists
5. Quality and formalization

Table 2: Quantitative Governance Framework Indicators in each territory

Category	**Indicator**
Social Equity	Number of peope actually involved in the tourism value chain
	Number of families actually involved in the tourism value chain
	Number of associations integrated into the tourism value chain
	Number of service providers
	Total incomes from tourism per year
Environmental sustainability	Deforestation rates
	State of habitats
	Declaration of Protected Areas
	Ecosystem representation
Positioning of each destination as a tourism, peace and coexistence region	Number of people who convert from labor in illegal industries to tourism
	Hectares of illegal crops reforested for tourism
Satisfaction of tourists	Number of tourists

	Increment in tourism
	Level of tourist satisfaction
Quality and formalization	Number of establishments registered with the National Tourism Registry
	Number of certified destinations

Although the instruments for collecting and evaluating these indicators are still being designed, the following initial results have already been obtained:

• Visitor arrivals have increased considerably from 9,593 in 2014 to 21,117 in 2016, with the largest influx of foreign visitors from 85 nationalities (ICAHN).

• In the last five years, the number of visitors to the municipality of La Macarena, Meta has increased. Of 1,506 tourists and visitors that were in 2010, the number rose to 15,500 in 2015, that is, multiplied by 10. It grew by 929%. Of this total, 1,800 were foreigners and 13,800 Colombians. In 2016, 1,791 foreign visitors arrived, matching the 2015 record.

• The main attraction is Caño Cristales, which for many is "the most beautiful river in the world" or, “the river of five colors", because of the chromatic color of its algae. Currently, the Ministry of Commerce, Industry and Tourism, through the National Tourism Fund, advances the construction of trails in the area, whose investment amounts to $ 3.5 billion.

• In Mocoa and Valle de Sibundoy, Putumayo, between 2012 and 2016 the number of non-resident foreign visitors increased by 29.39%, from 541 in 2012 to 700 in 2016.

• In the Gulf of Urabá - Darién: in 2012, 1,864 travelers visited the natural areas, while in 2011, 4,882 people traveled in 2016, with a 161% growth.

• In tourism infrastructure, between these two pilot regions, the Putumayo and the Gorab area of Urabá - Darién, the Ministry has invested about $ 14 billion over the last five years in projects such as signage, parks, boardwalks and tourist information centers.

Inputs for public policy created by all stakeholders: The second result is the creation of base documents for the definition and implementation of public policy.

Greater sense of belonging: The third result identified is the increase in the sense of belonging within state processes (legitimacy, trust). Given that, thanks to the participatory and horizontal framework, the strategy translates into concrete facts that respond to that collective planning, strengthing confidence in the State.

Replicability of the Governance Framework: Cooperating with communities to seek a collective vision of tourism as a productive and sustainable tool, through multi-level and pluralistic institutional arrangements, can become a replicable model. Currently, regions such as Cauca, Montes de María, South of La Guajira and Norte de Cesar, Guaviare and Caquetá have requested participacion in the program.

Strengthening of the social fabric at a community level: Tourism, Peace and Coexistence working groups were strengthened due to the fact that the Framework and processes were reviewed at various phases by various participants: indigenous and Afro-Colombian communities; ex-combatants, victims and tourist entrepreneurs; public entities at local and national level; residents and other stakeholders. Individual violence is transformed into forgiveness; coexistence, and group violence is diminished within the common goal that strengthens the necessary social fabric.

Networking to strengthen ties that contribute to business improvement: Instilling entrepreneurial skills was easily achieved given the existing genuine interest of participating and learning. The communities share among themselves the solutions to particular cases, found in the co-creation process, allowing them to learn from the experiences of other regions. This has generated authentic knowledge and stronger links concerning work and collaboration between pilot regions.

Access to new markets: Collaborative work, coverage and impact at a central level facilitate access to markets for the participants given that it is a relationship between allies which help each other grow. In this framework, the State serves as a capacity-building and coordinating entity with and between potential tourism markets.

4. Discussion

To present the Governance Framework as a reference for an innovative model that facilitates coordination with all interest groups, the conditions of the territories analyzed in the Framework of the Peace Accords are discussed first. Later, a discussion on ecotourism as an opportunity for environmental sustainability, social equity and cultural preservation is discussed. Finally, the model of co-created governance as a reference for other sustainable development initiatives in the post-conflict context is presented.

The Territories that were analyzed and the Peace Agreements

Due to the mapping process of each territory, the synthesis of results created by the Ministry of Commerce, Industry and Tourism of Colombia for Tourism, Peace and Coexistence is presented below.

Synthesis of conditions of tourism, peace and coexistence in Putumayo:

***Map 1**: Colombia with the Tourism, Peace and Coexistence nodes in Putumayo*

***Map 2:** Municipalities participating in the process*

Putumayo is a department with unique natural and cultural characteristics that make its tourism potential of great value for the social and economic development of the region. The location of the department on the Amazon Basin, the diversity of ecosystems, the great flow of water, the variety of flora and fauna, ethnic multiculturalism and the symbolic richness of its traditions and customs account for the suitable and exceptional conditions for the Development of tourism (Puerta Lopez, 2016).

Historically, the department has had an important presence in the armed conflict due to its particular characteristics, which make it a strategic area for armed groups-- especially in the Middle and Lower Putumayo areas. This is due to the weak presence of the State; the fact that it is a border department; the geographic conditions that are favorable to illicit crops; and river conditions that facilitate mobility for micro-traffic, among other reasons (Puerta Lopez, 2016).

Although tourism still does not represent a significant industry in the regional economy, 72 formal tourism operators in the area have been identified since 2016, generating approximately 158 jobs. The data and field work reveal that tourism is beginning to develop, with distinctions in two priority areas: Mocoa, which offers nature and adventure tourism typical of the Amazonian region; And Sibundoy Valley, with an especially cultural and spiritual tourism offer due to the traditions and customs of the Inga and Camentsá peoples.

This inludes tourism centered around traditional medicine such as yagé, handicrafts, the Carnival of Forgiveness, and others (Puerta Lopez, 2016).

This is how the two zones combine to create a complementary regional offer, which has not yet been synthesized, but is still very attractive for tourism development in the region. This offers a viable option to tackle some of the structural problems of the department, such as dependency on agriculture and oil; poverty, unemployment and lack of opportunities (Puerta Lopez, 2016).

Synthesis of conditions of tourism, peace and coexistence in La Macarena:

Map 3: *Colombia with the Tourism, Peace and Coexistence nodes in La Macarena*

Map 4: *Municipality of La Macarena*

The territory has great potential in terms of nature and biodiversity. The municipalities included in the pilot are surrounded by imposing mountains, crystalline rivers, waterfalls, plains, petroglyphs and archaeological sites that have not yet been studied in depth. Having been deeply affected by the Colombian armed conflict, communities in each municipality have struggled to change the stigma that prevails over them. There is still a long way to go, and the social and political conditions of municipalities are not ideal. However, tourism has proved to be a very strong tool for development (Puerta Lopez, 2016).

The municipality of La Macarena claims almost all of the tourism in the territory due to Caño Cristales-- a national destinations recognized even at international level. Access to Caño Cristales and its surrounding area is regulated by the National Army, which conducted a previous study of the area and eliminated illicit crops before the opening of the park for the tourism (several sources, field work, April and May 2016). The Army has a very strong presence in this municipality-- both inside and outside of the town, and is a fundamental player for tourism given that it guarantees the safety of both tourists and operators. The tourism season usually starts in June and decreases towards the end of the year, depending on weather conditions. The township of La Macarena, is isolated from other municipalities, both logistically and geographically (Puerta Lopez, 2016).

Synthesis of conditions of tourism, peace and coexistence in Urabá Antioquia and Darién Chocoano:

Map5: *Colombia with the Tourism, Peace and Coexistence nodes in La Macarena Urabá – Darién*

Map 6: *Municipality of Urabá – Darién*

The Urabá-Darién region is one of the nodes of the Tourism, Peace and Coexistence Project, which has the particularity of encompassing municipalities attached to two Departments: Antioquia and Chocó. This represents greater challenges to an appropriately functioning

The node is made up of twelve municipalities (from the Department of Antioquia: Apartadó, Chigorodó, Carepa, Turbo, San Juan de Urabá, Arboletes, Necoclí, San Pedro de Urabá and Mutatá, and Chocó Department: Riosucio Unguía and Acandí) with regional similarities-- but municipal peculiarities. At present, although the region is experiencing a calm period in terms of the armed conflict, there are still problems of coexistence, especially in the north area of the node (border with Panama) where black and white communities have had severe conflicts due to control of local tourist development (Puerta Lopez, 2016).

Two factors converge to make the Urabá-Darién region a potential node: it´s privileged geographic position, with high levels of bio-cultural diversity-- directly related to its natural resources (water, forest, land and minerals) and cultural (ethnic diversity); and the high resilience of the population, despite years of sustained violence (Puerta Lopez, 2016).

For the tourism sector to develop, formalize and grow, it is necessary to improve the environmental conditions both for the inhabitants and tourists. This includes public services, health and transportation access to the region. On the other hand, a project of this type should also strengthen the tourism sector in the area; serve to strengthen the social fabric of the municipalities; and work between different administrations to consolidate the Urabá-Darien as a destination Tourism, Peace and Coexistence (Puerta Lopez, 2016).

Synthesis of conditions of tourism, peace and coexistence in Teyuna:

Map 7: *Camino Teyuna Territory*

Teyuna or Ciudad Perdida is much more than a major nature tourism destination in Colombia. Its area of influence in the sector of El Mamey and Teyuna—formerly a coca-growing region dominated a decade ago by paramilitarism, and from a total absence of the State. Now, 10 years after the demobilization of paramilitaries in the region, in the village of Quebrada del Sol, there is a community that used touism as a legal industry to replace coca crops, strengthen its social fabric and forge a different reality. This initiative was a product of the reconciliation and reintegration process of ex-combatants in an effort to unite communities and manage tourism activities. Today, six trails and aproximately 3,500 people benefit from tourism, with 14,000 tourists annually visiting the region (Focus Group, Members of the Lost City Chain, May 2016) (Puerta Lopez, 2016).

It is also critical to emphasize that tourism in this region has supported strengthening the social fabric after the demobilization and reintegration process for regional excombatants. Not only is it evident throughout the tourism value chain, but to manage this activity, the communities created ASOJUNTAR: a case to highlight as an example of community strengthening through tourism. Today, this association, made up of the six community action boards of the Teyuna trails, which has one of the 6 operators that offer the tour to Ciudad Perdida or Teyuna, has been able to redistribute benefits to their communities. They have fixed roads; helped finance development projects; contributed to maintaining electrical energy infrastructure; and paid the salary of a teacher in Mamey, as well as that of the bursar and the plumber of the aqueduct of Quebrada del Sol (Focal Group, Members of the Chain of Lost City, May 2016) (Puerta Lopez, 2016).

Teyuna or Ciudad Perdida and a part of the path that connects it with El Mamey is within an ancestral territory of the indigenous communities of the Sierra Nevada, which are Kogui territory. At the level of coexistence tourism development must respect above all, the culture and determination of the communities on its territory. During the field work, it was identified that the peasant community of the lower part of the trail and the indigenous communities of the upper part have been able to find spaces for daily dialogue and concertation, seeking mutually beneficial relationships around tourist activity. However, the cabildo has filed a letter to the mayor requesting the closure of the trail (Interview, Carlos Iglesias, May 2016) (Puerta Lopez, 2016).

General considerations on territories and the Peace Agreements:

Concerning the initiatives in these referenced case studies, and in accordance with the pillars described above, it is essential to take into account what is stated in the Final Havana Agreement signed between the Government and the FARC-EP-- especially the first point Related to Integral Rural Reform (RRI). This particular point, given that Colombia continues to be a rural country, defines various issues related to land use, regulation, titling, extension, sanitation, demarcation, restitution, among others that are key to overcoming rural poverty-- which although improved, still remains high (DNP). This must be taken into account for tourist destinations that overlap with ancestral territories of ethnic peoples, such as in Ciudad Perdida with the Kogui, the Wiwa, Arhuaco and Cancuamo indigenous groups.

The "CONPES for Postconflict" (2016) also gives us insights on this topic. This explains that instruments for planning and territorial ordering in those municipalities where the conflict has been most acute have been weak and have overlapped, which has aggravated certain dynamics of the armed conflict through forced displacement, dispossession and unproductive use of land. In addition, land use conflicts have been exacerbated in much of the territory. On one hand, it is known that 25% of the national territory has conflicts over or underutilization of the soil. However, this percentage is even higher in some territories where the TPC strategy was co-created: the Meta and Antioquia - along with Caqueta, these territories concentrate around 50% of land-use conflicts.

On the other hand, there are no clear boundaries for natural reserve areas, páramos, natural parks, indigenous reserves and collective territories. This is problematic not only for the dynamics already mentioned, but also for the dynamics of tourism in these areas. An example of this is the situation in Teyuna (Ciudad Perdida) where some indigenous peoples such as the Kogi expressed reluctance towards tourism in their territory. This is why it will be fundamental for the strategy to define territorial limits that reconcile the interests of the different communities that converge in touristic areas. In this regard, it is important to know that 42% of the forests and 50% of Colombia's National Natural Parks (NNP) are located in conflict municipalities, where tourism emerges as an opportunity for the country's social and economic development.

Therefore, when articulating efforts with entities that, under the framework of the post-agreement seek to implement "Programs of Development with a Territorial Approach (PDET) which is projected to be executed in indigenous and afro-colombian communities, should contemplate a special mechanism to incorporate the ethnic and cultural perspective in the territorial approach. The Territorial Approach Development Programs (PDETs) are an important tool for materializing actions from different sectors that are considered necessary for post-conflict areas. This includes a five-year participatory planning process, which may include coordinated exercises such as those previously mentioned in this article.

In La Macarena, there are concerns of deforestation for coca cultivation and oil projects in the area. 42% of the NNPs in Colombia have been affected by coca crops and 28% by illegal mineral extraction (CONPES, 2016, page 23). According to the CONPES document, this environmental problem in the country is associated with the poor administrative capacities in the of the Regional Autonomous Corporations (CAR). 85% of the early deforestation warnings reported in the second half of 2015 occurred in conflict territories under CAR jurisdiction (IDEAM, 2016). This reiterates the need to strengthen institutions in the country, especially key actors such as CARs.

The importance of the point on Solution to the Problem of Illegal Drugs for a Strategy of Tourism, Peace and Coexistence lies in that it legitimizes the need to recognize and address the economic situation of populations that, due to poverty, have had no other choice for their survival. Where Teyuna is an emblematic case for the way in which tourism as an economic activity replaced the business of coca cultivation, the fundamental participatory, voluntary and concerted nature of the processes are constructed into the PNIS alongside the communities. The importance given to the theme of environmental recovery of areas with illicit crops has been a concern on the part of the population of La Macarena, given the environmental damage that caused deforestation in the territory.

On the other hand, the closures of the agricultural frontier and the protection of reserve areas (for example, the proposed Peasant Reserve Zones (ZRC)) proposed in points 1 (RRI) and 4 (on illicit crops) is a point for which we are also responsible, as it favors recovery plans and environmental sustainability-- taking into account that agritourism has been proposed in some territories such as Putumayo, and will be key points for communities involved in the Strategy.

Likewise, it is critical to coordinate the Tourism, Peace and Coexistence Strategy with measures established in the Final Agreement in the section on RRI with respect to the topics of Social Development, including: health, rural education, housing and drinking water; also, along with other stimulus for agricultural production and economic solidarity and cooperation the former includes technical assistance, subsidies, credit, income generation, marketing and formalization of labor. According to CONPES for post-conflict, the construction of a stable and lasting peace requires eliminating the causes and consequences of inequalities in economic, social and environmental development in the areas most affected by the armed conflict in Colombia.

Sustainable Tourism

Within the 2030 Agenda for Sustainable Development Goals Framework, the Tourism, Peace and Coexistence Program contributes at least to the following: SDG 1: Eradicate poverty in all its forms around the world; SDG 4: Ensure inclusive and equitable quality education, and promoting opportunities for lifelong learning for all; SDG 5: Achieve gender equality and empower all women and girls; SDG 6: Ensure the availability and sustainable management of water and sanitation for all; SDG 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all; SDG 11: Ensure that cities and human settlements are inclusive, secure, resilient and sustainable; SDG 15: Protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation, and curb the loss of biological diversity; SDG 16: Promote peaceful and inclusive societies for sustainable development, facilitate access to justice for all, and create effective, accountable and inclusive institutions at all levels; And, SDG 17: Strengthen the means of implementation and revive the global partnership for sustainable development.

Thus, according to the strategies formulated in each territory, ecotourism is the most heavily selected tourist product, followed by cultural tourism. According to Gale and Jal (2009), there are at least 85 definitions of ecotourism, which, leave much to the interpretation of the reader, but the more or less cohere around three criteria, namely that "(1) attractions should be predominantly nature-based, (2) visitor interactions with those attractions should be focused on learning or education, and (3) experience and product management should follow principles and practices associated with ecological, socio-cultural and economical sustainability "(Gale & Hill, 2009).

Ecotourism, in an environment like the one described above, where peace can take place in an environment of sustainable development, in which social equity and environmental sustainability are the dimensions that support it, ecotourism is described by the participating communities as the ideal. Ecotourism is an opportunity to expand markets on existing tourist attraction supply, and continue to expand on other ecotourism opportunities in the area. According to the aforementioned authors, "namely ecotourists and their motivations, empirical research has shown that those who have partipated in some form of nature-based tourism (which qualifies them as" ecotourists "in a number of published studies) tend to be slightly Older (between 35 and 54 in particular), better educated and more affluent (and, therefore, prepared to pay more for them holidays) than those who do not participate.

This presents and opportunity given the ecotourist´s willingness to pay and their intention to understand, respect and preserve the social ecosystem they encounter on their trips. These territories are especially biodiverse, where they inhabit indigenous, peasant and Afro-Colombian communities, in addition to being settled in unique ecosystems that are especially vulnerable. An ecotourism Framework in which the Governance Framework tends to participation, coordination, capacity building, monitoring and control is key to achieving sustainable development goals.

The Strategy for a flexible, adaptive and pluralistic Governance Framework: National and Local sectors, the tourism value chaning and the territories

Within the Framework for the initiative of the Ministry of Commerce, Industry and Tourism to contribute to peace from the potential that tourism represents for development, the process called Tourism, Peace and Coexistence is carried out within the Framework of the Tourism and Peace program of the Vice Ministry of Tourism. This process was based on the design of a multilevel governance Framework, which through co-creation --or collaborative creation—as the methodology, allowed the design, among members of the chain and representatives of interest groups, of the strategy of Tourism, Peace nad Coexistence for each pilot territory. This involved an empowerment process for members of the tourism chain and related organizations on their development processes, which reflects the intention of its members to promote a dynamic, co-responsible peace; favor parity and support a relationship between the central government and the territories.

The methodology to elaborate the Governance Framework and subsequent cooperation of the Tourism, Peace and Coexistence Strategy for each territory began with the adoption in 2014 of the "Declaration of Bogotá - Peace through Tourism". Subsequently, all four Pilot experiences were adopted: Road to Teyuna (Lost City) of the Sierra Nevada of Santa Marta (Magdalena), La Serranía de la Macarena (Meta), Putumayo and "Urabá - El Darién" (Antioquia - Chocó). They were subscribed by the World Tourism Organization - UN UNO; together with the Ministry of Commerce, Industry and Tourism - Vice Ministry of Tourism of Colombia; tourist associations, academia and representatives of communities from different regions. The territories, upon evidencing the progressive arrival of visitors, saw that it could be an opportunity for their development and present their initiative to work jointly with the Central Government for the development of sustainable tourism. This initiative was soon formalized through the creation of the Committee for Tourism, Peace and Coexistence through Resolution 3159 of 2015, as a space for concerted action by the Ministry of Commerce, Industry and Tourism alongside the territorial entities, regional businesses and the communities within the territories. Committees meet periodically during the year, evidencing the need to work in the tourism planning in the long term as an instrument for strengthening social relationships in a peaceful environment.

Thanks to this initial Governance Framework, which was subsequently supplemented in a flexible manner according to the characteristics of each territory, a mapping of opportunities, challenges, constraints and leadership in each territory was carried out to resolve, in a participatory way, how the Governance Framework should be structured within each territory. The result is a unique structure for each territory embedded in a general and horizontal framework that is coordinated at the central level of the country. Thus, six (6) co-creation exercises were developed for a Strategic Management Model in each of the pilot destinations with the participation of 172 members of the community, actors in the tourism production chain and institutions such as the National Parks Unit Natural, ICANH, Ministry of Defense and other territorial entities. The different participants included indigenous people, afro-colombian communities, the National Army, National Police, tourism entrepreneurs (guides, transporters, hoteliers, etc.), artisans, peasants (victims and non-victims) and ex-combatants.

Pilot Destination	Name of Strategy
Camino Teyuna – Santa Marta	Poporo: Teyuna
Darién Chocoano	La Chócora
Urabá Antioqueño	La Mola: Un Mundo de Colores
Putumayo	Mocoa
Valle del Sibundoy	La Estrategia Divichido / Nÿetscang Sendënanmeng
La Macarena – Meta	Ruta Sierra de La Macarena

A Governance Framework is, in short, a structure that allows or facilitates a collective vision of reality. The Model allows to recognize the critical elements necessary to direct the efforts between actors which will fulfill objectives. In this sense, the Governance Framework, to establish and carry out strategies of tourism, peace and coexistence, starts from a framework of self-understanding, principles, schemes and tools. Its purpose is to establish a general guide for future initiatives and to consolidate the intention of the territories to have and carry out in a co-responsible way their strategy of Tourism, Peace and Coexistence.

Stakeholders and their articulation

The interest groups of the Tourism, Peace and Coexistence Strategy are classified as local, departmental and national (both public and private); community, and market actors (Figure 1: interest groups for articulation through a co-ordinated Governance Framework).

Figure 1: Interest groups within the co-created Governance Framework

• Local actors refer to the inhabitants of each territory, represented in their plurality and multiculturality by leaders in the co-creation process. Likewise, this group includes the members of the tourism chain in each territory: tour guides, hotel owners, restaurant owners, artisans, transporters, among other service providers. Representatives of the public offering in the territory are also part of those considered as local actors.

• The departmental actors refer to the representatives of the related public offerof the participating departments.

• The market refers to current and potential ecotourists.

• National stakeholders refer to the representatives of the related public offer.

At the national level, the Ministry of Commerce, Industry and Tourism through the Vice Ministry of Tourism is the entity that promotes the process and plays an active part at the central level of the National Committee for Tourism, Peace and Coexistence. It seeks the articulation of new key players for the dynamization of the general strategy and of each territory. It also recognizes that there are other actors and instances that precede or add to framework to the National Committee for Tourism, Peace and Coexistence. The Presidency of the Republic heads the political structure proposed for the implementation of the post-conflict strategy, with the Inter-Institutional Council of the Post-Conflict serves as an advisory area. The High Council for Post-Conflict is the coordinating body and the Office of the High Commissioner for Peace is responsible for peace negotiations. The different interventions of entities of the National Government and the Subnational Governments will be supported in each function.

At the technical level, the DNP is considered as a support entity for the formulation of Peace Contracts, a possible instrument for the implementation of the strategies, as well as the project strategies and program targeting that will be financed by different sources of public investment in those territories prioritized as PDET. On the other hand, the Territorial Renewal Agency (ART) was created as a technical-operational instance of the High Council for Post-Conflict, whose function is to coordinate the interventions of national and territorial entities in rural areas affected by the armed conflict, which are prioritized by the National Government "through the execution of plans and projects for the territorial renewal of these areas, which will allow their economic and social reinvigoration and their institutional strengthening, so that they are integrated in a sustainable way for the country's development" (CONCESTS of the Postconflict, 2016, pp. 71-72). It is also in charge of the Development Projects with Territorial Approach (PDET).

The Colombia Peace Fund is the instrument for channeling and coordinating financial resources, as well as different executing entities of the national government. This initiative seeks to materialize economic, social and environmental dividends for peace, articulating international cooperation, as well as various national and international funds to support the post-agreement and sustainable development in Colombia.

Another entity is the National Land Agency, also a state agency and part of the RRI of the Final Agreement. This is of a technical nature and is responsible for the social ordering of the territory, which implies managing access to land as a productive factor, promoting legal certainty about it and specified within its use, the social function of the property.

To promote productive projects in non-agricultural issues, the Ministry of Trade, Industry and Tourism, in partnership with the ADR, will seek to align synergies in the territories and, in partnership with the Department of Social Prosperity (DPS), will support projects within poor and vulnerable populations.

On the other hand, local governments, as departmental and municipal public entities, as well as mayors and governors, should coordinate the peace agendas in the territories--taking into account the participatory exercises, and the prioritization and implementation of development projects defined in the framework of the Final Agreement. The network of local governments should also coordinate actions with the ART to identify the goods and services requested by the communities, as well as those needs that must be financed through sources other than the territorial entities. Governments should ensure the communication and articulation of municipal and national governments.

Regarding the issue of Unsatisfied Basic Needs (NBI), the Ministry of Housing, City and Territory is currently developing pilot projects for the implementation of a program that will allow the adjustment of the policy so that the objectives of access to water services can be reached; and sanitation, through the generation of sustainable investments and integrated intervention schemes aimed at closing gaps, will also be achieved.

Finally, the creation of the Multipurpose Land Records Office is a tool that provides property information to contribute to the legal security of real property rights; strengthens local tax authorities and supports territorial social and economic planning. This tool is of great importance to clarify land tenure and legal and legal frameworks to local communities.

Concerning the environment, it is essential to take into account the role of the Ministry of Environment and Sustainable Development, which guides CARs (Regional Environmental Corporations) in updating environmental determinants in the area of their jurisdiction. It will also provide guidelines for the advice and participation of CARs in the elaboration of POTs and PODs in those municipalities and departments most affected by the armed conflict - territories that coincide several times with those prioritized as pilot territories for the Tourism Strategy, Peace and Coexistence.

Along with National Natural Parks (PNN), the Ministry of Environment and Sustainable Development will identify co-management figures from environmentally strategic territories when there are conflicts of land use. In terms of strengthening environmental governance, the Ministry of Environment and Sustainable Development will promote training programs for CAR and PNN officials, with the support of the DNP.

Of particular interest is the issue of development of sustainable economic alternatives, since the DNP will facilitate efforts through which the green business plans of the Ministry of Environment and Sustainable Development will be articulated with sectoral programs that involve the use of biodiversity, emphasizing In the sector of commerce, industry, tourism and rural development.

In this way, value chains that develop green businesses will be identified and developed in collaboration with the Ministry of Agriculture and Sustainable Development, CARs, Mayors and Governors. On the other hand, the implementation of sustainable productive systems will be accompanied by the Ministry of Environment and Sustainable Development and the Ministry of Agriculture and Sustainable Development.

In terms of recovery and conservation of strategic ecosystems, the Ministry of Environment and Sustainable Development and the DNP will formulate guidelines for the implementation of the scheme for Payments for Environmental Services (PES) in those territories affected by the armed conflict. With the guidance of the Ministry of Environment and Sustainable Development and the participation of the municipalities, NNP and CARs in the areas with the highest incidence of conflict or prioritized PDET, the Ministries of Mines and Energy, Defense and High the Post-Conflict will formulate a strategy to recover areas degraded by illicit crops and mining.

In this regard, it is also necessary to understand that the forest and carbon monitoring system (SMByC) developed by IDEAM will be strengthened, which will allow for the evaluation of the effectiveness of territorial investments for the control of deforestation, productive reconversion (agroforestry and silvopastoral) and native forest area, among other benefits.

In the theme of Peace and Coexistence also articulates institutions such as the National Police and the Communal Action Groups. In addition, a post-agreement mechanism will define a governance mechanism through which administrative authorities will be integrated into the Integrated Rural Security System. It will also define the intersectorial entity that will be responsible at the national level to coordinate and streamline the institutional capacities of the Citizen Coexistence and Security System.

The issue of education - especially access financing for education - was also among common themes in the pilot territories of the Tourism, Peace and Coexistence Strategy. In this regard, it is essential to take into account the Ministry of National Education (MEN) and the recent Public Policy of the National System of Tertiary Education (SNET) “as a strategy for articulating post-formal education, will allow greater access of the population in vulnerable situations to technical, technological and university professional training programs, as well as the certification of competencies, thus reducing the access gap in the municipalities most affected by the conflict. Access will also be encouraged through special funds and scholarship credits”.

The processes that are supplied through the Governance Framework

To promote the governance model created and to follow the strategy of Tourism, Peace and Coexistence – the general model and that of each territory - the following processes were co-created:

- Coordination: to generate adequate spaces and methodologies to promote consensus. Given that this is a process with wide national coverage and therefore the sum of institutional wills, it is necessary to reach a consensus between actors for decision-making and strong and lasting processes.

- Mobilization: broadly disseminating the advances that are generated to seek and add new initiatives. Thus, recognition of the objectives of the strategy will promote a favorable environment for compliance within the community.

- Accountability: build trust in stakeholder groups. Staying accountable to stakeholders (community in general, members of the value chain, related institutions, organizations, among others) is a key factor for process sustainability and for reducing the stigma that Colombia in these territories.

- Measurement and learning: to recognize if what has been proposed is being achieved, in what way, what are the good practices, the lessons learned and the incorporation of this information for accountability and decision making. Thus, measurement and learning as transversal processes will justify the technical, economic and time-consuming resources to achieve the Vision.

- Strategy building: This process has to do with the constant and strategic decision-making to fulfill the great objectives of Tourism, Peace and Coexistence in Teyuna, which is to make a sustainable tourism that brings well-being to the community and preservation to the environment. The generation of strategy is a constant process of review and adjustment of the current strategy to reach Vision 2021, and once this term expires, it involves the design of a new vision and a new strategy to achieve goals.

- Execution of the strategy: carry out the national and territorial strategy reaching the vision. In order to materialize, the Committee of Tourism, Peace and Coexistence, should work to make the strategy a upblic policy, thus ensuring distribution of actions and resources to all parties; Design standards, practices, follow up, measurement, and decision making to materialize each of the defined purposes.

5. Conclusions

Based on the establishment of innovative governance frameworks, emerging from co-creation as a participative, inclusive and creativity-enhancing methodology, it is shown how in a post-conflict scenario collaborative strategies can be developed. In this case, for the Tourism, peace and Coexistence Strategy.

The fact that it is communities that have the initiative to be involved in a process of transformation for a stable and lasting peace, legitimizes institutional arrangements and the strategy development. The initiative becomes more effective and produces results, generating capacities within the populations that will execute and live the experiences generated by the processes. Not only communities, but also at the central level, actors learn to work in a decentralized and innovative way to produce high impact and sustainable results.

Recognizing the historical moment in Colombia, and as a contribution to territorial development, the Central Government (Ministry of Commerce, Industry and Tourism) has found in the co-creation strategy an effective methodological instrument for territorial transformation affected by conflict in tourist destinations, converting them into environments with the goal of generating sustainable development processes that go hand in hand with “2017: International Year of Sustainable Tourism”, which promotes reconciliation alongside culture, nature and strengthens tourism value chains, thereby empowering communities and their territories.

A similar process of building and implementing participatory governance is desirable but not easy to adopt as it is not political-- but fundamentally technical-- for development. As the fundamental results are seen in the long term, and transparency is the basic criteria, the traditional political and neoliberal structure may not be appropriate or open to undertake such structures.

Colombia is a multi-ethnic and multicultural country, accustomed to centralist welfare policies that have weakened local capacities. Such a strategy opens the way to demonstrate that it is possible, if there is a common incentive, to boost community empowerment, enabling entrepreneurship, autonomy, initiatives and strengthening the sense of belonging to the territories and their diversity.

Decisions made through pluralistic and multilevel governance structures are adopted in a sustainable manner and do not depend so much on changes in local administrations, as they involve diverse interest groups such as the private sector, community, academia, and others. They do not respond to the dynamics of the public sector.

Tourism can bring collective benefits when it is done in a responsible and progressive way which takes care of the environment; promotes participatory local economic growth; provides experiences for both tourists and host communities; and focuses on human interaction and the experiences that we all seek.

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Forests and Conflict in Colombia

This draft:

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By:

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Summary -- This paper offers evidence on the relationship between armed conflicts and their environmental impacts. For the case of Colombia, using a unique yearly municipality panel dataset (from 2004 to 2012) and an instrumental variable approach to control for possible endogeneity between forest cover and forced displacement, there is evidence that the armed conflict is a force of forest protection and growth. The Revolutionary Armed Forces of Colombia (FARC) began engaging in discussions with the national government in 2012 to attempt to end Latin America's longest-running internal conflict, which endured for more than half a century Forest degradation often increases in post-war situations. These findings spotlight a need for increased protection of Colombia's forests.

JEL codes: D74, Q2

Keywords: *forest cover, forest change, reforestation, deforestation, armed conflict, violence, forced displacement, land abandonment, coca crops*

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This paper is based on a chapter of my doctoral thesis in Economics at the University of Sussex, at Brighton, United Kingdom. I acknowledge Professor Barry Reilly, PhD supervisor, for his superb guidance. I also express gratitude to Tsegay Tekleselassie from the University of Sussex for his comments.

Table of Contents

1 Introduction

The toll of civil conflicts goes far beyond human suffering and the damage to physical infrastructure. Conflicts may also cause the degradation and destruction of local environments and biodiversity. This paper offers evidence on the relationship between armed conflicts and the forest cover for the case of Colombia.

Little attention has been given to the impact of conflicts on the environment. In fact, most conflict studies investigate the effects on socioeconomic and institutional outcomes, such as the countries' macroeconomic performance, human capital and asset accumulation, or civil political participation. For example, from a macroeconomic viewpoint, Collier (1999) using a cross-country dataset (92 countries, 1960 to 1992) estimates a GDP per capita annual rate decline of 2.2% for a country that experienced a civil war relative to its counterfactual, on average. Likewise, Hoeffler and Reynal-Querol (2003) using a global dataset (211 countries, 1960 to 1999) shows that civil wars that last five years or more reduce the country's average annual growth rate by 2.4% on average.

Regarding human capital accumulation, Justino et al. (2013) examine the impact of violence in Timor Leste in 1999. While in the short term (2001), authors found supporting evidence that the school attendance was reduced; in the longer-term (2007) primary school completion declined particularly for boys exposed to peaks of violence during the 25-year long conflict. Similarly, Shemyakina (2011), for the case of Tajikistan, found that girls aged between 7-15 years old in 1999 are about 11 percentage points less likely to be enrolled in school if their household's dwelling was damaged during a conflict period (1992-1998).

With respect to assets accumulation, Deininger (2003) using households data from Uganda found that the conflict affected negatively investment and non-agricultural enterprise formation between 1992 and 1999. The household income decision on investment was affected by the imposition of war taxes by the rebel forces.

On the subject of civil political participation, Bellows and Miguel (2006) investigates the socioeconomic and institutional outcomes in 2004 and 2005 in Sierra Leone, some years after the civil war period (1991-2002) ended. The supporting evidence shows that political mobilization measures became higher in areas that experienced more violence.

In turn, understanding how conflict affects forests could provide a reflection on the needs to promote natural resources conservation with the corresponding governmental engagement in structural forest governance regulations that are particularly important in preventing the escalation of conflicts. For the case of Colombia this is relevant since the Revolutionary Armed Forces of Colombia (FARC) began engaging in discussions with the national government in November 2012 to attempt to end Latin America's longest-running internal conflict. In October 2016 voters in Colombia rejected a landmark peace deal with FARC rebels (with 50.2% voting against it). Currently the country is divided mainly about some of the terms of the peace deal such as what's the fair time in prison for crimes committed by the rebels, in what way those rebels found guilty of crimes be barred from jail and running for public office, and how can the FARC use their illicit gains to pay a compensation to the conflict victims. A renegotiation of the peace deal is on going. Colombia's President, Juan Manuel Santos, was recently awarded Nobel Peace Prize, in recognition of his "resolute efforts" to end the conflict.

In Colombia, the effect of the conflict on forests is often regarded as ambiguous. On the one hand, the persistent presence of the country's illegal armed groups[1] in protected areas prevented territorial industrialization and colonization trends, helping these areas to remain free of damage (Álvarez, 2003;Dávalos et al., 2011). In fact, guerrilla groups often served as the local environmental authority, taking explicit decisions on nature conservation, enacting and enforcing unofficial laws limiting hunting, fishing, and deforestation (Dávalos, 2001; Sanchez-Cuervo and Aide, 2013).

The environmental friendly attitude of the guerrilla is usually linked to the prevailing economic and military interests in the area. Conserving the forests helps rebel forces to hide and to establish safe-heavens with transit corridors for troops, supplies, drugs, or

[1] During the period covering this study the armed conflict comprised mainly two guerrilla organizations known as the Revolutionary Armed Forces of Colombia (FARC) and the National Liberation Army (ELN). Additionally, there exists in the shadows a third actor; a right-wing paramilitary group known as the United Self-Defence Forces of Colombia (AUC), which, even though signing a demobilization agreement in 2003, remains active in criminal and drug-related activities.

illegally extracted natural resources such as timber or minerals (Álvarez, 2003;Dávalos et al., 2011).

On the other hand, in other areas, illegal armed groups have caused devastating effects on the ecosystem, destroying oil pipelines, engaging in illegal mining, and clearing forests to gain land for the cultivation of illicit crops. The war on drugs has exacerbated this situation. Chemically or manually, coca eradication automatically causes localized deforestation in the area in which it is conducted. Coca producers then tend to move to even more remote locations such as national parks or other protected areas where chemical fumigation is prohibited. New coca plantations are then established which leads to a cycle of deforestation (Dávalos et al., 2011).

This paper enriches the existing literature by identifying the direction on the relationship between armed conflicts and forests in Colombia. The identification strategy used relies on exploring the causal effect that the forced displacement has had on forest cover at the municipal level.

Accordingly to official figures more than 5.2 million persons have been internally displaced forcibly between 1990-2012. In a country of 46.6 million inhabitants, this represents 11.2% of the population. Illegal armed groups are the main responsible parties. In fact, it well known that violence against civilians has not been random; instead it has been a deliberate strategy of war. Illegal armed groups have displaced peasants in order to secure control of valuable land rich in natural resources, to carry out legal or illegal economic activities such as mining or planting illicit crops, or use the land to establish troops camps, storing illegal drugs and weapons. Selective killings, massacres, death threats, disappearances, forced recruitment and the property damages are forms of attacks carried out by these groups to frighten inhabitants, which eventually leads to forced displacement (Roche-villarreal, 2012; Moya, 2012; and Ibáñez, 2009).

The research presented here provides an important contribution to the literature. This study goes beyond others by using a unique annual Colombian panel dataset of forest cover satellite imagery at the municipal level that goes from 2004 to 2012. Furthermore, it addresses the endogeneity problem between conflict and the environment using an array of appropriate econometrics techniques. A Fixed Effects (FE) Instrumental Variable (IV) approach is used to solve the potential endogeneity problem between forest cover and forced displacement occurrence.

The main result of this study is that the armed conflict has been a force of forest protection and growth in Colombia, but the estimated effect of the conflict on forestation is small. Yet, since forest degradation frequently increases in post-conflict situations; the government will need to be ready to deploy conservation policies in those areas that are currently under control of the guerrilla when the peace finally arrives.

The paper is structured as follows. The next section presents a literature review which is followed by describing the empirical modelling issues; a fourth section describes the data and the descriptive statistics; a fifth reports the empirical results; a sixth performs an approach that examines the role of time-invariant variables of considerable interest in explaining forest cover; and a final section offers some concluding remarks.

2 Literature Review

Most of the literature that links conflict and the environment reveals the connections between the abundance but mismanaged natural resources, armed conflicts, and underdevelopment; known as the "resource curse" (See, for example, Auty (2004); Ross (1999); Collier and Hoeffler (1998)[2]; and Sachs and Warner (1995)).

The findings are somehow mixed in terms of the duration of conflicts and the presence of forests. For example, Collier et al. (2004) investigates the causes of civil war, exploiting a database of 161 countries over the period 1960-1999 (79 civil wars) in conjunction with logistic regressions, and illustrates that the extent of forest cover is not statistically associated with longer conflicts. In contrast, De Rouen and Sobek (2004) take advantage of a database containing information about 114 civil wars in 53 countries between a 1944 to 1997, and using probability and duration models[3], find that

[2] In Collier and Hoeffler (1998) study about the economic causes of conflicts countries experiencing civil wars had lower forest cover (29%) than their counterparts (31%).
[3] Logit models are used to explain what shapes the probability of civil wars outcomes (i.e, government victory, rebel victory, truce, or treaty), whereas a hazard analysis identifies the factors that determine the time to reach each outcome.

highly forested countries with conflict presence have a significantly decreasing probability of ending the civil war.

Nonetheless, cross-country studies are subject to academic debate. Often the forest cover is calculated for the whole country, and it is likely that only some parts of the country experienced the conflict, being not highly forested. Hence, Lujala (2010) shows that the location of the natural resources are key determinants of conflict durations using a dataset known as PETRODATA, which contains the geographic coordinates about the location of hydrocarbon (crude oil and natural gas) reserves for 111 countries. According to the author's research, if these resources are located inside the actual conflict zone, the duration of the conflict doubles.

There is also a growing literature that tries to make explicit reference to the relationship between civil war and the consequences for forest cover. In particular, progress has been made in terms of incorporating spatially explicit forest cover statistics due to the evolution and development of user-friendly satellite data. Once again these studies offer mixed results regarding the direction of the impacts of conflicts on forests, and are usually subject to the inherent mechanics of country conflicts, which demonstrate the need for more fine-tuned research.

Focusing on the experience of Colombia, the Fergusson et al. (2014) study is among the very few that addresses the endogeneity problem between conflict and forests. In particular, the authors focus on examining the impact of the paramilitary expansion characterized by the perpetration of selective massacres and by forcing large populations to flee in order to secure territory during the late 1990s. They instrument paramilitary attacks with the distance to the Urabá region that constituted the epicentre of the paramilitary activity. Using satellite images for the years 1990, 2000, 2005 and 2010, and estimating cross-sectional models separately controlling for municipality fixed effects, they detect a negative effect of the paramilitary expansion on forest cover.

Dávalos et al. (2011), also for the case of Colombia, use forest cover maps at 1-km grid[4] spatial resolution to quantify forest changes in the northern Andes, Chocó and the Amazon regions, which in fact are the largest coca leaf producing zones, between 2002

[4] A network of lines that cross each other to form a series of squares.

and 2007. Logistic regressions controlling for the grid distance to the closest newest coca fields and the area of coca cultivation around 1 km^2, and the population, road accessibility and climate controls, among others, reveal that the cell probability of transition from forest to nonforest increases with shorter distances to the newest coca fields and with the area of coca cultivated in its boundaries. This article suggests that establishing larger protected areas could help reduce deforestation and preserve biodiversity.[5]

Viña et al. (2004) concentrate their analyses on the region along the Colombia-Ecuador border. Using satellite data between 1973 and 1996. The authors compare images to calculate the rates and patterns of land-cover change in the border. Their comparison suggests that forest cover loss is higher on the Colombian side of the border - 43% versus 26% on the Ecuadorian side. They do not deploy an econometric model to identify specific factors driving these results. However, they suggest that the illegal coca production happening mainly on the Colombian side might explain the differences.

Álvarez (2003), using information obtained through semi-structured interviews with local civilians and members of guerrilla groups situated in the main forested regions of Colombia (e.g. the Macarena mountains, Munchique National Park, Tambito Nature Reserve, the San Lucas mountain range, and the Churumbelos mountains) emphasize that the relationship between conflict and forest cover is ambiguous. On the one hand, the author finds evidence of "gunpoint" conservation in some sites, which means that the guerrilla groups, such as the ELN in the San Lucas mountain range, carried out conservation. In this particular case, this was done by placing landmines[6] or posting signs that warn of landmines in patches of the forests. In turn, the forests served the guerrillas as cover from government surveillance and air strikes. On the other hand, guerrilla groups also expedited deforestation. For example, in the Choco Department lowlands, forests were converted into cattle ranches or coca plantations.

Among the international studies that are also relevant is Stevens et al. (2011). Their

[5] Fjeldså et al. (2005) detect similar results, concluding that the eradication campaigns lead to constant relocation of drug dealers, therefore, making illicit crops one of the main causes of deforestation.
[6] Landmines are in effect a 'negative capital stock' that the society accumulates during conflict. They continue to kill and mutilate people long after the actual fighting ended (Hoeffler and Reynal-Querol, 2003).

paper investigates the forest cover changes on two sites, with a total area of circa 160,000 ha, located at the Atlantic Coast of Nicaragua over a period covering the civil war (1978 to 1993). Based on a forest and non-forest images pixels[7] classification detection methods[8] used for both sites, authors find that in the first 5–7 years of the conflict, reforestation was greater than deforestation due to forced displacement, but once the conflict ended people returned to their lands and the deforestation almost doubled the level of reforestation that had occurred during the conflict.

For El Salvador, Hecht and Saatchi (2007) using visual interpretation of satellite imagery data of forest cover between 1990 to 2007, highlight the expansion of woody vegetation, especially in the northern provinces, in mountainous zones at the edge of agricultural frontiers, and in regions that had been under the control of the Farabundo Martí Front for National Liberation. They conclude that woodland resurgence is positively correlated with the occurrence of the civil war. They mention the fact that many people fled the country to avoid being killed.

Nackoney et al. (2014), for the Democratic Republic of Congo, comparing satellite imagery across two decades (1990–2010) with an algorithm that uses surface reflectance to detect image changes, report that primary forest loss and degradation rates occurring during the conflict decade (1990–2000) were over double the rates of the post war decade (2000–2010). This suggests pressure on the forests during conflict. Despite the fact that their images do not consider forest regrowth, the authors highlight that after the end of the war in 2003, the rate of primary forest loss taking place within the agricultural zones increased, meaning that in the post-war era people returned from remote forested areas to their homes, clearing forests in order to regenerate the food production.

[7] Pixels are the smallest elements of an image that can be individually processed in a digital screen.
[8] Based on a classification scheme, the pixel classes were divided into specific land cover categories, which included forests (deciduous, mixed, secondary) and non-forest (agriculture, rangeland, and barren land) types.

Table 1: Selected studies on the relationship between conflict and forests

Author	Published Journal	Sample coverage	Methodology	Conflicts impacts on forests
Collier et al (2004)	Journal of Peace Research	Cross-country overtime (1960 - 1999) 161 countries	Probability model (logit)	No impact
Fergusson et al (2014)	Working paper CEDE series, Universidad de los Andes, Colombia	Colombia overtime (1990, 2000, 2005 and 2010)	Cross-sectional and instrumental variables models	Negative (due to paramilitary activity expansion)
Dávalos (2001)	Environmental science technology	Colombian regions (Northern Andes, Chocó and the Amazon) overtime (2002 - 2007)	Probability model (logit)	Negative (due to coca production)
Viña et al (2004)	Journal of the Human Environment	Colombia & Ecuador border region overtime (1973 - 1996)	Satellite imagery analysis	Negative (due to coca production)
Alvarez (2003)	Journal of Sustainable Forestry	Colombia main forested regions (Macarena mountains, Munchique National Park, Tambito Nature Reserve, the San Lucas mountain range, and the Churumbelos mountains) 2003	Not Econometrics (interviews)	Ambiguous (due to "gunpoint" conservation)
Stevens et al (2011)	Biodiversity and Conservation	Nicaragua's Atlantic Coast (160,000 ha) overtime (1978-1993)	Satellite imagery analysis	Positive (due to displacement)
Hecht and Saatchi (2007)	BioScience	El Salvador overtime (1990 - 2007)	Satellite imagery analysis	Positive (due to displacement)
Nackoney et al (2014)	Biological Conservation	Democratic republic of Congo overtime (1990-2010)	Satellite imagery analysis	Negative (due to pressure on natural resources)
Burgess et al (2015)	Environmental Research Letters	Sierra Leone overtime (1990 and 2000)	Log linear regressions	Positive (due to displacement)

In contrast, Burgess et al. (2015) for Sierra Leone, merging satellite imagery of forest cover with chiefdom-level conflict incidents (151 observations) for the years 1990 (prior to the civil war) and 2000 (just prior to the end of the civil war) (not inclusive), and based on linear and log-linear models estimation, found that conflict prevented local deforestation: conflict-ridden chiefdoms experienced significantly less forest loss relative to their counterparts due to migration.

In conclusion, the constraints in making research progress in this area have been a lack of data on both conflict and forest cover at the subnational level. Some studies concentrate their analysis only on particular biomass (eco-regions), while others are confined to the effects of a single perpetrator of violence. Very few adopt a clear or clean identification strategy, and address the endogeneity problem between conflict and forests. The aim of this paper is to start to fill both these conceptual and econometric gaps (Table 1).

3 Empirical Strategy

The research question is tackled empirically by using instrumental variables and panel data methods. The variation of the dependent and explanatory variables over time and across municipalities is exploited to identify the effects of the armed conflict on forest cover. Equation (1) outlines the specification to be estimated:

$$Forest_{i,t} = \gamma FD_{i,t} + \beta X_{i,t} + \alpha_i + \lambda_t + \varepsilon_{i,t} \tag{1}$$

where $Forest_{i,t}$ is the share of municipality i's area covered by forest in year t. The conflict variable is the *forced displacement rate per inhabitant* ($FD_{i,t}$). Following from the literature review, the forced displacement variable captures the presence of extreme violence in a given municipality. According to Ibáñez (2009), violence against civilians is not random, instead it represents a deliberate strategy of war or conflict.

In Equation (1), γ is the primary parameter of interest. In order to identify a causal effect, the error term ($\varepsilon_{i,t}$) needs to be uncorrelated with the forced displacement rate per inhabitant (i.e. the main variable of interest ($FD_{i,t}$) must be exogenous). However, there are at least three possible reasons why the $FD_{i,t}$ may be endogenous (i.e. correlated with the error term).

First, it is expected that **measurement error** plays a large role in the estimation of γ due to data on $FD_{i,t}$ may be subject to underreporting. Not every forced displacement person reports his or her status to government offices. In fact, while there should be relatively good data collection in larger cities, many of the smaller municipalities may have a lot of missing data.[9] Thus, measurement error may conceal the true impact of

[9] The government Registry for Displaced Populations (RUPD) consolidates forced displacement statistics. The RUPD objective is to legally recognize displaced households and to quantify the demand for aid. Displaced persons approach local government authorities to declare, under oath, the circumstances of

$FD_{i,t}$ on forest cover. Since underreporting is likely to be negatively correlated with the $FD_{i,t}$ the estimate of γ is likely to be downward biased.[10]

Second, **simultaneity** could also bias γ. On the one hand, violence may be particularly widespread in forested regions. The illegal armed groups are profit-driven actors and therefore, natural resources such as faunas, timber, minerals, and tree crop booms attract them to the forests. These groups often enter into conflict with the local people or with each other. For example, it is well known that the FARC and other criminal gangs, known locally as "Bacrims", have sought control of the illegal mining activity in remote forestlands. In the department of Choco illegal armed groups have violently secured control of territories, which are used by locals to carry out illegal gold mining. Then, the FARC charge the miners a gold production tax and a fee for using each unit of machinery (i.e., excavators).[11]

On the other hand, the presence of illegal armed groups affects forests conservation. Historically, the Colombian government have often neglected remote regions and their inhabitants. As a result local populations have limited commitment to local governments, and look to other groups to perform traditional government functions. Thus, the guerrillas have taken advantage and have performed natural resources management and conflict resolution to legitimize their role as a local political actor in those regions. For example, it has been well documented that the ELN have protected forests in the Serranía de San Lucas, a forested massif located in the department of Bolívar, northern Colombia, because of their major role in the local hydrology (See Álvarez, 2003; and Dávalos et al., 2011). In the Serranía de la Macarena, a set of mountains located in the Department of Meta, eastern Colombia, the FARC have violently enforced environmental protection. A noteworthy example is a ban they established on yellow catfish fishing, a threatened species, especially, when they were migrating up rivers and streams to spawn.[12]

their displacement. Then, public servants validate whether this is truthful. According to Ibáñez (2009) circa 30% of the displaced population is believed not to be registered.

[10] Think of the error term as being made up of the real error term plus a term reflecting forced displacement underreporting.

[11] See the article entitled "El medio ambiente: la víctima olvidada" a online special edition of Semana Magazine retrieved from: http://sostenibilidad.semana.com/medio-ambiente/multimedia/medio-ambiente-conflicto-colombia/33709

[12] Ibid.

Third, **omitted variables** could potentially affect the estimation as well. The set of controls ($X_{i,t}$) may neglect some time-varying factors difficult to capture that are also correlated with forest cover and forced displacement. For example, Acevedo (2015) argues that in coca areas a coca yield increase should be associated with a decrease in forced displacement mainly due to the establishment of "coercive" institutions enforced by the illegal actors. Thus, forced displacement only occurs when farmers are able to escape safely from the coca-farming contract with the guerrillas and local drug barons. The negative correlation between the establishment of coercive institutions by guerrillas and the *forced displacement rate per inhabitant* would downward bias the estimate of γ.

In order to tackle these endogeneity concerns, an instrumental variable (IV) technique is employed, for which Equation (1) therefore corresponds to the second-stage equation.[13] The IV estimation seeks to separate the exogenous part of the total variance of the variable of interest from another part that is endogenous and correlated with the error term. Under the assumption that this separation is carried out correctly, the final estimates will be unbiased and consistent. In practice, it is necessary to find a set of variables, called instruments, which are exogenous to the model, but found to be correlated with the variable of interest. The two important features of a good instrument are that: i) it should be correlated with the endogenous variable; and ii) it should be uncorrelated with the error term. Both requirements for a good set of instruments should be tested empirically.

Thus, the first-stage Equation (2) is defined as:

$$FD_{\mathrm{i,t}} = \pi \mathrm{Z}_{i,t} + \delta \mathrm{X}_{i,t} + \alpha_i + \lambda_t + \mathrm{u}_{i,t} \tag{2}$$

where (Z_{it}) is the preferred set of instruments that includes the lagged values of the victims of massacres per 100,000 inhabitants, the number of conflict kidnappings per

[13] One alternative way to bypass the endogeneity problem is use the lag of the $FD_{i,t}$ variable. This might solve the simultaneity problem as it is unlikely that today's forest cover will influence armed conflict activity in the past. However, the weakness of this approach is that if there is indeed any inertia in the variables, the lags will not necessarily solve the endogeneity problem.

100.000 inhabitants, and the number of hectares of coca fumigated[14] and manually[15] eradicated in municipality *i*. The $u_{i,t}$ is an error term assumed to be normally distributed with zero mean and constant variance. The reasons behind the choice of these instruments are now discussed.

First, forced displacement is usually preceded by an escalation of violence, driven by exposure to more than one type of violence. In such instances, migration becomes the last resort to survive. One of the main reasons driving people to flee their homes is the occurrence of massacres. Massacres are considered events in which four or more people are murdered at once. Usually, illegal armed groups have conducted massacres as a tool of fear and intimidation in order to seize assets, disintegrate entire communities, and appropriate the territory (Calderón-Mejía and Ibáñez, 2015; Roche-villarreal 2012).[16] According to (Ibáñez 2009), the occurrence of massacres explain 21.1% of the total forced displacements.

Second, kidnappings, just like other manifestation of violence, serve to remind the local inhabitants that coercive threats are real, and that a violent event could happen to anyone within the community boundaries (Moya 2012). In fact, according to Ibáñez (2009) kidnappings explain 7.6% of the total forced displacements.

And, third, there is evidence of a positive effect of the drug trade on violence (Dell, 2015; Dube and Vargas, 2013; and Angrist and Kugler, 2008). The presence of coca has fuelled Colombia's long enduring civil conflict. Despite the fact that coca production seems to improve crop producers' income, violence increases sharply in the coca-growing regions. Guerrillas derive substantial income by taxing coca-growers. Violence is regularly used to enforce coca farming contracts in this illegal industry, which ultimately leads to displacement (See Acevedo, 2015; and Rabasa and Chalk, 2001).

The Forced Eradication Anti-Drug Programs in Colombia is one of the most aggressive

14 Aerial spraying is executed with a herbicide called glyphosate, commercially sold as Roundup. It kills the plants inhibiting their ability to produce amino acids. The herbicide is sprayed from small aircrafts as closely as possible to the coca crops.

15 Manual eradication is performed by a group of men who destroy coca crops by hand.

16 Most massacres were committed during the time of the right-wing paramilitary activity between 1999 and 2003, rendering this armed group responsible for 58% of these cases.

programs in the world.[17] Data from the Colombian Antinarcotics Police (DIRAN) suggest that in 2014 these programs treated around 68.050 hectares (UNODC, 2015). According to Rozo (2013) when the share of municipality area sprayed increases by 1%, the homicide rates increase by 4.56 per 100,000 inhabitants, the number of armed confrontations increases by 1.69, and the number of displaced people increases by around 41.6 in the municipality.

The vector $X_{i,t}$ represents the municipal characteristics that affect forest cover. In particular, equation (1) controls for the legal[18] extraction of valuable minerals such as gold, silver or platinum in the municipality *i* in year *t*. Due to the potential bias that its inclusion might cause from a possible simultaneity problem with the dependent variable, the lag of the mining presence variable is used. In particular, on the one hand, mining is expected to have a negative environmental impact. It involves increased erosion, loss of biodiversity, and the contamination of soil, ground and surface waters by chemicals. Mining also often requires the clearance of large areas of forest, both for the mine itself, but also to create room for the storage of the created debris, and for the roads and other infrastructure associated with it. Besides, mining is part of the mechanisms enhancing conflict driven deforestation. For example, when the prices of minerals increase and/or national security policies reduce the guerrilla groups and criminal gangs income (e.g from kidnapping and drug trafficking), these illegal actors frequently finance themselves through mining. For example, it is well known that the FARC controls mines legally or illegally with direct stake in operations or through extortion, respectively.[19]

On the other hand, mining usually occurs in municipalities' rich in environmental resources - from the Pacific lowlands and rivers to the Amazon to the coffee-growing

[17] Aerial spraying began to be implemented in Colombia in 1978. Manual eradication programs began in 2007 and maintain a modest size given its high costs in terms of human lives. Reports from Antinarcotics National Police estimate that since its implementation 135 men have been killed through explosions of mines hidden in the ground to prevent the eradication (Gaviria and Mejía, 2011).
[18] There are only official statistic for the legal extraction of minerals. At the moment the government is trying to formalise the status of traditional miners who operate without licenses, while simultaneously cracking down on those which serve rebels and criminal gangs.
[19] According to governmental estimates around 80% of all gold in the country is mined illegally, and that as much as 20% of the profits from these illegal endeavours go to the FARC, ELN and other criminal organizations controlling smaller share. See also the article entitled “El medio ambiente: la víctima olvidada” in a online special edition of Semana Magazine retrieved from: http://sostenibilidad.semana.com/medio-ambiente/multimedia/medio-ambiente-conflicto-colombia/33709

region. Around 18%[20] of Colombia's territory has either been licensed to, or is going to being solicited by national and multinational corporations in order to develop mining projects. This fact reflects the government's intention to turn the country into a mining powerhouse. Some requests have even been granted in protected forested areas such as national parks, indigenous territories and collectively held lands pertaining to afro-descendent communities, among others.[21]

Additional time varying control variables included are the municipal population and the municipalities' urbanization level. Both variables account for the pressure of human activities on forests, capturing the increased demand for food products and timber which leads to both the need for converting forests into land for agriculture and an over-exploitation of forests.

The income tax revenue per inhabitant, which mirrors the heterogeneity in the overall economic activities at the municipality level, is also included as a control variable. Due to the high degree of fiscal decentralization, Colombian municipalities differ in terms of their fiscal abilities. There is significant dispersion in terms of the municipalities' ability to raise local taxes or to invest them (Cardenas et al., 2016) .

Finally, the inclusion of municipality fixed effects (α_i) controls for any municipality-specific characteristics. The time fixed effects (λ_t) control for aggregate time trends in forest cover, and thus captures macroeconomic shocks and annual shifts in policies. The standard errors are clustered at the municipality level and are thus robust to the presence of autocorrelation and heteroskedasticity.

4 Data and controls

The panel dataset constructed consists of yearly municipal observations from 2004 to 2012 (inclusive). Table 2 presents the summary statistics. The primary outcome is the

[20] According to the Mining and Energy Planning Unit statistics (UPME, acronym in Spanish). This share corresponds to the current and potential mining areas estimates. See also the article entiled "En sus 130 años, la U. Externado entrega estudio sobre minería" in El Tiempo newspaper retrieved from: http://www.eltiempo.com/estilo-de-vida/educacion/universidad-externado-entregara-estudio-sobre-mineria/16510296.

[21] See the article "Fiebre minera se apoderó de Colombia" in Semana magazine retrived from http://www.semana.com/nacion/articulo/la-fiebre-minera-apodero-colombia/246055-3

share of municipality area covered by the forest ($Forest_{i,t}$) Its estimates are calculated by the International Centre for Tropical Agriculture (CIAT) using satellite images at a spatial resolution of 30 meters collected yearly by the Department of Geographical Sciences at the University of Maryland partnering with other major research centres[22] in the United States (Hansen et al., 2013). The availability of satellite-based information on hectares of forests for not less than three years in the period of study restricts the sample to exactly 848 municipalities (75.5%[23]). Between 2004 and 2012, the average share of the municipality area covered with forest is more than half (57.86%) (Table 2).

The primary conflict explanatory variable is the forced displacement rate per inhabitant ($FD_{\mathrm{i,t}}$) and its calculated based on estimates from the Information System of Displaced Population (SIPOD, according to its Spanish acronym), the Central Registry for Victims Office (RUV)[24] and the Observatory of the Presidential Human Rights and International Humanitarian Law of the Vice Presidency of Colombia. As discussed in Section 3, the main drawback on displacement statistics is under-reporting. In the dataset, around 10.57 people per 100,000 inhabitants were forcibly displaced due to violence at the municipal level on average. One municipality experienced a maximum displacement of 702.7 people per 100,000 of its population (Table 2).

Regarding the data sources for the instrumental variables, the victims of massacres per 100,000 inhabitants figures are based on data from Colombia's National Centre of Historical Memory. The statistics on the direct conflict kidnappings[25] per 100.000 inhabitants are taken from a conflict variable panel dataset constructed by the Centre of Development Economics Studies (Centro de Estudios sobre Desarrollo Económico, CEDE in Spanish), Universidad de los Andes, Bogotá, Colombia. Finally, the number of hectares of coca fumigated and manually eradicated in the municipalities is calculated using satellite-based information from the Integrated Monitoring System of

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[22] Google; the Department of Forest and Natural Resources Management, State University of New York; the Woods Hole Research Center; the Earth Resources Observation and Science, United States Geological Survey; and the Geographic Information Science Center of Excellence, South Dakota State University.
[23] Colombia has 1,123 municipalities.
[24] This registry, established under Act 1448 of 2011, contains the number of registered victims of human rights violations in the context of the armed conflict in the period from 1985 to present.
[25] Bear in mind that these types of kidnappings mainly target businessmen, political leaders and members of the army.

Illicit Crops of the United Nations Office of Drugs and Crime (SIMCI[26]-UNODC) and the Anti-Narcotics Directorate of the Ministry of National Defence in Colombia.

In the final municipality dataset, around 4.28 people per 100,000 inhabitants were killed in massacres, with a maximum of 124 people per 100,000 inhabitants; armed groups kidnapped one person (0.9) per 100,000 inhabitants; and the military fumigated and manually eradicated a total of 170 hectares of coca plants on average (Table 2).[27]

With respect to the time varying control variables sources, a dichotomous variable [Yes=1; No=0] representing the extraction of elements such as gold, silver or platinum is based on the municipal mining records from the Colombian Mining Information System (SIMCO, according to its Spanish acronym). About 14% of the municipalities have mining activities, producing gold, silver or platinum (Table 2).

The information on socioeconomic and geographic covariates such as the municipal population, the percentage of urban population, and the income tax revenue per inhabitant was provided by the National Administrative Department of Statistics (DANE, according to its Spanish acronym) and the National Planning Department (DNP, according to its Spanish acronym). The municipality average population is 31,846 inhabitants and almost half of these (42.5%) live in cities, and their inhabitants pay yearly on average COP 82,389.69 in income tax (Table 2**Table 2: Summary statistics**).

Table 2: Summary statistics

Variable	Mean	SD	Min	Max
Share of municipality area with forest [0-100]	57.86	25.92	0.67	98.98
Forced displacement per 1000 inhab	10.57	24.03	0	702.72
Victims of massacres per 100,000 inhab	0.37	4.28	0	123.99
Direct conflict kidnappings per 100.000 inhab	0.9	5.18	0	185.56
Hectares of coca fumigated and manually eradicated	169.98	1074.96	0	34432.53
Mining (gold, silver, or platinum) [Yes=1; No=0]	0.14	0.35	0	1
Population	31846.48	79644.27	861	1200513
Log Population	9.56	1.1	6.76	14
Percentage of urban population [0-100]	42.55	23.75	1.68	99.89

[26] This is known as the Integrated System for Monitoring Illicit Crops (SIMCI, according to its Spanish acronym).
[27] Not all municipalities of the country produce coca. In fact, only 16% of municipalities produce coca, on average.

Income tax revenue per inhab	82389.69	121061.73	9.8	2749220
Log income tax revenue per inhab	10.83	0.98	2.28	14.83

Statistics refer to N = 7279 observations for 848 municipalities during 2004-2012.

5 Results

5.1 Validity of the instruments

The first stage regression results are presented in Table 3 (the standard IV-diagnostic tests are presented in the bottom part).

Table 3: First stage results of the fixed effects IV estimation

Dependent variable: Forced displacement per 1000 inhab.

	(1) 1st Stage FE
L.Victims of massacres per 100,000 inhab	0.18**
	(0.082)
L.Direct conflict kidnappings per 100.000 inhab	0.15**
	(0.070)
L.Hectares of coca fumigated and manually eradicated	0.0013*
	(0.00077)
L.Mining (gold, silver, or platinum) [Yes=1; No=0]	-1.66
	(1.67)
Log Population	-21.9**
	(10.3)
Percentage of urban population [0-100]	-1.20**
	(0.52)
Log income tax revenue per inhab	-0.60
	(0.75)
Year 2006	1.32*
	(0.74)
Year 2007	2.71***
	(1.04)
Year 2008	1.41
	(0.95)
Year 2009	-3.64***
	(1.00)
Year 2010	-5.37***
	(1.14)
Year 2011	-3.91***
	(1.36)
Year 2012	-4.05**
	(1.59)
Observations	6826
R-Squared	0.627
F-stat	25.28
Cragg-Donald Wald F statistic	15.24
Hansen J statistic	0.428
Hansen p-value	0.807
Endogeneity test statistic	4.943

Endogeneity p-value (Ho: Regressor is exogenous)	0.0262

Std. Err. (in parentheses) adjusted for clusters in municipality
L (lag)
* $p < .10$, ** $p < .05$, *** $p < .01$

The selected instruments show a positive statistically significant relationship with the forced displacement per 1,000 inhabitants at least at the 10% level of significance. In particular, war strategies adopted by illegal armed groups and forced displacement are strongly linked. Indirect violence, including massacres and direct conflict kidnappings, play a stronger role in displacement. If the number of victims of massacres per 100,000 inhabitants in the previous year increases by 1, circa 0.18 persons per 1,000 inhabitants is forced displaced. It is found as well that an increase in 1 direct conflict kidnapping in the previous year per 100,000 inhabitants leads to 0.15 persons per 1,000 inhabitants to be displaced, on average and ceteris paribus and at the municipality level.

Drug production and forced displacement are also related; however, the magnitude of this relationship is small. If a municipality is subject to fumigation and manual eradication of coca crops in the previous year around 0.0013 persons per 1,000 inhabitants are forced displaced, on average and ceteris paribus. This goes in line with the literature that says that coca production is associated with the establishment of coercive institutions governed by the illegal armed groups, thus, forced displacement only occurs when farmers are able to escape safely from the region (Acevedo, 2015).

The Cragg and Donald (1993) test yields 15.24, indicating that the instruments are relevant. The Hansen (1982) J-test provides a p-value of 0.807. Thus, the null hypothesis of zero correlation between the instrument and the error term is upheld at the conventional significance levels. The endogeneity in the forced displacement per 1,000 inhabitants variable is confirmed by a Hausman test that yields a p-value of 0.026.

5.2 Main Results

Table 4 offers evidence on the relationship between the armed conflict and forest cover in Colombia. Column 1 presents the baseline results from the fixed effects (FE) estimation, and column 2 addresses the endogeneity of forced displacement per 1000 inhabitants by instrumenting it (FE-IV).[28] All models include the controls described in Section 3.

Table 4: Forest cover equation estimates

Dependent variable: Share of municipality area with forest [0-100]

	(1) FE	(2) FE-IV
Forced displacement per 1000 inhab	0.0028**	0.013**
	(0.0011)	(0.0064)
L.Mining (gold, silver, or platinum) [Yes=1; No=0]	-0.090*	-0.073
	(0.051)	(0.056)
Log Population	-3.07***	-2.85***
	(0.48)	(0.50)
Percentage of urban population [0-100]	-0.046**	-0.033
	(0.023)	(0.024)
Log income tax revenue per inhab	0.048*	0.056*
	(0.029)	(0.030)
Year 2006	-0.19***	-0.20***
	(0.012)	(0.017)
Year 2007	-0.40***	-0.43***
	(0.023)	(0.029)
Year 2008	-0.59***	-0.60***
	(0.031)	(0.033)
Year 2009	-0.84***	-0.80***
	(0.041)	(0.049)
Year 2010	-1.01***	-0.95***
	(0.050)	(0.063)
Year 2011	-1.21***	-1.16***
	(0.059)	(0.066)
Year 2012	-1.44***	-1.39***
	(0.067)	(0.075)
Observations	6826	6826
R-Squared	0.571	0.519
F-stat	108.6	103.8

Std. Err. (in parentheses) adjusted for clusters in municipality
L (lag)
* $p < .10$, ** $p < .05$, *** $p < .01$

The more appropriate method to make inferences is the FE-IV model in the light of the validity of the selected set of instruments used. The fact that the estimate for γ is downward biased in column 1 means that the instruments are successfully dealing with the three mentioned causes of endogeneity: measurement error, simultaneity, and omitted variables. An increase in one forced displaced person per 1,000 inhabitants, which represents a 9.46% increase with respect to the mean, increases the share of the municipality covered by forest by 0.013 percentage points, on average and ceteris

[28] Appendix A shows an estimation of the model that attempt to bypass the endogeneity problem by using the lagged values of the forced displacement per 1000 inhabitants.

paribus. The presence of armed groups means that large rural areas become inaccessible and thus are preserved and protected from deforestation forces. In this case, the armed conflict appears to be a force that favours forest protection and growth. As mentioned previously, this is because some of the armed groups practice a form of forest conservation, albeit in a highly localized and coercive manner for their own benefit.

Regarding the other municipality characteristics, a 10 percent increase in the municipality population is associated with a 0.285 percentage points decrease in the share of municipality area covered with forest. This effect is expected since it accounts for population pressure on forest resources and their conservation.

On the other hand, an increase of ten percent in the income tax revenue per inhabitant is associated with a 0.0056 percentage points increase in the share of municipality area with forest. Revenues are mainly generated in major cities reflecting the strength of local economies already in place. It also captures governance and the rule of law. The concentration of people in cities leaves room for nature. It is likely that major cities nowadays don't have considerable forests left to clear. Large industrial farms have already taken over rural areas and expanded further into the nearest forests.

Finally, the increasing magnitude of the negative year-specific coefficients associated with the time dummies is more or less constant (0.2, on average) revealing that forest losses increased at constant rate in the past years.

Alternative expressions of the conflict were used to test results sensitivity. First, often when exposed to high levels of violence, farmers tend to reduce the allocation of land devoted to legal crops. Instead illegal crops are planted and additional forest clearing occurs (Ibañez et al. 2013). However, when the presence of coca crops is used to estimate Equation (1), it is found that this variable has no effect on forest cover. This result is plausible since coca cultivation is only one of the drivers of the deforestation process (See Appendix B). Second, in addition to the forced displacement per inhabitant instrumented, the lag of direct conflict deaths per inhabitant is added as an additional explanatory variable. Both conflict variables turn out to be significant and positively impact forest cover. This gives additional support to the hypothesis that conflict is a force that favours re-forestation (See Appendix C).

6 Forest cover fixed effects

Forests play a crucial role in biodiversity conservation, purify the air, help to sustain the quality and availability of freshwater supplies, and provide essential services to local populations. Furthermore, forest preservation has been receiving a growing attention in the fight against climate change. The fixed effects model cannot accommodate time-invariant variables. Thus, the final estimation omits variables of considerable interest in explaining forest cover.

Equation (3) illustrates an approach that examines the role of time-invariant variables of considerable interest in explaining municipality forest cover:

$$\hat{\alpha}_i = c_i + \delta_i Z_i + e_i \text{, with } i = 1; \dots, N. \quad (3)$$

$\hat{\alpha}_i$ is the municipality i specific fixed effect estimate corresponding to the coefficient on the municipality dummy variables in Equation (1). Z_i is a vector of time-invariant covariates assumed to affect forest cover, which includes the municipality elevation, the average monthly precipitations, the distance to the department capital, a land concentration (gini) [0-100], and a soils quality indexes. c_i is the constant and e_i the error term.

Table 5: Time-invariant covariates summary statistics

Variable	Mean	SD	Min	Max
Municipality elevation (m)	1229.39	1238.16	2	25221
Avg. precipitation monthly (mm)	173.49	85.52	52.83	712.02
Soils quality index [1-8]	2.73	1.22	0	8
Land concentration (gini) [0-100]	69.46	10.7	0	99.79

N=848 municipalities during 2004-2012.

The source of the time-invariant covariates is a panel dataset constructed by the Centre of Development Economics Studies (Centro de Estudios sobre Desarrollo Económico, CEDE in Spanish), Universidad de los Andes, Bogotá, Colombia, which treasures official statistics produced by the National Administrative Department of Statistics (DANE, in Spanish), the Geographic Institute Agustin Codazzi (IGAC, in Spanish) and the National Planning Department (DNP, in Spanish). Table 5 presents the summary statistics.

An average municipality has an elevation of 1,229.4 meters and the precipitations levels reach 173.5 mm of rain monthly. The average land concentration Gini[29] index records 69.46. The soils quality index measures the suitability of the land for agricultural activities depending on land topography and soil types. It ranges from 1.0 (not suitable for agriculture) to 8.0 (fully suitable for agriculture). The average municipality has a soils quality index of 2.73.

In Table 6 the fixed effects estimates from the FE-IV model (Section 5.2) are regressed on time invariant variables using the method of Weighted Least Squares (WLS). Especially, the weights are proportional to the standard errors from the FE-IV model. Thus, the fixed effects that are more precisely estimated get a higher weight in the estimation: since each weight is inversely proportional to the standard error variance, it reflects the information in that fixed effect. Hence, a fixed effect with a small error variance has a large weight since it contains relatively more information than a fixed effect with large error variance.

Most of the regressors have strong explanatory power. This is confirmed by the R-squared that indicates that the regressors manage to explain almost 24.5% of the variation in the FE coefficients. Naturally, municipality elevation, average precipitations, and remoteness (the distance to the department capital in km) are associated with increases in the share of the municipality area cover by forest.

On the other hand, increases in the soil quality index, meaning further soils suitability for agriculture, are associated with decreases in the share of the municipality area covered with forest. In other words, legal or illicit agriculture per se is identified as a factor in forest degradation. This is exacerbated by poor agricultural technologies; which means that more land is cleared for agriculture.

[29] A Gini index of 0 represents perfect equality, while an index of 100 implies perfect inequality.

Table 6: Determinants of forest cover fixed effects

Dependent variable: Estimated u_i (fixed effects)

	WLS
Municipality elevation (m)	0.0016*
	(0.00085)
Avg. precipitation monthly (mm)	0.13***
	(0.011)
Distance to the department capital (km)	0.028*
	(0.015)
Soils quality index [1-8]	-3.78***
	(0.70)
Land concentration (gini) [0-100]	-0.035
	(0.088)
Constant	72.0***
	(7.46)
Observations	848
R-Squared	0.245

Std. Err. (in parentheses) adjusted for clusters in municipality
WLS model weighting proportional to the u_i Std.Err.
* $p < .10$, ** $p < .05$, *** $p < .01$

7 Conclusion

The literature on the impact of conflict and violence on forests is ambiguous and many studies fail to address the endogeneity issue of the relationship. On the one hand, violence could lead to more deforestation as armed groups exploit natural resources. On the other, the presence of armed groups also means that large rural areas become inaccessible and thus are preserved and protected from deforestation. In theory, the impact could go in both directions and, therefore, the direction of the effect remains an empirical question to be investigated. In addition, frequently these studies have not taken into account multiple perpetrators of violence and non-traditional factors associated with armed conflicts such forced human displacement and mining.

For the case of Colombia, using a unique yearly municipality panel data (from 2004 to 2012) and an instrumental variable approach, there is evidence that the armed conflict is indeed a force of forest conservation. In particular, the alignment between rural underdevelopment and the rural–urban migration as a result of the violence, along with the presence and control of the illegal-armed groups of some zones contributed to protect forests. However, this effect is negligible. For example, the estimated effect suggests that one person displaced per 1,000 inhabitants increase the share of the municipality covered by forest by 0.013 percentage points at the municipality level. Forest cover changes are also likely to be driven by other factors difficult to measure such as illegal mining, the conversion of forest areas into pastures, illegal logging and forest fires.

The results of this research are consistent with the literature that states that rural–urban migration due to violence promote ecosystem recovery due to the reduction of human pressure on natural resources (for example, Aide and Grau 2004; and Meyerson et al. 2007).

Forest degradation frequently increases in post-war situations. Some studies have shown that after the end of a conflict people resettled and expanded agricultural lands (See, for example, Stevens et al. 2011 for the case of Nicaragua's Atlantic coast). Governments also pacify former rebels and provide patronage to demobilize forces by promoting rural and agricultural development. In addition, people forced displaced by the conflict return to areas abandoned during the conflict, and new people enter into forest zones that were previously too dangerous to live in.

In conclusion, this paper advocates for an appropriate conservation strategy when peace arrives in Colombia. The government will need to be ready to deploy conservation policies in those areas that are currently under control of the guerrilla. In the past, the protected zones by the state helped in reducing settlements and illegal drug activity. However, this might not be enough in the future (Dávalos, 2001). Enforcement of conservation of currently protected regions and areas previously under a "gunpoint conservation" regime by the guerrillas will be fundamental. Rain forests and their watersheds support the lives of humankind; therefore, their protection and conservation is indispensable.

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9 Appendix

Appendix A: Bypassing the endogeneity using the lag of the forced displacement per inhabitant

The estimations here attempt to bypass the endogeneity problem by using the lagged values of $FD_{\mathrm{i,t}}$. Whereas the first column employs an OLS model, the second adds the municipality fixed effects that control for any time-invariant municipality-specific characteristic that may influence changes in forests.

The fixed effects exert high influence on the dependent variable, meaning that this method of estimation is the appropriate one. Regardless of the estimation method, OLS or FE, there is evidence of that the lag of $FD_{\mathrm{i,t}}$ is positively related to the forest cover.

Even though the lag strategy could in principle solve the endogeneity. If there is any inertia in the variables, as to be expected, then lagged measures of the past conflict variable may not be truly exogenous. This would imply that the estimated coefficient of interest could still suffer from a bias problem.

Table A. 1: Effect of lagged forced displacement rate on forest cover

Dependent variable: Share of municipality area with forest [0-100]	(1) OLS	(2) FE
L.Forced displacement per 1000 inhab	0.19^{***}	0.0022^{**}
	(0.029)	(0.0011)
L.Mining (gold, silver, or platinum) [Yes=1; No=0]	19.4^{***}	-0.088^{*}
	(1.56)	(0.052)
Log Population	-1.19	-3.14^{***}
	(0.93)	(0.49)
Percentage of urban population [0-100]	-0.20^{***}	-0.047^{**}
	(0.047)	(0.023)
Log income tax revenue per inhab	-0.65	0.049^{*}
	(0.92)	(0.029)
Year 2006	0.19	-0.19^{***}
	(0.25)	(0.012)
Year 2007	-0.29	-0.40^{***}
	(0.35)	(0.023)
Year 2008	-0.26	-0.59^{***}
	(0.41)	(0.031)
Year 2009	-0.70	-0.86^{***}
	(0.51)	(0.041)
Year 2010	0.31	-1.02^{***}
	(0.57)	(0.050)
Year 2011	0.82	-1.21^{***}
	(0.70)	(0.059)
Year 2012	0.28	-1.44^{***}
	(0.74)	(0.068)
Constant	80.2^{***}	90.7^{***}
	(12.4)	(4.99)
Observations	6826	6826
R-Squared	0.156	0.570
F-stat	26.72	108.6
Sigma		25.72
Sigma_e		0.503

Std. Err. (in parentheses) adjusted for clusters in municipality
L (lag)
* $p < .10$, ** $p < .05$, *** $p < .01$

Appendix B: Are coca crops to blame for forest cover loss?

Between 2001 and 2014 it is estimated that planting coca has caused the deforestation of around 290,992 hectares of forest, which is equivalent to a little over twice the area of Bogotá city (UNODC, 2015).

If the conflict variable in Equation (1) represents the *presence of coca crops* in the municipalities, the selected set of instruments that meet the econometric requirements are the lagged number of dismantled coca crystal laboratories and the confiscation of cocaine pasta base (Kgs).[30] In particular, both measures reflect the government capacity to counteract criminal activity in the municipalities, and are also highly correlated with the armed conflict. In addition, it is hard to state that they are correlated with forest cover.[31]

Table B. 1: Summary statistics when the presence of coca crops is used as an explanatory variable

Variable	Mean	SD	Min	Max
Presence of coca crops [Yes=1; No=0]	0.16	0.36	0	1
Dismantling of coca crystal laboratories	0.22	1.38	0	45
Confiscation of cocaine pasta base (Kgs)	53	416.16	0	18716.95

Statistics refer to N = 7279 observations for 848 municipalities during 2004-2012.

Around 16% of the municipalities have presence of coca crops. Regarding the set of instruments, the police dismantled 0.22 coca crystal laboratories and confiscate 53 Kgs of cocaine pasta base on average. The variables data source is the Anti-Narcotics Directorate of the Ministry of National Defense of Colombia (Table B. 1).

30 The “extraction” laboratories called “kitchens”, “Chagres”, “Chongos, “Saladeros”, “Picaderos” are basic constructions at the farmers houses for the extraction of coca paste base by processing raw materials (plant material) using organic solvents. Thus, the coca pasta base is an extract of the leaves of the coca bush. It contains coca alkaloids, and its purification yields cocaine. Then, the coca crystal laboratories are those in which the cocaine is obtained through the chemical processes.

31 Camacho and Rodriguez (2012) provide support for these instruments. In their study, the authors used an instrumental variable approach, in which contemporaneous armed conflict was instrumented with lagged government deterrence measures.

Table B. 2: First stage results when the presence of coca crops is used as an explanatory variable

Dependent variable: Presence of coca crops [Yes=1; No=0]	(1) 1st Stage FE
L.Dismantling of coca crystal laboratories	0.0098*
	(0.0050)
L.Confiscation of cocaine pasta base (Kgs)	0.000014*
	(0.0000081)
L.Mining (gold, silver, or platinum) [Yes=1; No=0]	0.0091
	(0.011)
Log Population	0.091
	(0.073)
Percentage of urban population [0-100]	0.0024
	(0.0035)
Log income tax revenue per inhab	-0.0058
	(0.0065)
Year 2006	0.0078
	(0.0065)
Year 2007	0.0026
	(0.0071)
Year 2008	0.0096
	(0.0086)
Year 2009	0.015
	(0.0091)
Year 2010	0.0079
	(0.010)
Year 2011	0.012
	(0.011)
Year 2012	0.0085
	(0.012)
Observations	6826
R-Squared	0.89
F-stat	702.49
Cragg-Donald Wald F statistic	13.87
Hansen J statistic	0.0372
Hansen p-value	0.847
Endogeneity test statistic	0.021
Endogeneity p-value (Ho: Regressor is exogenous)	0.885

Std. Err. (in parentheses) adjusted for clusters in municipality
L (lag)
* $p < .10$, ** $p < .05$, *** $p < .01$

Table B. 2 presents the first stage results. Both instruments signal the municipality's potential of producing coca. The strength of the instruments is assessed with the Cragg-Donald Wald F statistic (1993). The hypothesis of weak instruments is rejected. The F-stats for exclusion of instruments is 13.87, well above the threshold of 10. The Hansen (1982) J-test p-value is 0.84, hence, instruments are indeed exogenous.

Table B. 3: Effect of the presence of coca crops on forest cover

Dependent variable: Share of municipality area with forest [0-100]

	(1) FE	(2) FE-IV
Presence of coca crops [Yes=1; No=0]	0.027	-0.0030
	(0.073)	(1.17)
L.Mining (gold, silver, or platinum) [Yes=1; No=0]	-0.095*	-0.094*
	(0.052)	(0.051)
Log Population	-3.13***	-3.13***
	(0.49)	(0.50)
Percentage of urban population [0-100]	-0.049**	-0.049**
	(0.023)	(0.024)
Log income tax revenue per inhab	0.046	0.046
	(0.029)	(0.030)
Year 2006	-0.19***	-0.19***
	(0.012)	(0.014)
Year 2007	-0.40***	-0.40***
	(0.022)	(0.022)
Year 2008	-0.59***	-0.59***
	(0.031)	(0.033)
Year 2009	-0.85***	-0.85***
	(0.041)	(0.044)
Year 2010	-1.03***	-1.03***
	(0.050)	(0.051)
Year 2011	-1.22***	-1.22***
	(0.060)	(0.061)
Year 2012	-1.45***	-1.45***
	(0.068)	(0.068)
Observations	6826	6826
R-Squared	0.568	0.568
F-stat	107.3	107.5

Std. Err. (in parentheses) adjusted for clusters in municipality
L (lag)
* $p < .10$, ** $p < .05$, *** $p < .01$

Table B. 3 present the results from the second stage estimation . While column 1 shows the FE estimation, column 2 addresses the endogeneity problem using FE-IV. The coefficients and the standard errors from the FE-IV estimates are almost identical to those from FE indicating that the potential endogeneity has a negligible influence on the dependent variable. This indeed is confirmed by an endogeneity test, which yields a p-value of 0.885 (Table B. 2). In the light of this, the more efficient method to make inferences is the FE model.

The FE shows that the presence of coca crops has no effect on forest cover on average. These results are plausible since coca crops account for only a small percentage of total deforestation rates. In addition, compared to a root like cassava, which requires a lot of space and effort to harvest but brings in a relatively small amount of money, coca plant has a dense leaf cover and fetches high prices. This means that coca farmers can get a lot of value out of little space.

Appendix C: The lag of the direct conflict deaths per inhabitant as an additional explanatory variable

$FD_{i,t}$ is instrumented in the same way as in Section 5.1. The endogeneity problem of the direct conflict deaths per inhabitant variable is bypassed using the lag.

Table C. 1 presents the first stage estimation results. In this estimation the lag value of the victims of massacres per 100,000 inhabitants is not statically significant. Despite this drawback, the results are shown for illustrative purposes. The Cragg-Donald F statistic of 11.88, being higher than 10, indicates that the instruments might work, and the Hansen (1982) J-test p-value of 0.84 confirms the exogeneity of these instruments. According to the p-value (0.0223) from the endogeneity test, the FE-IV fixed effect model is the appropriate one to correct potential coefficients bias.

Table C. 1: First stage results when direct conflict deaths per inhabitant is added as an additional explanatory variable

Dependent variable: Forced displacement per 1000 inhab.	(1) 1st Stage
L.Victims of massacres per 100,000 inhab	0.098
	(0.084)
L.Direct conflict kidnappings per 100.000 inhab	0.16**
	(0.072)
L.Hectares of coca fumigated and manually eradicated	0.0014*
	(0.00078)
L.Direct conflict deaths per 100.000 inhab	0.17**
	(0.069)
L.Mining (gold, silver, or platinum) [Yes=1; No=0]	-1.58
	(1.66)
Log Population	-21.6**
	(10.0)
Percentage of urban population [0-100]	-1.13**
	(0.50)
Log income tax revenue per inhab	-0.33
	(0.74)
Percentage of urban population [0-100]	1.46*
	(0.75)
Log income tax revenue per inhab.	2.78***
	(1.04)
Year 2006	1.81*
	(0.98)
Year 2007	-3.21***
	(1.02)
Year 2008	-5.08***
	(1.15)
Year 2009	-3.67***
	(1.36)
Year 2010	-3.82**
	(1.58)
Year 2011	-3.67***
	(-2.69)
Year 2012	-3.82**
	(-2.42)
Observations	6826
R-Squared	0.63
F-stat	24.57
Cragg-Donald Wald F statistic	11.88
Hansen J statistic	0.332
Hansen p-value	0.847
Endogeneity test statistic	5.225
Endogeneity p-value (Ho: Regressor is exogenous)	0.0223

Std. Err. (in parentheses) adjusted for clusters in municipality
L (lag)
* $p < .10$, ** $p < .05$, *** $p < .01$

Table C. 2 shows the second stage results. Column 1 the FE, and Column 2 the FE-IV models results, respectively. The results show that the magnitude, sign, and significance of the coefficient on the forced displacement per inhabitant does not change substantively compared to the specification that excludes direct conflict deaths (Section

5.2). The direct conflict deaths per inhabitants turns out not to be significant in the FE-IV model. These results suggest that the estimate of the coefficient is robust to the choice of covariates in the model.

Table C. 2: Effect of forced displacement and direct conflict deaths per inhabitant on forest cover

Dependent variable: Share of municipality area with forest [0-100]	(1) FE	(2) 2nd Stage FE
Forced displacement per 1000 inhab	0.0027**	0.014**
	(0.0011)	(0.0066)
L.Direct conflict deaths per 100.000 inhab	0.0012**	-0.00083
	(0.00061)	(0.0015)
L.Mining (gold, silver, or platinum) [Yes=1; No=0]	-0.090*	-0.072
	(0.051)	(0.056)
Log Population	-3.07***	-2.83***
	(0.49)	(0.50)
Percentage of urban population [0-100]	-0.046*	-0.032
	(0.023)	(0.024)
Log income tax revenue per inhab	0.050*	0.055*
	(0.029)	(0.030)
Year 2006	-0.19***	-0.20***
	(0.012)	(0.019)
Year 2007	-0.40***	-0.43***
	(0.023)	(0.030)
Year 2008	-0.59***	-0.60***
	(0.031)	(0.035)
Year 2009	-0.84***	-0.80***
	(0.041)	(0.047)
Year 2010	-1.01***	-0.95***
	(0.050)	(0.061)
Year 2011	-1.21***	-1.16***
	(0.059)	(0.065)
Year 2012	-1.44***	-1.39***
	(0.067)	(0.074)
Observations	6826	6826
R-Squared	0.572	0.510
F-stat	101.9	95.12

Appendix D: Determinants of forest cover fixed effects

Table D. 1: Determinants of forest cover fixed effects (OLS model)

Dependent variable: Estimated u_i (fixed effects)

	OLS
Municipality elevation (m)	0.0015*
	(0.00080)
Avg. precipitation monthly (mm)	0.13***
	(0.011)
Distance to the department capital (km)	0.029*
	(0.016)
Soils quality index [1-8]	-3.59***
	(0.71)
Land concentration (gini) [0-100]	-0.044
	(0.088)
Constant	72.3***
	(7.49)
Observations	848
R-Squared	0.237

Std. Err. (in parentheses) adjusted for clusters in municipality
WLS model weighting proportional to the u_i Std.Err.
* $p < .10$, ** $p < .05$, *** $p < .01$

Rural Sustainability through Production-Conservation corridors with Colombian dry forest Campesino communities

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Abstract

Colombia's usual approach to conservation establishes people only as a driver of ecosystem degradation and proposes the constitution of restricted-use isolated areas possessing exceptional natural values, but leaves aside the social aspects and cultural values guiding the relationship between people and the natural resources in a territory. For instance, the tropical dry forest (TDF), an ecosystem facing extinction, only has a 6.4% representation within the National System of Protected Areas. Additionally, the restrictive conservation status given to these areas have not completely benefited endangered ecosystems; instead, protected areas have caused estrangement between communities and their territory. This breach has inevitably resulted in additional pressure on biodiversity assets, the increase of illegality in the procurement of key natural resources and the displacement of vulnerable communities. It is known that biodiversity contributes to ecosystem goods and services which support human well-being. The long term perspective, on the other hand, has to take into account those cultural and social values affecting nature and human opportunities in a negative or positive way, to enhance benefits and minimize impacts through conscious actions applied as everyday practice. The Conservation Landscapes Program was designed to improve conservation and livelihoods, while strengthening social capital and participation. This paper will focus on how the local values and perceptions of nature and production, as well as the social capital were important to motivate actions ensuring the sustainable management of their territories. Also, it will explain how innovation, in the form of external ideas and practices, entered into this dialogue to achieve the program's objectives, that is, what it meant aligning the means and the ends. Other topics emerged as the program progressed, such as the situation and agency of women in conflict and displacement situations, in relation with conservation activities, food security and sovereignty. The project shows that conservation can be aligned with other societal goals, minimizing tradeoffs, and creating "win–wins" for communities and nature, while promoting better institutions at different levels. For the pilot phase Patrimonio Natural (NGO) introduced the conservation-production corridors as the strategic approach to plan and conserve the TDF with 300 Campesino families in 7 Nodes distributed in the Colombian Caribbean region. Within this approach, the team used human centered design methods and mapping tools such as participatory territorial planning, action-based Conservation agreements and the application of landscape management tools to work along Campesino families in reframing their relationship with the forest. This approach allowed rural communities to decide over their territory with key information at hand and to generate a valuable relationship. This new relationship enhanced productivity and biodiversity recovery bringing new products to the market and securing basic needs. Also, the recovery of techniques and the introduction of technology, gave Campesinos the necessary tools to improve their health and well-being. Ninety kilometers of production-conservation corridors where created, in collaboration with Campesino communities, improving their quality of life and income and protecting biodiversity. Economic, social and environmental sustainability are starting to be achieved on a small scale, but escalating calls for the involvement of all stakeholders including policy makers.

Keywords: Biodiversity conservation, Tropical Dry forest, Participatory approaches, Integrated landscape management

1. Introduction

Conservation of biodiversity in the context of development programs is continuously challenged to consider holistic perspectives and innovative options, in order to achieve successful results. The dry tropical forest, due to its extreme fragmentation in Colombia, requires identifying and testing different approaches that include the people in its design. The autonomy and freedom of choices offered to campesino communities is crucial to promote appropriation and application of effective techniques. The cultural and social context must be included in the preparatory moments of the conservation and development projects, thus counting with the local knowledge on the landscape and its natural assets. Several criteria applied by a program for tropical dry forest conservation and examples of its actions will be examined, focusing on the need to establish a new dialogue between science and local knowledge and also between city and rural area dwellers, to recognize and foster cooperation which will benefit conservation of nature and livelihoods.

2. Methods

Two sets of methods were used in this work: 1. Secondary information for environmental status and former or current activities in the Caribbean region, coupled with GIS techniques to characterize and design the potential for conservation actions in the Tropical Dry Forest, and evaluate their advance; and 2. Participatory methods for understanding the natural, cultural and social context, promoting its assessment with the communities and establishing projects adapted to such knowledge within broad conservation objectives. The first set was based on current knowledge of the status of tropical dry forest in Colombia, as compiled in the National Reports on Biodiversity (Chaves and Arango, 1998), or in other publications concerning its particularities, adaptation strategies, dynamics and structure, along with the threats and actions for conservation (Díaz, 2006). Of special importance was the publication of the official dry forest map (Instituto Humboldt, 2013), which was used for selecting the main areas for the program's activities, based on the occurrence of important forest remnants within a mostly deforested matrix (92% of tropical dry forest has disappeared, remaining only 8% in the whole country) (***Figure 1***).

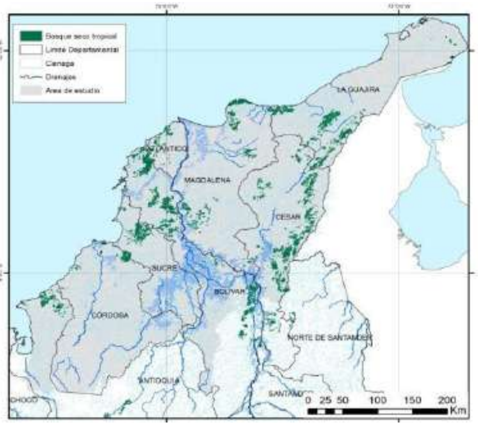

Figure 1. *Map of Tropical dry forest remnants in the Colombian Caribbean, based on Instituto Humboldt, 2013.*

Conservation biology practice has underscored the negative effects of fragmentation and isolation of patches, which can be checked by establishing new connections between habitat patches in a region. Although there is considerable debate on the effectiveness of establishing corridors as connections (Berges et al., 2011), for this program a mixture of connectivity measures was proposed: small corridors, stepping stones in deforested areas, protection and enhancement of existing patches by enriching with native trees, especially those threatened and useful species. The emphasis was given more to establishing physical connections in the landscape (structural connectivity) than providing habitat to certain species (functional connectivity). GIS analysis calculated the most effective ways for connecting forest patches with the least resistance and the shortest paths, within the main nucleus of remaining dry forest in the Caribbean (***Figure 2***).

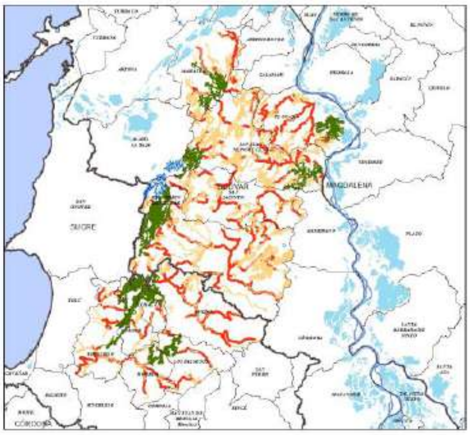

Figure 2. *Potential connectivity corridors in the Montes de María area, Bolívar, Colombian Caribbean region. Green and sand colors indicate largest remaining dry forest patches, while red indicates main paths for connecting patches, enhancing conservation options for the dry forest (Adriana Rojas, GIS expert, Conservation Landscapes Program 2013).*

The program was also based on the vulnerability brought to these areas by deforestation in a scenario of climate change, and the need to maintain or improve water and soil availability and qualities by enhancing or re-establishing forest cover. The second set of methods is founded on the concept of cultural landscapes as considered by Carl Sauer, where the current status of a landscape is a result of the natural forms and the transformations brought by human occupation, including a history of such occupation (Sauer, 1925). According to this perspective and the contextual analysis indicating that rural dispersed, diverse and rather isolated communities occupied the tropical dry forest areas, where deforestation was linked to agricultural practice and natural resources were used for subsistence, a culturally significant view and participation was essential. Also, because protected areas restricting human occupation would not be feasible as a conservation strategy for populations already having suffered conflict and displacement, an integrated landscape management was indicated. Participatory tools (van der Hammen et al., 2012) were used for a contextual understanding of the territories in each of four selected nodes. These tools included direct field observations with local participants, life histories, assessment of human, social, natural, financial and physical capitals. Then followed the self-diagnostics with focal groups, where social maps were traced, inventories in each culturally distinct space were made, calendars of production and use were established and economic systems were learnt. An assessment of the situation was obtained through a description of problems and potential solutions. A set of social maps were obtained for each territory, in which the people traced the connectivity passages (***Figure 3***), roughly following the former GIS analysis.

Figure 3. *Map drawn by the community, identifying the main topographic features, streams, national Park, natural reserve and the preferred connectivity corridor. The cultural landscape is reflected in the site and people names, main landscape features, and the connection which follows the cultural practice of leaving strips of forest alongside the streams and along the hilltops as hedgerows. (Patricia Navarrete, workshop facilitator, Conservation Landscapes Program, 2013).*

3. Results and Discussion

Tracing the structural connections in the landscape with a participatory approach was beneficial in the sense of the community acceptance of this proposition, but it is important to consider that negotiation has a role for both sides: the program and the communities. The constructivist procedure of the participatory assessments is built on the local knowledge and the willingness to create a set of options to solve perceived problems: on one side are the program objectives of conserving the dry forest and achieving sustainable livelihoods, while on the other side the people see the relative scarcity or disappearance of natural resources, coupled with the necessity of widening production areas by cutting down forests. In campesino communities, due to the impacts of armed conflict on local leaderships, the individual actions tend to prevail over the collective ones, but landscape management needs thinking collectively, so the social cartography at the landscape scale was an important tool to understand the need to care for water along the course of rivers or streams (***Figure 3***). Sometimes field trips were made for people to discover that the stream was the same, even though it had several different names; this situation was common when people were new settlers because of former displacement.

In addition to participatory methods, some criteria had been used to establish the limits of the program in its contribution to landscape management, devising incentives for sustainable production and improved income (***Figure 4***), based on: a) enhancing diversity; b) using agro-ecological and soil conservation techniques and c) linking producers to selected markets.

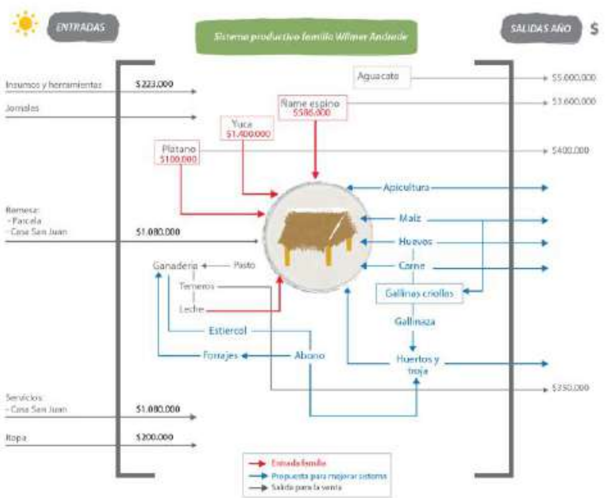

Figure 4. *Example of a household economy in San Juan, Bolívar. Their income derives from farm produce (in red), but must be supplemented by working as a casual laborer. Additional new options for the farm were identified in blue, such as apiculture and different crops. (Patricia Navarrete, workshop facilitator, Conservation Landscapes Program, 2013).*

Regarding diversity, the self-diagnostics had indicated that seeds for crops were greatly diminished or had disappeared (***Figure 5***) due to displacement and market forces which selected just a few varieties for mass consumption.

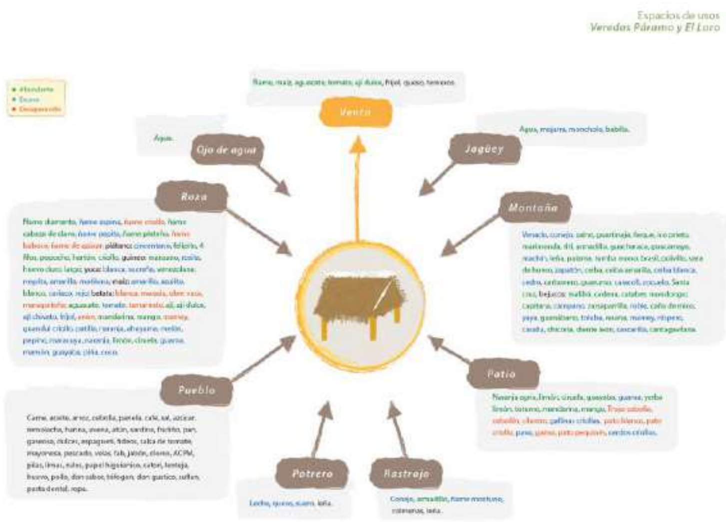

Figure 5. *Use spaces as identified by the communities in San Juan (Bolívar) through focal groups. Roza is the plot for planting food: lost varieties of seeds are shown in red, scarce ones in blue and abundant in green. Basic foodstuffs, clothes, cleaning and personal care products are obtained in the village, so a monetary income is needed in addition to their own subsistence production. (Patricia Navarrete, workshop facilitator, Conservation Landscapes Program, 2013).*

Apart from that, families had reacted to armed conflict by splitting, the women and children staying in the nearest town while the men returned to the fields. It is well known that women are the stewards of plant conservation, due to their role in the nutrition and well-being of the family (Howard, 2003). In this process, the contribution of women, especially regarding several crop varieties and medicinal plants was lost, affecting food security, family nutrition and economy, and losing the transmission of traditional knowledge to the young people. A strategy was devised to recover the lost wealth by a seed exchange in which some indigenous seed custodians brought their diversity and associated knowledge to the recipient communities, complemented by reflections on the importance of maintaining their autonomy regarding production with their own seeds. The women's role was highlighted when a community group living in a rural area but deprived of land planted a collective "mother plot" to recover lost seeds, was followed by establishing small kitchen gardens for each family in the small spaces available near their homes. The initiative was started as a "community pot" event, where the women's culinary knowledge was recovered, important recipes identified and then re-enacted by the whole group as a creative space for transmitting traditions. This strategy followed similar actions which aim to recover and make new interpretations of traditional dishes as a form of cultural revival (Cárdenas, 2014; Duque, 2016) (Figure).

Another option for enhancing diversity was to find natural resources which could be sustainably collected as an economic option for communities. Based on the abundance of useful palms in Colombia (Henderson et al. 1995), and on the existence of a group of botanists dedicated to their study, (Grupo de Palmas, Universidad Nacional de Colombia, Bogotá) the program supported an assessment of the best potential species for this purpose, pertaining to the dry tropical forest region. Three of them were outstanding: the "corozo de lata" (*Bactris guineensis*), the "palma amarga" (*Sabal mauritiiformis*) and the "palma de vino" (*Attalea butyracea*) (Figure 6).

Figure 6. *A most useful trio of palms: the lower Corozo palm in the foreground; to the right the Amarga palm; in the background the Vino palm.*

The fruit of the corozo palm is used for preparing a refreshing beverage or ice creams, and is well known in the region; despite this, no one had examined the requirements for sustainable use. A biology student, and also a member of an indigenous community, was in charge of developing this assessment. One of the interesting findings was that the pollination of the fruit is made by small beetles, and that drier climate conditions may affect the quantity of fruit available in a particular year. The use of pesticides which could kill the beetles could then inhibit the fruit production, endangering the economic opportunity for communities. Although other requirements were identified, it is important to mention that this palm was incorporated as a new source of income for a group of indigenous families, in addition to subsistence crop production, timber plantations, fiber cultivation for traditional crafts and cattle ranching, emphasizing the multi-functional role of farms in the Caribbean. Once the sustainability of fruit collection was devised, a small transformation enterprise was established to sell frozen fruit pulp for restaurants and other businesses. The value chain identified for this natural resource may in the future include other sub products as natural ingredients for cosmetics or nutrition supplements. Capacity building on sustainable management and business skills for community members selected by the indigenous authority were crucial aspects for the success of this initiative.

Regarding the introduction of agro-ecological techniques, as well as soil and water conservation measures, was identified through the participatory diagnostics and field trips. One of the main problems was soil fertility, so one of the main skills-building activities was to prepare organic fertilizer with local materials, such as crop and kitchen waste, manure, bones and forest fungi. Several techniques were experimentally prepared with the people, and the one that captured mostly their attention was the inoculation of the compost heap with forest micro-organisms. The effectiveness of this fertilizer has meant that now the farmers recognize the value of standing forests.

Another common problem in the area was soil degradation, leading in the short term to desertification, as established by tropical dry forest researchers, who identified that more than 70% of deforested lands are suffering this degradation process (Pizano and García, 2014). Many of the areas were so dry and compacted by cattle that no plant was able to survive the dry season. Some experts were consulted and they suggested applying the techniques championed by Primavesi (Primavesi and Molina, 1984). An agro-ecological expert experienced in the dry tropical areas of Mexico was in charge of introducing this innovation through a hands-on method with small groups of farmers. The basis of the strategy is to break soil resistance by enhancing water infiltration with ditches and small dykes, mostly following the contours of the terrain. The "key line" technique also identifies in the natural topography the key points to make small reservoirs and as a whole establish in selected areas of the landscape the conditions for water retention, promoting plant growth, from herbs, to shrubs, to trees. At first the farmers were curious and participated in the experience somewhat half-heartedly. After six months and having survived a five month dry season without losing any animals from lack of forage, one of the farmers was not only convinced of the benefits but also contributes to disseminate the proof of the effectiveness of such technique.

Another agro-ecological initiative directly linked to forest conservation has been apiculture. These groups of hives, managed collectively, are located at the forest borders. A local expert was hired to build capacity in interested farmers, and small groups of white-clothed bee-keepers are now collecting substantial honey harvests. This experience has led the communities to recognize that preserving the forests, water and soils means improved economic options, so they are happy to be the forest and water stewards.

There is another side which had to be considered when searching for access to markets for these farmers, given that part of the strategy was to provide market incentives if the people would care for the connectivity mosaic and the forests. These farmers had relations with some institutions (***Figure 7***), but private enterprises were not present, so it was necessary to search for them.

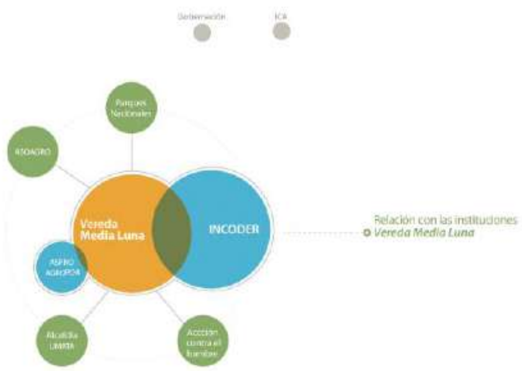

Figure 7. *Relation of farmers with local, regional and national institutions. The strongest link was with Incoder, the government office in charge of assigning lands to previously dispossessed farmers. The National Parks and the Mayor´s Office were close to the communities and associations in the Media Luna area, but no private business with a potential for new markets was present.*

The potential clients of dry forest products are not aware of the complexities of production, its vulnerability due to climate conditions, the difficult access to the farms and the demanding tasks involved; neither have they understood a harvest calendar or the volume of production available in a given moment (***Figure 8***). Given the niche market involved, a restaurant chain was identified as the best option to promote this new business relation between local farmers and urban dwellers.

Figure 8. *Crop calendar in San Juan, Bolívar. Traditional knowledge relates weather conditions with sowing and cropping moments for each type of produce and each variety. As an example, different Ñame root varieties are planted according to soil quality and sun conditions in each plot. Particular crops are only available at certain times of the year and urban markets need to know this to establish new relations with farmers.*

Once the production calendar was understood by the restaurant managers as potential buyers, linking farmers to markets implied visits both to farms and to the restaurant's premises. Willingness from both sides was endorsed by building trust and forging connections between real people, those making crops happen and those making appetizing food to appear on the fancy dish of a restaurant. Then, all of them understood the qualities of each of the partners; the effort involved in their labor, and also established human bonds that could sustain the necessary steps to arrive to successful business relations. This began after a difficult "El Niño" drought year, when the farmers had been losing crops because no rains would appear. Again, the seed custodians were called to assist with materials resistant to the severe dry conditions, and a small bean adapted to grow in dry areas was identified; a crop was obtained and the restaurant chain was called to inquire on potential purchases. They made several experiments and introduced the beans to their salad bar, with instant success. For them it was also a matter of not requiring a change in the menu; only after a year of trial, a new dish was designed and introduced as a seasonal option. The experience was good and finally the dish now appears in the regular menu. After the process, they were willing to explore other potential products, so dry forest honey was on trial. In this case, giving basic information was necessary, because the person in charge of purchases was puzzled by the different colors of the honey batches. They then understood the reason for this and are now proud to include dry forest honey in their menus. Local research was promoted to identify, among other aspects of dry forest trees, more precisely the main flowering trees and time of occurrence (López et al., 2016), which influence the color and taste qualities of honey, in order to give consumers information to enrich the experience.

Not every potential market, though, is ready to enter into such complexities in order to give an opportunity to certain types of farmers; normally it is more of an imposition of a list of products they are ready to purchase, and a strict set of instructions on how to comply with the volumes and qualities of production required in their business. They would hardly be willing to explore new products, flavors or qualities, or else accept small batches of produce with uneven qualities. Exploring this situation to evaluate the potential of several markets, a call was made to a group of chefs in one of the regional cities where the restaurant business is particularly active; the farmers also participated in the exchange of views and requirements of each of the parties, but many obstacles were found, mainly due to the specialization of each group in their respective tasks, which meant less time affordable to develop purveyors on the farmers' side. On the chefs side, it was difficult to continuously create dishes for a varying supply with unknown characteristics. A coupled solution was proposed: universities and culinary schools would experiment with the local diversity, and the farmers associations or a related organization would be in charge of preparing the conditions for a streamlined link from the farms to the market. Although the business capacities on the purveyors' side were enhanced by the program, their organizations are still weak to respond to stringent requirements. Other, more culture-centered options have been explored (Duque, 2016), including the local and regional valuation of culinary traditions as a space for creation of innovation within tradition. This space was created when a well-known chef was invited to share her skills with the dry forest communities and cook with them according to their own recipes, including her expertise and twist of imagination to bring out the unique qualities of an ingredient. After these experiences, the women in particular were highly motivated: they recognized the professional quality of their guest, but there was a more noteworthy emergent aspect, because the women felt their power came from their own traditions, their own source of knowledge, the local experts, the flavors stemming from the earth and their own hands (***Figure 9***).

Figure 9. *Different generations of women from a San Juan community empowered for innovation within tradition. They gathered to prepare local traditional food based on their own produce and wild plants.*

4. Conclusions

The former section has stressed the strong linkages between the natural lay of the land and the uses to which such territories have been put over hundreds and even thousands of years. Although memories do not recognize the succession and antiquity of layers, when inquiring for the use of a certain fruit tree or herb, a world of relations appears. First, the original hunters and collectors represented in some people that still appear to roam the land as their ancestors did; then the first agricultural experiences, the expertise of the root crops and the understanding of their qualities, needs, soils adapted to rearing them; the mixing of the native origins and the African new inhabitants; lastly, the social adaptations to risk and insecurity that may soon open other opportunities with a peaceful context. Striving for a long term perspective of conservation of a ravaged land, better knowledge of the land is a pre-requisite for successful action, so exchanges between local experts would be advised.

Diversity is still waiting for its full potential; a set of options was identified through participatory research, involving some of the young people, but much is still needed to promote better conditions for people based on their natural resources and the varieties designed by generations of farmers. A concern for the transmission of knowledge is the ruptures due to armed conflict and the disappearance of important leaders. A new generation of applied research would be needed, within a wider dialogue between diverse actors.

Stemming from their own resolution and collective effort, women have great potential to develop solutions to their problems in rural areas, once they realize that their memories related to family care carry their power to the world around their homes and beyond, including water and forests as care-givers to the land and the people.

Innovation brought by external agents, if carefully introduced and experimented with the people in each distinct portion of their territories, has enormous potential once it demonstrates its benefits. These advantages can be thoroughly realized if the ambassadors of the innovations are the people themselves.

The market has been widely thought to be a powerful key to success for rural dwellers in search of sustainability; the preparation of both sides in this endeavor is necessary, along with transparency in thought and action. Exchanges of perspectives can uncover undetected conditions affecting the potential relations, and activities to forge trust and equal relations can be crucial.

The recognition of value of their own resources within the local inhabitants, including most notably the knowledge required to manage the land, soil, plants and animals, along with other physical and climatic qualities of the landscape, is one of the most important assets for a long term conservation of such natural and cultural resources.

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A MANAGEMENT MODEL FOR THE SUSTAINABILITY OF CULTURAL THEATERS IN THE CITY OF BOGOTA – COLOMBIA

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Content

Abstract

Bogota is a metropolitan city of more than seven million inhabitants. It has a rich tradition of arts and popular culture. Over the last few years, the institutional framework and infrastructure for cultural management has been improved substantially. Bogota is well-known for its cultural diversity and management of different public festivals, and at the same time, it is possible to find a vast variety of popular artistic expressions in the local communities. Consequently, UNESCO recognized Bogota as one of the most musically creative cities in Latin America.

This paper presents a theoretical as well as a practical model for the sustainability of the artistic and cultural expressions in the city's public infrastructure (theaters), as well as the business model for fundraising and financial balance. Based on a systemic view of the arts performance, we proposed the creation of an infrastructure network for Bogota that integrates the individual theaters by organizational, financial, marketing, operational, organizational, logistical, human resources and fundraising processes for optimizing money and resources: in other words, to establish a public network of municipal theaters.

All the theoretical support of this paper is based around a concept: social networks in organizations and the systemic approach where every actor of the network has its own function for sustainability. That has always been a challenge for cultural managers: the financial gain as well as the cost effective cultural programming in terms of audience preferences. This paper aims to reduce this gap between effective cultural management and financial balance. Some references used to support the present research are: Granovetter (1985), Powel, W.W., Smith-Doer (1994), Scott, J (2000), Fligstein, N (2001), Boyd, (2000), Borgatti, S.P. and Foster, P. (2003), Smith-Doer, Powell, (2005).

As mentioned before, this work is based on the systemic approach to the cultural sector. We proposed five principal subsystems for its management: i) Government, ii) Planning and Intelligence, iii) Monitor and Control, iv) Coordination, v) Management of day to day responsibilities and functions. We followed a participative methodology to develop the sustainable arts and business model. In this paper we present the basis for participation of the different institutions involved, how decisions were made, and how they could be improved.

The proposed Management Model seeks to enable a proactive change process, led by e The District Department of Culture and Sports (SCRD) and The Bogota Philharmonic Orchestra (OFB) to overcome the internal operational weaknesses and to create a sustainable cultural programming for the citizens. There is an uneven and differential distribution of income within Bogota's population, which requires these cultural agencies to create differentiated and specialized events for the public, guaranteeing that it is free for some.

To continue Bogota's recognition as a cultural epicenter of Latin America, this process towards a new Sustainable Management Model must be propelled by these principles: i) taking advantage of cultural opportunities, ii) creating and strengthening an institutional and political coalition, iii) communicating this new vision within public institutions, iv) empowering the players, v) establishing short term results and achievements.

Keywords: strategic sustainable management of cultural infrastructure through creation of a network of public theaters, cultural management, marketing, financial, logistics and monitoring tools of cultural spaces in a metropolitan area and fundraising. Business models for public cultural infrastructure and sustainability strategies: leadership, organizational culture, corporate sustainability actions and behaviors.

1. Introduction and methods

The current globalization and change environment, in which Bogota's Cultural Management unfolds, generates important challenges and threats, as it also offers innumerable opportunities that the *Distrital Cultural System* should use. To display a proper response to these opportunities it's necessary to have a Model that addresses internal weaknesses (for example, difficulties found in: coordination, programming, advertising of the cultural offering, articulations between public-private sectors, articulations between public spaces, Mobility systems and security, insufficient financial resources, inadequate personnel, organizational structure and quality monitoring plans). In turn, the model proposes potentiating the strengths in the articulation with external players, stakeholders, cultural entrepreneurs, donors, international cooperation, artists and basic organizations acting at a territorial level. Effectively incorporating strategic stakeholders for the Cultural Management is a priority that must be developed.

The proposed Management Model seeks to enable a proactive change process, led by the SCRD (District Department of Culture and Sports) and the OFB (Bogota Philharmonic Orchestra), (agencies of the Cultural Government of Bogota). The final goal would be to create a sustainable cultural programming for the citizens through the entire cultural infrastructure. This programming should also make good use of the global, competitive, cultural and economic forces that drive the significance of culture as a development factor of a city, and its role in the fulfillment of its inhabitants' rights. As a cosmopolitan and globalized city, Bogota must count with a diverse and high quality cultural offering that isn't an exclusively governmental responsibility. There should be joint efforts when working with private sector initiatives and projects, such as the construction of the new cultural project of the Julio Mario Santo Domingo Theater. Conjointly, special attention must be placed in taking advantage of Bogota's competitiveness and its inhabitants' increasing income. Although, it must be taken into account that there's an uneven and differential distribution of income and possibilities within Bogota's population, which require solutions that are focused on a differentiated and specialized cultural offering by type of public, guaranteeing that it's free for some.

The change process towards a new Sustainable Management Model must be propelled by these next principles: i) a clear sense of urgency in its completion and capitalization of the opportunities identified in the environment, ii) Creating and strengthening an institutional coalition that has a politic will for change, sufficiently capable of attaining the required resources. This coalition must be fundamentally composed between the SCRD and OFB, with a shared Vision and Mission, iii) Communicate and socialize this new vision within these institutions through socialization exercises with functionaries, stakeholders and citizens by means of increasing involvement and interaction, iv) empower other players, particularly friends of the Cultural facilities Network, the entrepreneurial sector and organizations of artists, v) Establish short term generation of results and achievements that back up the new vision, where the role played by the metropolitan theaters (with new and swift programming) is fundamental.

In order to drive the change process, this study sets up seven strategic guidelines of action:

1- Create a Cultural Sustainable Management System based on a network of Public Theaters that are decentralized and accessible to most of the population. This system's Corporate Government must include the Treasury Department and the District Department of Education besides the representatives of local cultural entrepreneurs and artists, representatives of potential audiences. The cultural facilities must be articulated with the city's public space, Mobility and security systems, and a network of complimentary services such as restaurants, hotels, other private theaters, etc.

2- The Cultural Sustainable Management System will revolve around a strategic axis, focusing on a predefined, inclusive, diverse, versatile and high quality cultural programming. It should include every single facility (theater, stages) and allows the execution of major events. This programming will take into account the gratuitousness of many of the spectacles and the formation of audiences. Also, the System will have the responsibility of shaping audiences with the active contribution of district schools, the Department of Education and local mayoralties.

3- Consolidate a Sustainable Cultural System with a solid Entity that acts as a central node and specializes in managing the city's cultural facilities and promoted to become Business Unit with autonomous decision-making and accountable of its own profitability.

4- Financially speaking, it's important to implement an accounting of costs for each theater and each system, and include indicators of financial execution (besides the ones related to budget execution) that aim to achieve sustainability in the long term.

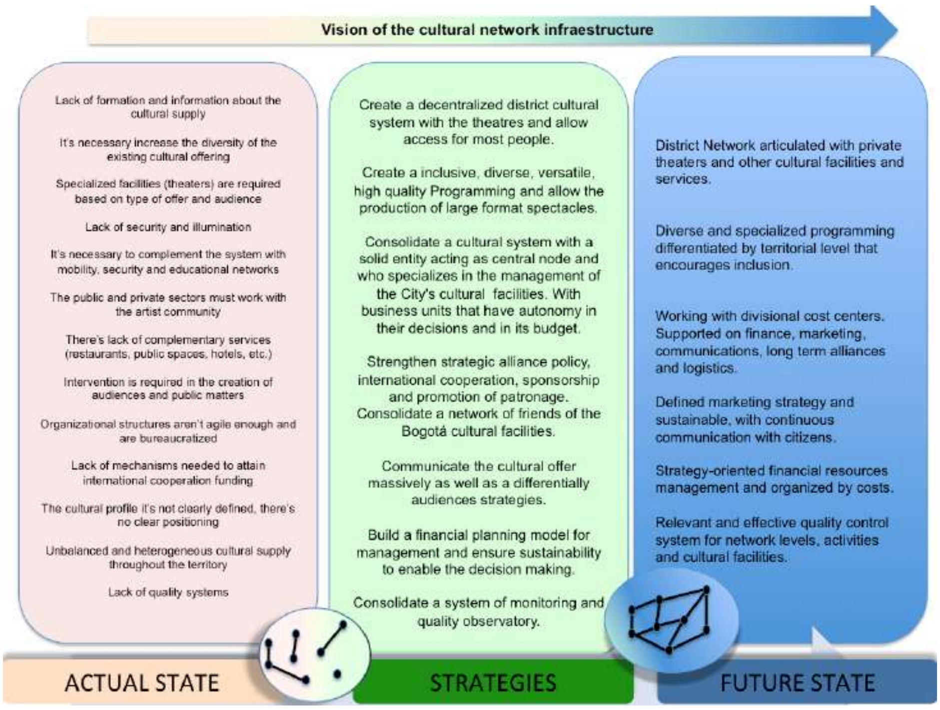
5- Market and communicate the cultural offering on a massive scale that includes the whole system and each theater involved, having a differentiated approach to each audience.

6- Manage with a Sustainable Financial Planning Model. It should guarantee sustainability and allow wise decision making related to the types of contracting, nature of alliances, tariff designs, and auditing costs of events, theaters or systems.

7- Create a monitoring quality system of the cultural offering, that also overviews cultural processes and includes the creation of audiences, results of attendance and impacts on citizens. This system must include a balance scorecard and management indicators that are made public and can be questioned by the citizens.

These strategies are supported in the analysis and diagnosis of the current situation and the development of a *Vision of future* that was built in a participative manner during the study and that inspires the process of change. The study drawn from primary sources like workshops with public officials, interviews to the theaters managers, open discussions of the model and secondary sources consulted as publications, journals magazines etc. This process expresses itself in specific missions for the Public Facilities System and for each particular theater in each territory.

GRAPH 1 FUTURE VISION



2. Problems, threats and challenges of the sustainable cultural management of the system

The proposed management model for the sustainability of the district's theaters is based in the idea of attaining an internal interconnectivity between theaters and an external interconnectivity (which has to do with main stakeholders; potential audiences, existing audiences, artists, patrons, other public entities, among others). This interconnection and inter-institutional cooperation must develop as a skill of building a Network (RED).

Principles for Sustainable Cultural Management of the Network (RED)

We establish as a central element of the Sustainable Management model the consolidation of a system of Theaters and the development of a network, which we will call RED (*Red de Escenarios Distritales* or District Theaters Network), that would enable sharing of resources and information. It will also allow the possibility of working around global objectives shared by all the members of the system, articulate themselves to other networks and evaluate them-selves periodically so that they can use and share lessons accomplished individually by each facility, therefore feeding this system in a proactive manner. It's fundamental to comprehend that Public Cultural Management can't be based in an exclusively governmental or state model, and that's why an active participation is required of private sectors, entrepreneurs, patrons, artist organizations and society in general. It's essential to begin by

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stating that the public cultural offering is immersed today in a competitive environment that requires to become differentiated by means of its polyvalent and multicultural focus, its gratuitousness in the offering of hundredths of massive spectacles and its quality. This wouldn't be possible without a guarantee of financial and social sustainability of the RED public facilities system. For this to happen, it's necessary to keep the contribution of the district's budget, which must also be incremented in order to fulfill the objectives of the city's development plan and the related cultural policies. It's expected that results and impacts should be attained in order to achieve these budget increases. The Public Facility System must demonstrate quantitative results, maintain acceptable quality standards (measured with indicators) and reflect the impact generated to education programs, developing values and fulfillment of cultural rights for the people of Bogota. Because of this, a focal point of the management model will be developing information, monitoring and feedback systems that are based on quantifiable indicators for processes, results and impacts.

Taking in consideration the preceding, the Mission created is inspired and integrated by principles of Public Management and Cultural Management. It contemplates the following elements:

- Cultural management must act in a competitive environment, that's why the public supply of cultural services must differentiate itself through gratuitousness, quality and specialization
- Public management must be decentralized on a territorial level
- Public management must be participative, therefore there's a need of spaces for discussion, negotiation with artists, entrepreneurs and others involved
- Cultural management ought to be measured in processes, results and impacts through indicators.
- Cultural management should be oriented via public policies, but its implementation can be done in collaboration with the private sector.

3. Vision and mission of sustainable cultural management for a metropolitan area

To determine the mission and vision of the RED, we identified some differences between Theaters in terms of size and vocation. In this way a classification arises:

1. **Metropolitan:** equipment that lends services to the whole Capital District and to the region. Generally they have a high urban and social impact.

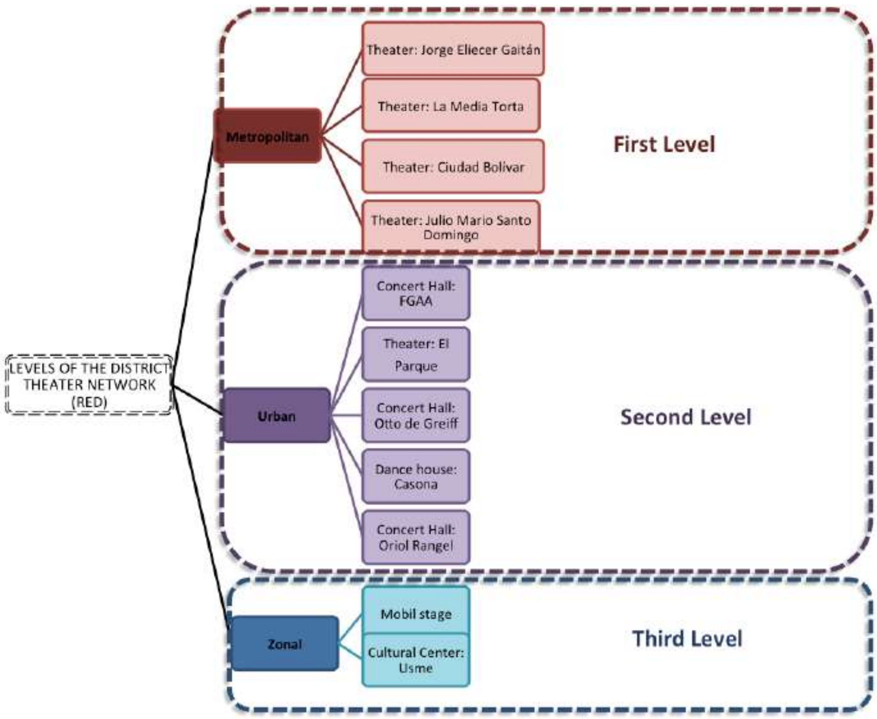
2. **Urban:** comprises equipment that excels their urban influence to an ample size of the city's territory and generates high urban and social impact. This is related to their magnitude, utilization, level of specialization, institutional pre-eminence, high urban impact, or services and infrastructure requirements

3. **Zonal:** they lend specialized services to the population of urban areas; generally they're more extensive and complex than a simple neighborhood or small groups of homogenous neighborhoods. They're considered to have medium urban and social impact as they're developed in specialized buildings, generate an intense inflow of users at certain special days

or hours, require parking zones, can generate traffic or congestion and favor the evolution of complementary uses in the area of immediate influence.

4. **Neighboring:** first necessity equipment of and district coverage that attend to community residents and laborers of their immediate area of influence. They've high social impact as they develop themselves in establishments of reduced size, they don't generate much traffic nor congestion, or noise, or inflow, and they're not propitious for any significant complementary use.

GRAPH 2 LEVELS OF THE DISTRICT THEATER NETWORK



MISSION OF THE DISTRICT THEATER NETWORK (RED)

The District Theater Network implements a policy that guarantees the cultural rights and the city's right to dispose of the optimal physical, human and technical conditions that are done with impartial, sustainable and progressive criteria.
It works in an articulated manner, and thanks to a complementary, relevant and high quality programming, it guarantees that everyone can live artistic experiences, display cultural

practices, value and spread their memories and heritage; but also live and value those of others. In the same way, it guarantees the right to take part in building and enjoying safe, friendly and diverse environments.
The network promotes artistic, cultural, urban, social, financial and administrative sustainability of its theaters in the metropolitan, urban and zonal levels. It also stimulates the relationships between them at a regional, national and international level.

VISION OF THE DISTRICT THEATER NETWORK (RED)

In 2014, the Network of Public Theaters would have qualified its management model (programming, human resources, audiences, organization, communication, marketing…), in order to integrate and strengthen a cultural supply that's polyvalent, inclusive and diverse in Latin America.

The levels of action in the metropolitan area

First level: Metropolitan scale

MISSION:

The District Theater Network implements a policy that guarantees the cultural rights and the city's right by disposing of optimal physical, human and technical conditions with impartial, sustainable and progressive criteria.
We promote the link and development of artistic sectors, the organizations that promote the city's cultures, as well as promoting those of its audiences' and community's, depending on its metropolitan nature. They lead actions to promote the joint responsibilities related to the cultural sustainability of the immediate environment and the next. They implement management models that guarantee their administrative and financial sustainability. They Plan and execute polyvalent and diverse programs, that have big formats and coverage, with regional, national and international projection.

Second Level: Urban scale

MISSION:

We promote the link and development of artistic sectors, the organizations that promote the city's cultures, as well as promoting those of its audiences' and community's, depending on its Urban nature. They lead actions to promote the joint responsibilities related to the cultural sustainability of the immediate environment and the next. They implement management models that guarantee their administrative and financial sustainability. They Plan and execute polyvalent and diverse programs, that are also specialized and allow the interaction of specific population and regional groups.

Third level: Zonal scale

> *We promote the link and development of artistic sectors, the organizations that promote the city's cultures, as well as promoting those of its audiences' and community's, depending on its Zonal nature.*
> *We lead actions to promote the joint responsibilities related to the cultural sustainability of the immediate environment and the next. They implement management models that guarantee their administrative and financial sustainability. They Plan and execute polyvalent and diverse programs, that allow free artistic and cultural expressions of the communities and stimulates the neighborhood relationships.*

Specialized Vocations by Theater

The members (theaters) of each of the RED scales have a specialization level that depends on its Metropolitan, Zonal or local nature. Therefore, Bogota counts with Staging for children's theatre, variety of dances and musicals, academic music, operas and lyric arts, typical and traditional folklore, and forms of integral Staging represented by The Jorge Eliecer Gaitán Theater (an epicenter of cultural diversity).

4. Theoretical approach

- **A systems approach and Networks for collaboration**

System is an organizational concept to organize. It consists of a series of elements (such as cultural Theaters) and the relationships among them. First of all, a system must stamp itself with an identity that will differentiate it from its competitors and the environment. This identity will limit the system so that it may recognize a series of required inputs from its environment (talent, creativity, financial resources, entrepreneurial capacities and logistics) and the products presented to the people (varied and multicultural programming/events of high quality, decentralized by Theater). The Cultural Theater System (RED) transforms inputs into products through processes that are integrated and shared by all theaters/stages and which also enable continuous learning and feedback. These processes generate learning cycles and virtuous circles that enhance the positive impact of the system over the city and its people. It's important to maintain a definite identity of the system when facing an uncertain environment, but simultaneously it needs to be dynamic and learn to adapt to change and environmental challenges. This requires the development of information and communication systems between the constituting elements of the main system.

Each of RED's elements must be able to access such a system and give it feedback. It must spawn a transformation of the current undesirable situation. To think in the organization of the public Cultural Theaters as a system, implies committing to the idea of achieving its goals efficiently and effectively. It means to understand that these goals derive from the city's public policies and they hold culture as one of people's rights.

The propose model suggest that the system must have a **Government Subsystem** that incorporates those players that control valuable resources for the system and aren't being considered currently. Because of this, there's a need to include the Treasury Department (*Secretaría de Hacienda*) that defines the total budget resources given to the system and which will be important for RED's government. This subsystem must also count with an executive committee that makes the day to day decisions, and a Programming committee that articulates the distinct nodes in the system into a unique Cultural program that is coherent, collective and quality oriented, but also allows a timely planning of finances, marketing, and communications for the system and each Stage/theater. This Government subsystem is in charge of leading and directing the ensemble of management subsystems. It gives the strategic direction through clear and executable policies, indispensable for good decision making.

Secondly, create the **Intelligence or Planning Subsystem**. This enables envisioning future trends of cultural and artistic supply, as well as monitoring cultural tendencies and modalities happening outside the Network system; by this we mean international, national and district environments. This subsystem must have the capacity of predicting how the cultural facilities should behave in the future, in order to satisfy new trends and evolving audiences.

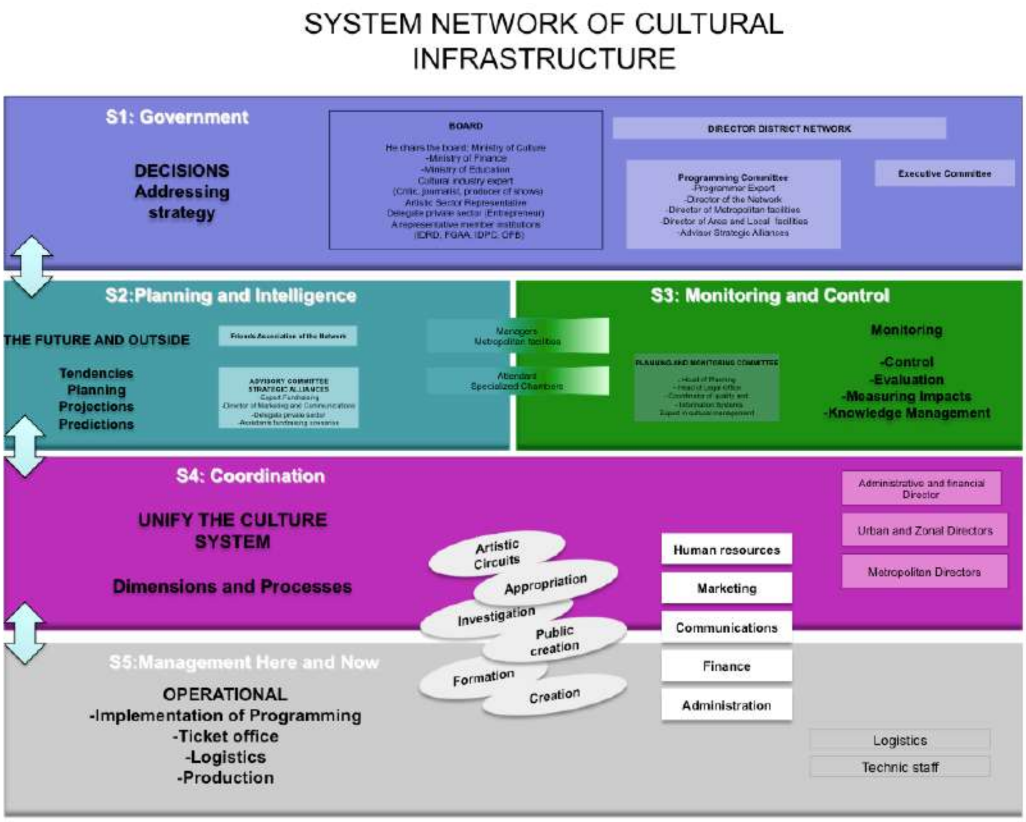
Thirdly, the creation of a **Control Subsystem** assures quality standards in the implementation of the system's cultural programming. For this to happen, it requires a monitoring system that allows permanent examination of indicators (processes, results and impact), and based on them generate permanent feedback on the decisions made.

Fourth: The **Coordination Subsystem** guarantees that each Stage performs according to the system's objectives and doesn't drift uncontrollably. This subsystem must act through the unification of the system's culture, so that all of the Theatre's members share the same values and objectives; this can be obtained via socialization and training initiatives. In equal measure, committees should be strengthened, as they enable teamwork between members of various cultural facilities. The most important committee is the Programming Committee that guarantees that activities between theaters/stages don't overlap, that resources and information are being shared, and that it knows beforehand the program and schedule of the whole system. There should also exist an Executive Committee that oversees logistics and operations of the overall system. Other coordination mechanisms are the "task force" that must be created temporarily to resolve non-permanent requirements such as organizing Festivals.

Fifth; the **"Here and now" Operation Subsystem** lets each Theater act autonomously and decentralizes them, but always keeping under common objectives and the guidelines provided by the Coordination Subsystem. Each Theater must act autonomously with its immediate environment. This means that the responsibility of articulating the network between private Stages/Theaters and the Mobility and Security subsystems lies on each particular Theater. Additionally, each Theater must be able to resolve independently central aspects of its operation such as: box office (ticket sales), subcontracting, rent issues and its own human resources, among others.

Next, we present a graph that illustrates each of the Subsystems that take part of the Network System (RED).

GRAPH 3 SYSTEMS



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GRAPH 4 SUBSYSTEM DEFINITIONS

SYSTEM	FUNCTION	RESPONSIBLES
Government Subsystem	It is responsible for leading and managing the full range of management subsystems. This provides the strategic management with reports of clear and enforceable policies for decision making.	Board of Directors, the Executive Committee and Programming Committee
Planning and Intelligence Subsystem	Is responsible for foreseeing future trends regarding cultural and artistic as well as to track trends and cultural patterns that occur outside the system, on the international, national and territorial within the District.	Committee of strategic alliances and partnership network friends.
Planning and Intelligence Subsystem	Is responsible for ensuring quality standards in the implementation of system programming. This requires the design and implementation of a monitoring system that allows for continuous monitoring of process indicators, outcomes and impacts and that they are based on continuous feedback to produce a decision making system	Planning and Monitoring Committee and its members, Head of Planning and its members.
Coordination Subsystem	Is responsible for coordinating the management of unifying culture system so that members of all facilities share the same values and objectives, which should be achieved through socialization and training sessions.	Metropolitan Scenarios Director, Director of Urban and Zonal scenarios
Operation Subsystem: Here and Now	Is responsible that allows each stage act with autonomy and decentralized manner while adhering to common objectives and guidelines subsystem coordination. Each scenario must act autonomously with its immediate surroundings.	General Staff

- **The need for financial sustainability**

To develop this work, a Financial Simulation Model[1] was designed based on the theory of Cost Centers. As first measure it was built a **base line** of available information (income and costs) of the following theaters: *Teatro Jorge Eliécer Gaitán* (TJEG), *Julio Mario Santodomingo* (JMSD), *la Media Torta* (MT), *Cinemateca* (CM), *Otto de Greiff* (OG), *Oriol Rangel* (OR) and the *Escenario Móvil* (EM). This exercise took into account information corresponding to results of 2010, which assumes that the majority of Stages/Theaters are financed with resources that come from the district's investment budget. This implied making certain assumptions and estimations in order to capture the real financial situation of these theaters.

Three **income** sources were identified for each theater: i) District Budget, ii) Renting, and iii) Box-office (ticket sales). Of these income sources the only fixed source of financing is the district's budget after its approval. Conversely, renting and the box-office (ticket office) are sources of variable income, as they depend directly on the demand from lessees and audiences attendance to the different productions and co-productions offered by district Theaters.

[1] Excel document "Financial Model", which contains instructions for the use of the financial model.

On the other hand, we identified **outflows** that are constituted by fixed and variables costs. Therefore, fixed costs are represented by: Operational costs, insurances, Theater contractors, maintenance, costs of inputs and communications. Variable costs are mainly composed by own productions: these represent one of the most important variables in the financial model. Therefore, they were established four scenarios in which different sorts of programs were exposed considering the existing three types (which were explained earlier):

- High-end Production Cost
- Medium-end Production Cost
- Low-end Production Cost
- Co-productions

Based on this information, scenarios were devised for the simulation model using the results from the baseline scenario. And so, they were proposed four new Theaters, were the numbers of 'own productions, co-productions, new income sources and the total amount of variables costs' vary depending on the generation of new resource acquisition mechanisms for district Stages/Theaters. These mechanisms could be: Sponsorship of co-productions and productions, donations, corporate social responsibility and international cooperation. These allow running the simulation with different possibilities and combinations that adjust to the sustainability needs of each particular art facility.

- **Modern marketing approaches for cultural development**

This strategy seeks for RED to generate communication and alternative marketing mechanisms, which are currently having a considerable impact for **beneficiaries, financers and "legitimizers" of the RED network**. Therefore, the activities will lever the management of the marketing and communications office (which aim is to create visibility and opinions in interactive media) are:

- Acquiring a digital culture and ecologic conscience.
- Use of metrics
- Obtaining indicators and evaluations from the metrics
- Alliances and agreements with digital communications media
- Decentralized productions of contents (two way communications)
- Continuous editorial production
- Cultural blogger network
- Inclusive workshops
- Network of cultural journalists

- **Vocation on Cultural Programming: an axis for developing a differentiated system**

To secure a diverse cultural supply of high impact and top quality, we suggested a strategic and planned programming. This should act in coordination and in a complementing way, so that it may institute a supply that holds all degrees of artistic possibilities and its diversity. For this to happen

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we identified the differentiating elements in the programs of each Theater: such as the vocation of the Theater, the kind of production, the focus of the offering and the specialization of audiences.

- **A diversified and qualified programming**

The activity fulfillment schemes used in the Stages/Theaters are classified depending on the use given to each Theater, which is related to the activity performed. The next chart describes different production categories of the RED networks.

GRAPH 5 PRODUCTION CATEGORIES OF THE NETWORK (RED)

Category	Type	Description
Own Production	Production	Own initiative, all costs of the event are for the Theater
	Co-production Type A	Own initiative, the costs of the event are shared with the co-producer
Co-production	Co-production Type B	Initiative by other organisms, the costs of the event are shared with the co-producer
Renting	TYPE A	Renting for an event of a third party at closed doors
	TYPE B	Renting to a third party for events of performance arts
	TYPE C	Renting for private events where there is stage visibility
Loan	Public entities	Inter-institutional Alliances

Program planning by Levels

The proposal is to construct an artistic programming committee, integrated with members of the RED network and experts, which bring an appropriate planning of the Programs that are related with the vocation of each of the Theaters involved. This committee, located at the highest levels of the network, has the main function of advising the Theater directors about the best programming for each theater and auditorium of the network. It is composed: by three arts advisors (music, theatre and dance), by the network (RED) Director, the Director of Metropolitan Theaters, the Director of Urban and Zonal Theaters, and the Advisor of Strategic Alliances. The committee will meet monthly, where it will study and validate or adjust the program proposals of each of the Theater Directors involved in the RED. This job requires rigorous planning associated with the budget forecasts and the policies for strategic alliances that will be implemented on each Theater. Those strategies should guarantee its financial sustainability. In the next chart, it’s a suggested summary of the Program Strategies for each Theater:

GRAPH 6 PROGRAM STRATEGIES

Levels	Specialization of programming	Specialization in public	Main dimensions
METROPOLITAN FACILITIES			
Theater: Jorge Eliecer Gaitán	Popular Performing Arts	General Public	Arts Circuits, Formation
Theater: La Media Torta	Colombian Culture	General Public	Arts Circuits, Formation
Theater: Ciudad Bolívar	Performing arts	General Public	Arts Circuits, Formation
Theater: Julio Mario Santo Domingo	Classic Performing Arts	General Specialized Public	Arts Circuits, Formation
URBAN FACILITIES			
Concert Hall: FGAA	Urban Music	Youth	Arts circuits, Formation
Theater: El Parque	Children's theater	Children	Creation, Formation
Concert Hall: Otto de Greiff	Academic Music	Specialized	Creation, Investigation
Dance house: Casona	Dance	Dance professionals	Creation, Investigation
ZONAL FACILITIES			
Mobil stage	Performing arts	Local	Arts circuits, Formation
Cultural Center Usme	Performing arts (Dance emphasis)	Local	Arts circuits, Formation

- **Organizational and logistic approaches**

It was proposed a redesign of the organizational structure for the RED Network: a divisional structure that focuses on grouped tasks, depending on the specific demand of products and services, markets and clients. In this regard, given that the citizens are offered an ensemble of associated services to a cultural offer (concerts, workshops, artistic spectacles), it’s very important to make a distribution by business units that are autonomous and efficient. These B.U.s will be called: “Cross Management Unit”, “Metropolitan Theaters Unit” and “Unit of Urban and Zonal Theaters”.

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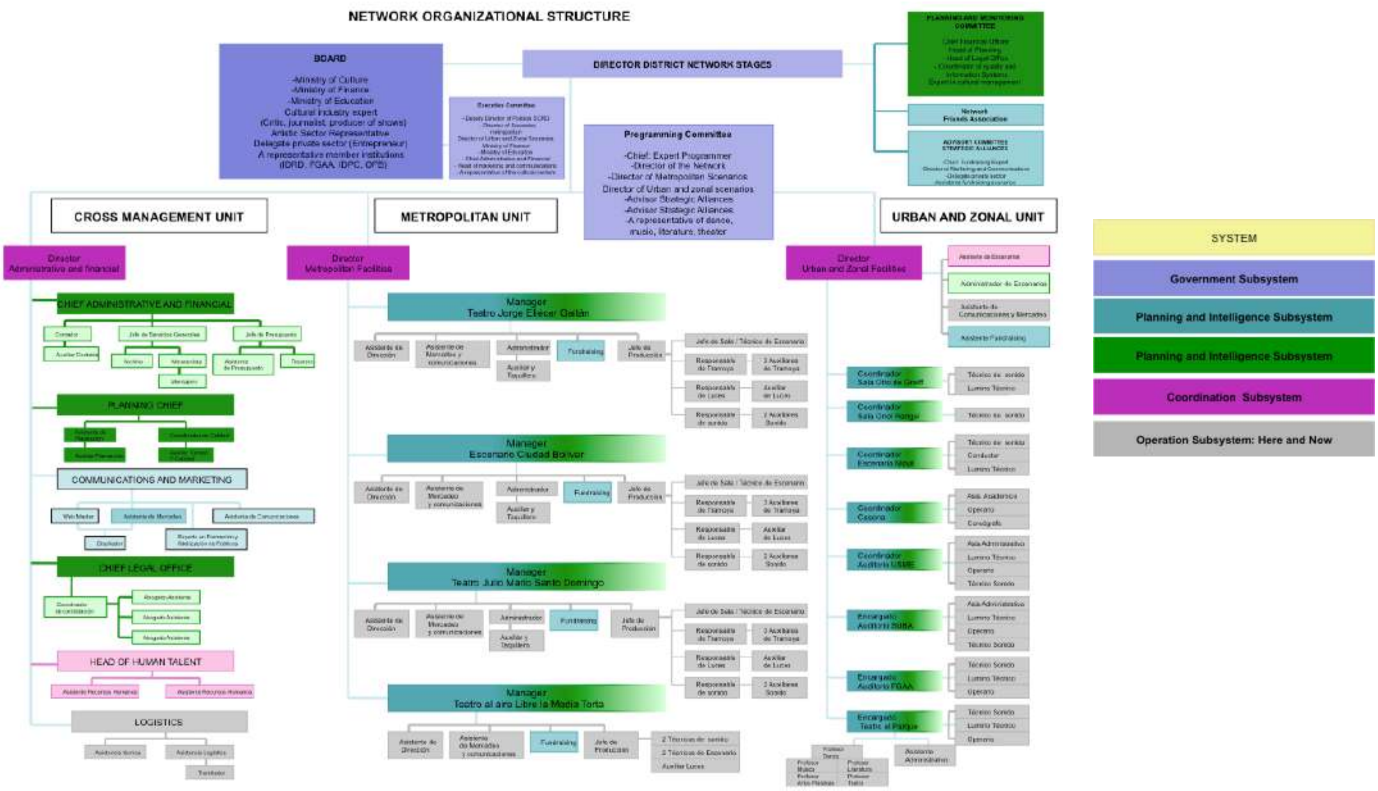
GRAPH 7 ORGANIZATIONAL STRUCTURE OF THE NETWORK SYSTEM



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5. The proposed model

- **Cultural Stakeholders management**

The main stakeholders are those who have direct influence and the secondary have more of an indirect influence over the planning of Stage/Theater activities.

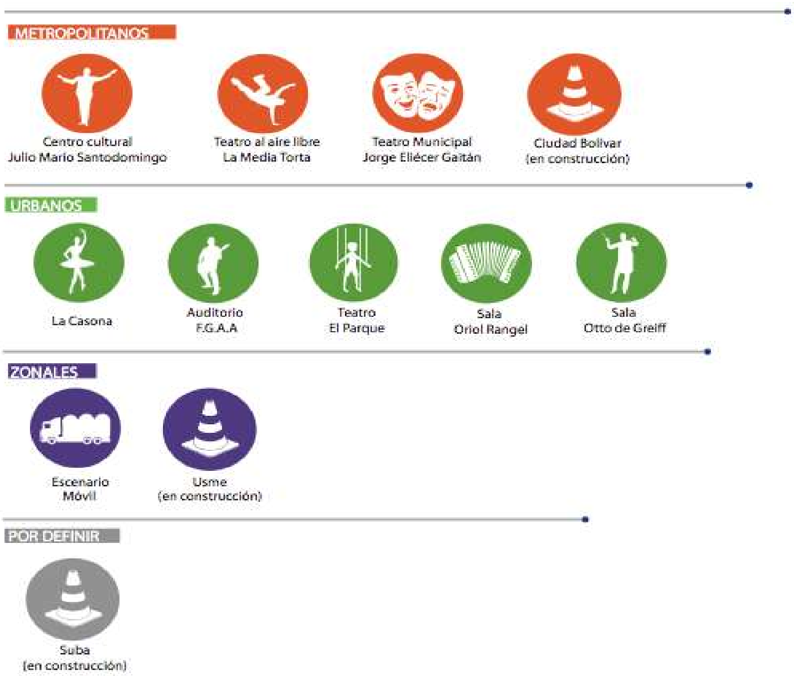
GRAPH 8 SYSTEM STAKEHOLDERS

MAIN STAKEHOLDERS		
	DESCRIPTION	EXAMPLE
Related entities	Public entities have a major impact on the theaters, concert halls, auditoriums etc. Influence from the standpoint of administrative, financial, control, collaboration and more. You use the facilities for institutional activities.	Department of Culture Recreation and Sports
		Department of Education
		Bogota Council
Assistant Public	Each theater has a faithful public and other temporary	Depends on the segmentation: demographic, for creation of public, economic etc
Regulators	Are the entities they audit and monitor the work of the theaters. Ensure compliance with the law.	DPAE
		Mayoralty
		The Police
		Comptroller
Staff	Employees of each of the theaters	Manager
		Lighting technician
		Sceneshifter
Suppliers	Companies or individuals that provide products and services to theaters	Stationery
		Logistics
		Catering
Cultural Managers	People driving the performing arts sector of the city	Entrepreneurs
Artists	Performers, poets, actors, dancers, composers, musicians and others.	Colectives
		Enterprises
		Associations

GRAPH 9 SECONDARY STAKEHOLDERS

SECONDARY STAKEHOLDERS		
	DESCRIPTION	EXAMPLE
Media	Allies with the media to schedule and promote cultural activities	TV Chanels
		Radio stations
		Newspapers
General public	Society in general is related to the theaters. They are public, neighbors, friends etc...	Citizens
Private sector and ONGS	Organizations that financially support the theaters or asking the loan facility for the development of their activities	Foundations
		Show business entrepreneurs
		Sponsors
Critics	People who give feedback and generate topic around the theaters and its cultural offer	Experts
		Artists
		Journalists
Universities and academia	Academic institutions that joint activities with the theaters	Universities
		Academies
		Schools

GRAPH 10 THEATERS ICONOGRAPHY[2]



[2] Image designed by Vladimir Enciso, Graphic Designer.

GRAPH 11 REPRESENTATIONS OF SOME STAKEHOLDERS AND THE THEATERS[3]

- **Public-private alliances**

Strategic alliances are essential for the Network's sustainability. For purposes of this study, some Guide material was created for alliance attainment. The most important aspect is the typology of strategic alliances (structured for the RED network) which revolves around these next parameters:

a) Intra-institutional Alliances: they reflect the alliances occurred between entities assigned to the Department of Culture, Recreation and Sports (*Secretaría de Cultura, Recreación y Deportes*).
b) Inter-institutional Alliances: alliances with public institutions on a national and/or district level.
c) Public-Private Alliances: alliances with private companies or the third sector (NGOs), based on commercial and philanthropic transactions.
d) International Cooperation.

[3] Ibid.

- **Audience creation and citizen involvement**

The main objective of Audience building strategies for the RED network is the expansion of audiences, which is translated in attracting clients and building loyalty. The activities to achieve such objective are based in three essential strategic focuses, illustrated in the following chart:

GRAPH 12 FOCUSES FOR AUDIENCE BUILDING

Axis	Objective	Strategy
Expansion	Quantitative increase attendance	Acquisition and retention
Deepening	Increase public involvement	Understanding and training
Diversification	Enlarge the social base of the public	Creation and generation of new public

The periodic studies of audiences enable audience segmentation due to the data obtained from each Theater's attendance. Such data, ranges from demographic, economic, social and cultural characteristics of the audiences, which are the main input when constructing strategies for communication, loyalty and audience creation.

GRAPH 13 TYPOLOGY OF AUDIENCE SEGMENTATION

Form of Organization	Organized public
	Free Public
Strength of the link	Loyal
	Usual
	Potential
	Captive
Frequency ratio	Recurrent
	Sporadic
	No Public
Knowledge of the field	Specialized
	General public
	Amateur
Related Activity	Print
	Netizens
	Visitors
	Viewers
Special public	Any disability
Age	Children
	Young
	Adult
	Seniors

- **Monitoring of public Management**

In order to guarantee the quality of the RED services, tools such as monitoring and accountability are essential. To achieve this, a Planning and Monitoring Committee was proposed. This committee will be part of the **Monitoring and Control Subsystem** responsible for supervising and following each of the activities of The Transversal Management Unit, the Metropolitan Theaters Unit and the Urban and Zonal Theaters Unit. The proposal is to implement an Integrated System of Management Measurement that possesses its own management system, which is based on a group of indicators, derived from the RED network and theaters' own strategic plans. This will ultimately permit a complete performance evaluation of the objectives and support any corrective decisions.

- **Information systems for a modern marketing of cultural services and management**

The marketing strategy seeks to exhibit the Theaters' labor in order to guarantee that the Cultural offering is recognized and enjoyed by all stakeholders. To achieve this objective, the following points were addressed:

1. Brand generation, starting from the RED Network.
2. Constant monitoring of tendencies.
3. Understand that the industry's stakeholders have diverse demographic characteristics.
4. Guarantee that the capitals received for the Theaters' cultural exercises will be executed as stated by each presented project.
5. Satisfy the needs of the community and promote dialogues
6. Understand the strategic alliances for each level.

TARGET MARKET

The marketing plan is focused on the training, research, creation, artistic circuits and appropriation of the activities of the performance arts, the immersion of audiences in these activities and acquiring resources. Hence, the main clients of the RED Network were identified: beneficiaries, financers and legitimizers.

- **Beneficiaries** are favored directly by the different projects developed around the theaters. Because of this, the attending audiences and the artists are the biggest groups that define this first target market of the RED Network.

- **Financers** are benefactors of whom it is expected to receive capitals (businesses, organizations, consulates, public entities among others) that contribute to lever the development of projects proposed by the RED, for a single Theater or a number of them.

- **Legitimizers** generate opinions about the performance of theaters by means of their experiences and perceptions, becoming references for beneficiaries and financers.

MARKETING MIX

Products / Services: The RED principal products are the Theaters/Stages that shape it. Simultaneously, these theaters offer services based on the performance arts cultural offering. It involves:

- Productions and Co-productions
- Educational activities and creation of citizen involvement projects
- Research programs
- Infrastructure that can be leased

Price: This study required the elaboration of a financial simulation model that could determine prices of tickets, leasing and box offices. The model takes into account the forecast for several Theaters, in order to determine different pricing possibilities that might be required to achieve financial equilibrium and long-term sustainability.

Communication and divulgation channels: Each of the target markets mentioned is given a strategy. In the case of the beneficiaries it's proposed an **intensive distribution** strategy, financers are given a **Selective distribution** strategy and **legitimizers** will follow the same strategy as the financers.

Promotion: During the making of the study, promotion was found to be significantly weak. It was proposed to develop a strategy that followed the following principles:

- Database creation
- Public Relations
- Networking with related companies
- Creation of Results reports for the projects and activities of RED
- Inter-institutional promotion
- Intra-institutional promotion
- Strategies for audience building
- Brand build-up

GRAPH 14 PROPOSED BRANDS[4]

[4] Image proposals for RED: Henry Osorio, titular professor of La Universidad de los Andes, Design Department, designs Images.

6. Limitations of the model

The proposed model assumes a change process that leads into a sustainable and articulated management. As well as there are forces that guide this change, there are others that oppose it: for example, at the organizational level we find heavy and rigid structures that are articulated, within bureaucratic decision schemes and limited human resources. There are also conflict and power issues between entities that slow up the networks cooperative job, and high uncertainty of financial resources due to it depending mainly of district's budget. The institutions are waiting for an annual budget to be defined only to execute it; but without strategy. The stages need to be the top of mind in terms of the budget distribution: the District Administration has the authority to reorient the cities' expenditure into cultural issues. But the closed governmental model of cultural management is not enough; today there are immense opportunities to become private sector allied.

They were identified differences in vision and orientation between the executing entities. Therefore it becomes very important to generate a common vision between the main players that will act as a Cultural System and a Network of Theaters; where the collective decisions prime over the individual. Hence, this study becomes an implementation challenge, which must procure to be done gradually and organically.

7. Future research

From the development of the study, there are established some questions that suppose some research and future analysis:

- How to coordinate the implementation of a sustainable systemic model that builds a Theater network for the arts performance?
- Is it worth enough to built cultural networks or arts circuits throughout Colombia using the proposed model?
- How can we generate alliances with international Theaters?
- How to make the city's cultural offering project itself as a touristic attraction for international audiences?
- What are the social, economic, environmental, cultural impacts of the sustainable networks built around Theaters of the arts performance in Bogota?
- Are music, dance and theatre, cornerstones for a competitive artistic programming?
- Are the city's cultural policies suitable to motivate a cultural progress? Or on the contrary, do they obstruct the evolution of the theaters?
- What are the strategies to develop Patronage and Fundraising in Colombia (a rising trend in the country)?

The proposed model arises between these and other questions. This work is merely a beginning that invites to reflect about the real potential of the cultural sector and the achievement of the declared mission and vision of RED.

8. Conclusion

The final outcome of this work sets an ensemble of recommendations that came out of the analysis and evaluation of the administrative and financial sustainable management of the cultural theaters related to arts performance in Bogota:

Stakeholders

- A tight relationship must be developed with the involved stakeholders, based on mutual support and cooperation. All this in order to build an integrated, sustainable cultural ecosystem in Bogota.

Programming and production Strategies

- The proper sustainable management of a theater depends mainly of the anticipated long-term planning of the program, since the financial, communication, marketing and logistic.
- Each theater must have its own identity and a programming that would enable it to differentiate form the rest of cultural offerings in the city.
- Even though self-production is the riskiest modality (financially speaking), it's important to promote it because the identity of the theater depends on it.
- Co-production is a modality of programming which is fairly profitable (financially speaking), because costs and risks are shared. This requires great level of planning, coordination and agreement between co-produces, that's why it demands a great quantity of teamwork.
- Leases are an important income source; these require specific planning and investment of human and operational resources. The leasing policy must be coherent with the artistic and social vocation of the Theater/stage.

Organizational Structure

- The RED network must have a division arranged in business units that guarantees autonomous planning and centralizing in the execution of projects.
- The key elements for the succeed Sustainable System: The articulation via subsystems, the organizational culture, the specialty and capacity of the attached personnel, the equilibrium between work satisfaction and hiring expenditures, and the elements for supervision and accountability.

Strategic Alliances

- Inter-institutional and intra-institutional alliances must strengthen for sustainability.
- The viability and financial sustainability of the network depend in great measure on these alliances of national and international cooperation.
- In the national context, cultural patronage is a very scarce endeavor; the management of these resources must become a challenge and a priority for the RED team.
- The strengthening and consolidation of a Friends Association for the Red Network is crucial for the administration of resources stemming from the private sector.

Strategy and Financial Model

- It is necessary for the RED to reduce the financial dependence on public resources.
- Diversification of the sources of income it's an imperative condition for the financial sustainability of RED, this includes potential income sources that haven't been really developed: box-office, leases, sponsorship, patronage and international cooperation.
- Financial Management in terms of Cost centers helps to identify clearly how income and expenditures are distributed in each theater.
- There's a need to create and keep a financial memory for each theater, and for the network as a whole.
- Constant monitoring of the theaters' market is critical for guaranteeing that prices are within a reasonable range, prices which the audience is willing to pay.

Marketing and communications

- The goals and formulated objectives for this plan, must agree with the mission of RED and each of theater vocations, in order to adopt coherent policies that enable good relationships with each of the target markets defined for RED (Beneficiaries, Financers and Legitimizers).
- Guarantee that actions taken will concord with the expectations of these markets.
- The development of digital and interactive communication is without doubt, one of the most interesting strategies defined, because in the future they will be constituted as the main communication tool for clients.
- It's necessary to adopt a cultural brand that generates the perception of unity network.

Monitoring and quality system

- The implementation of a monitoring and feedback system is the base to integrate measurement of: cultural programming, finances, communication, marketing, human resources, etc.
- It is vital for fulfill and exceed the network objectives to design relevant indicators with appropriate variables to measure sustainability.
- It's necessary to hold the Theater Directors responsible of their theaters' performance, as they must be held accountable for each aspect of their management.

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Sharing Water: Transboundary Water Governance and Management in Southern Africa

Wednesday, 14th June - 14:00 - SD 701 - Oral Paper

Prof. Larry Swatuk [1]

1. *University of Waterloo*

Water falls and flows, while states occupy fixed space: in Southern Africa, with its odd amalgam of colonially defined borders, this is a problem. The organization of the region's states stands at odds with the character of its water resource flows, both in space and in time. If people and ecosystems are to survive and thrive, this natural resource must be managed holistically, i.e. in terms of the hydrological cycle as that cycle changes through time. The historical approach to water management worldwide is the capturing and taming of a fugitive and wild resource – note the language of discipline and control. Where the resource is shared by two or more sovereign states, however, resource capture – physically through the application of various infrastructure and legally through the codification of actions in policy and law – is bound to be problematic: socially, politically, economically, environmentally and possibly militarily. For many years there has been speculation regarding the possibility of water wars in the region, with several basins having been identified to be 'at risk' of violent conflict. Hence the importance of sharing water fairly and sustainably.

The focus of this paper is on the process and practice of sharing the region's water by Southern African Development Community (SADC) member-states. The paper illustrates how Southern Africa serves as a mostly willing subject for global experiments in IWRM and good water governance. SADC's long-standing relationship with the EU and the Nordics, which began in the late 1970s in the struggle against apartheid, ensures an endless stream of money, technology, expertise and comradely good will. The nature of the region's political economy demands fundamental reforms in the way water is used and by whom. But, paradoxically, it is also this political economy which, in the context of neoliberal globalization, encourages decision makers to stay the course: more mines, more cash crops, less deliberate state intervention on behalf of those most in need. So, the 'institutional configurations and orientations' remain centred on the sovereign state, with state governors being the recognized seat of decision-taking authority, and with (often foreign) expert knowledge constituting the scientific and technical basis for action. We remain, unfortunately, a long way from the IWRM/good governance ideal.

Fostering political participation for better water services: evidence from three cities in India

Thursday, 15th June - 10:15 - SD 701 - Oral Paper

Mr. Francesco M. Gimelli [1], ***Dr. Briony C. Rogers*** [1], ***Dr. Joannette J. Bos*** [1]

1. *Monash University*

Evidence indicates that the delivery of urban water services in a manner that fosters secure lives among the marginalised is impacted by individuals' ability to meaningfully engage in political processes that govern water. In many cities in the Global South the marginalised are peripheral participants in the political process, either being used as vote-banks or lacking the confidence to engage in the political process. This reality leaves the lived needs and realities of the marginalised outside of decision-making processes, while reducing the transparency and accountability of water governance in the Global South. There is a need to understand how the capacity of political participation among the marginalised can be strengthened in a manner that leads to the delivery of water services that addresses their lived realities and meets their needs and aspirations. This paper draws on interviews with forty-two community members and water development professionals in Faridabad, Delhi and Mumbai, India, to explore their experiences with the political processes impacting on the delivery of water services to slum areas. It identifies five political barriers impeding the ability of individuals to access - and improve their access to – water services, and discusses how these can be addressed by explicitly incorporating a strategy of fostering political participation as a component of urban water development initiatives.

Liquidity Constraint, LPG Stoves and Charcoal Consumption: A Randomized Controlled Trial in Tanzania*

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April 12, 2017

Abstract

The high start-up cost of modern cooking appliances has been shown to be the key factor that hinders transition of households from biomass energy to clean energy in developing countries. We designed a randomised controlled trial to identify the impact of relaxing households' liquidity constraints on LPG stove adoption and charcoal use in urban Tanzania. In collaboration with a local micro-finance institution, we randomly assigned households into a subsidy treatment and a credit treatment and measure the impact on charcoal consumption both 4 months and 15 months after the stoves have been distributed. We show that, relative to households in the control group, adoption of LPG stoves reduced charcoal consumption by about 27% in the treated group 15 months after the intervention. However, providing subsidies for stove purchases resulted in a much larger reduction in charcoal use (32%) than did providing access to credit (24%). We highlight the importance of relaxing households' financial constraints and improving access to credit to encourage urban households to switch to clean energy sources and save the remaining forest resources of Africa.

JEL Classification: G21, G31, O10, O13, Q23, Q51.

Keywords: Charcoal, LPG Stoves, Deforestation, Liquidity Constraint, Credit

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1

1 Introduction

Charcoal is the main source of cooking energy for households in urban areas of many Sub-Saharan (SSA) countries (Campbell et al., 2007; Mercer et al., 2011). In the urban parts of Tanzania - the country on which we focus in this paper - the proportion of households that use charcoal to meet their main cooking needs increased from 47 percent in 2001 to 71 percent in 2007, and Dar es Salaam city alone consumes 500,000 tonnes of charcoal, half of the total annual charcoal consumption of the country (World Bank, 2009). On the other hand, many SSA countries - including Tanzania - have been experiencing economic growth which resulted in increased income and living standard in urban areas in the past decade (AfDB, 2014). The fact that charcoal consumption has been increasing with increasing income is contrary to the predictions of the "energy ladder theory", which has been the key theory in explaining energy transition in developing and emerging countries (Heltberg, 2005; Masera et al. 2000). This theory postulates that households consume biomass fuels such as fuelwood and charcoal at lower levels of income and switch to modern fuels such as kerosene, natural gas, and electricity as their income increases. In this paper, we use a novel randomised controlled trial (RCT) to shed light on the key factors that induce households in urban areas of Africa to shift from biomass fuel (charcoal) to modern fuel, Liquified Petrolium Gas (LPG).

Using biomass fuels such as charcoal has serious environmental, health, and climatic implications. The use of charcoal for cooking in urban areas and firewood in rural areas of SSA has been a prime cause of deforestation and forest degradation (Campbell et al., 2007; Brown and Bird, 2008; Mercer et al., 2011), clearly resulting in loss of irreplaceble biodiversity and degradation of local ecosystems (Allen and Barnes, 1985; Geist and Lambin, 2002; Hofstad et al., 2009; Köhlin et al., 2011). Biomass fuelwood use is also associated with indoor air pollution, which claims 3.3% of the global burden of disease, especially that of women and children and causes about 2 million premature deaths per year (WHO, 2009). Recent studies also documented that biomass fuel, often burned in inefficient cookstoves, contributes to climate change through its emission of harmful greenhouse gases, including black carbon and carbon dioxide (Sagar and Kartha, 2007; Kandlikar, et al. 2009; Grieshop et al., 2011).

Transition to cleaner fuels is conditional on adoption of appropriate cooking appliances, which can have significant financial implications for poor households, who will forgo consumption of other items to acquire them (Edward and Langpap, 2005; Lewis and Pattanayak, 2012). Using carefully executed randomised controlled trials, a few studies (Smith-Sivertsen, 2009; Miller and Mobarak, 2013; Hanna et al. 2016) have investigated the factors that promote adoption of improved biomass cookstoves and their impact on indoor air quality, health, and fuelwood consumption in rural areas of developing countries. These studies identify social networks, availability of continuous technical support, cultural factors, and good designs that meet households' expectations as important factors that promote the adoption and continued use of improved biomass cookstoves. The few existing studies focusing on adoption of modern (clean) cookstoves use observational data (e.g., Edward and Langpap, 2005; Alem et al. 2014) and point out the high start-up cost as the key factor that hinders households from switching to appliances that use clean energy, such as LPG stoves.

The key question is then whether helping urban households relax liquidity constraints can induce them switch to modern cookstoves, or whether dependence on charcoal for cooking is driven by cultural factors that cannot be altered by public policy in the short-run. In this paper, we provide the first rigorous evidence on the causal effects of relaxing households' liquidity constraints on adoption of high-cost cooking appliances (LPG stoves) and on charcoal consumption. In order to shed light on our hypothesis, we collaborated with Tanzania's largest micro-finance institution (WAT-SACCO) and randomly allocated households in Dar es Salaam, the largest city in the country, into a "purchase through subsidy" treatment and "purchase on credit" treatment, which constituted three types of credit schemes (payback daily, payback weekly and payback monthly) repayable in six months. To the best of our knowledge, this paper is the first to conduct a randomized controlled trial to understand the factors that drive switching to cleaner energy sources and the corresponding reduction in charcoal consumption.

We take advantage of our randomised design to estimate the impact of adoption of LPG stoves through subsidy and on credit schemes on charcoal consumption. In order to study the effects, we conduct comprehensive baseline, midline (four months after the stoves have been distributed), and at endline (15 months after the stoves have been distributed). Our results indicate that LPG stove adoption overall resulted in a significant reduction in total charcoal use by the treatment group. Specifically, intent to treat (ITT) estimates indicate that households in treated communities consumed 31.8 percent less charcoal compared to the control group four months after the program was rolled out, and 27.4 percent less charcoal 15 months later. This amounted to a reduction in charcoal consumption from about 19 kg/week at the baseline to about 16 kg/week during the midline follow-up and 15.8 kg/week during the endline follow-up. We find much larger (34.5% and 31.5%) reductions in charcoal consumption during the midline and endline follow-ups respectively by households who adopted LPG stoves through subsidy compared to those who acquired them through credit (29.1% and 23.6% reductions at midline and endline follow-ups respectively).

Africa's tropical forests have significant carbon sequestration capacity but are at greater risk than those in other parts of the world, disappearing three times faster than the world average (Mercer et al. 2011).[1] Our findings have significant implications for policies that aim at promoting transition of households to cleaner energy sources, and saving the remaining forest resources of the continent. Although LPG is fossil fuel, it is much more efficient and emits way less CO2 and zero black carbon compared to charcoal.[2] Consequently, LPG can play a significant role in energy transition in developing countries. Given that reducing the startup cost of LGP stoves has significant impact on their adoption and consequently on charcoal use, governments, international donor agencies and other stakeholders should consider channeling resources to improve affordability of LPG stoves to the poor.

The rest of the paper is structured as follows. The next section describes the study area, experimental set-up, and timeline. Section 3 presents descriptive statistics of key variables for both the treatment and control groups. Section 4 presents experimental results on the impact of LPG

[1] The study by Mercer et al. (2011) actually documents that 30 million ha of Africa's forest, an area equivalent to the size of Finland, was deforested during 2000-2010, 80% of the harvested wood was burned to meet cooking energy needs.

[2] IPCC (2006) assigned a global warming potential (GWP) factor zero to LPG, i.e., it is not a greenhouse gas.

stove adoption on charcoal consumption, the key outcome variable of interest. Finally, section 5 concludes the paper.

2 Experimental Design

2.1 Study Area

Our study was conducted in Kinondoni and Temeke, two of the three districts of Dar es Salaam, the largest city of Tanzania. These two districts are located at the two extreme ends of the city, separated in between by Ilala, a third district. Ilala, which we used for the pilot, is the smallest district both in terms of geographical size and population.[3] Dar es Salaam is the most populous region in Tanzania (with nearly 5 million people) and over 70% of its population uses charcoal as their main source of cooking fuel (NBS, 2012). The heavy reliance on charcoal is evident from the open charcoal markets spread throughout the city. Approximately 1 million tonnes of charcoal is consumed for cooking in Tanzania annually and Dar es Salaam alone consumes half of this amount (World Bank, 2009).

Tanzania has recently discovered huge reserves of natural gas, which is expected to play a significant role in the country's economy by transforming the energy sector and boosting the gross domestic product.[4] Since 2010, several offshore natural gas discoveries have been made by the BG Group in partnership with Ophir Energy, and Statoil in partnership with Exxon Mobil, reaching around 30 trillion cubic feet of recoverable natural gas reserve. With more discoveries envisaged, a pipeline has been constructed to transport natural gas from Mnazi Bay (the central point of discovery) to Dar es Salaam. These discoveries are expected to significantly reduce the cost of gas and electric energy and create the incentive for households to switch away from charcoal to meet cooking energy needs. However, this transition could be significantly constrained by the relatively high startup cost of modern cooking appliances, especially for poor households. Findings from the baseline survey, which we present in the next sections support this skepticism. Almost all households we surveyed (99 percent) stated a high level of awareness about LPG stoves and their benefits but felt constrained not to adopt, mainly because of the high initial cost.[5]

Our study is conducted at an important time to provide useful and policy relevant evidence on the constraints that households face in adopting modern cookstoves and switching away from charcoal, as well as the roles public policy can play in tackling these constraints.. Given the similarities of many Sub-Saharan African countries with Tanzania in terms of access to energy, the findings from this study will also have significant relevance to other African countries.

[3] See figure A1 in the appendix for map of Dar es Salaam.

[4] http://allafrica.com/stories/201504030134.html.

[5] Currently, less than 4 percent of households in urban Tanzania own modern cooking stoves such as electric or gas stoves (NBS 2012).

2.2 Sample Selection and Design

In order to conduct our experiment, we chose two wards from each of Temeke and Ilala districts, from a total of 34 and 30 wards respectively. We chose Sandali and Azimio wards from Temeke district, and Manzese and Mwananyamala wards from Kinondoni. The selected wards are the residences of a majority of the low income urban households in Dar es Salaam and share similar socioeconomic characteristics but are located at a distance from each other. The wards benefited reasonably equally from the Community Infrastructure Upgrading Program (CIUP) implemented by the Dar es Salaam city council between 2005-2010. The program involved improving the quality of roads, footpaths, drainage, sanitation, solid waste, street lighting, public toilets and drinking water (URT, 2004; URT, 2010).

We approached ward secretaries - government officials responsible for administrating wards under districts - to provide us with the list of all sub-wards, the lowest administrative units in urban areas (also known as streets), ranked by the average economic status of resident households. We then selected the top four streets by their rankings in terms of economic status from each ward to participate in our study, which gave us a total of 16 streets. The key argument for selecting households this way is the fact that re-filling LPG gas once the startup gas runs out requires a bulk purchase (as opposed to low cost daily purchase for charcoal, which is common in the city) and thus the targeted population should be able to afford such costs. Finally, we asked the 16 sub-ward leaders to prepare a roster of eligible households in their streets, from which we randomly selected a total of 722 households to participate in the baseline survey. Eligibility criteria required that the selected households never owned/used an LPG stove and used charcoal (but not kerosene) as their main source of cooking energy.[6]

In order to minimise contamination (spill-over effects from treatment groups to the control group), we assigned treatments at street (sub-ward) level. The sampled streets are scattered across the districts and are reasonably large by geographical size and demographics, with an average of about 3000 households in each sampled street. Street-level randomization also makes implementation of the program relatively easier as it seems fair from households' point of view, and is politically acceptable to the ward leaders. It is therefore important to note that our randomization is done at street-level but the outcome variables of interest are measured at household-level.

We are interested in answering three key research questions: first, we want to identify the impact of LPG stoves (regardless of their mode of acquisition) on charcoal consumption, the key outcome variable of interest; second, we are interested in exploring whether the impact on charcoal consumption is different depending on the mode of acquisition (subsidy or credit); and third, we want to assess the degree of stove use and satisfaction with the stoves by households under the two treatments. We thus randomly assigned five streets into the credit treatment, four streets into the subsidy treatment and kept the remaining 8 streets as the control group. As a result, 216 households were potentially assigned to the credit treatment, 209 to the subsidy treatment and 299 to the control group.

[6]The proportion of households that use kerosene gas in Dar es Salaam is only about 7.8% (NBS 2012).

2.3 Timeline and Implementation

We obtained a research permit for this project from the office of Dar es Salaam Regional and Districts Administrative Secretaries, and implemented a fact-finding survey of 40 urban households during October-November 2014. The aim of this survey was to document both qualitative and quantitative background information about knowledge, adoption and usage (and non-usage) of both LPG and charcoal stoves in all districts, important information that we later use to design our interventions. We designed a short questionnaire and conducted a few focus group discussion sessions that allowed us to obtain informative responses. At this stage, we also included a set of questions on households' maximum willingness to pay for an LPG stove package and whether they would like to have the stove package on subsidy or on credit and pay for it bit by bit over a certain period. We found encouraging responses from households regarding knowledge and willingness to adopt LPG stoves, either on credit or through subsidy programs. We also found that high start-up cost seemed to be the main factor that hindered households from acquiring the stove.

We conducted a comprehensive baseline survey during March-April 2015, covering all 722 sampled households in the 16 sub-wards. In the baseline we included questions on demographic and other socioeconomic characteristics, cooking habits, stove use, and awareness and willingness to pay for LPG stoves. This was important information given that the cost of acquiring the stove package is reasonably high and it is natural that some households may not be willing to buy it either on credit or through a subsidy. In addition to household-level information, we collected community-level information such as distance to the nearest charcoal market, access to roads, etc.

In early May 2015, we conducted a pre-intervention survey to check whether the households who were assigned to the treatment group were willing to buy the LPG stove. During this time, we informed the treatment group that their household was one of the households randomly selected to receive an LPG stove through a subsidy or credit and that the stoves were planned to be delivered approximately 1-2 weeks after the pre-intervention survey. The households were then asked whether they would like to be a part of the program. Only 296 households of the 425 households who were randomly chosen to participate in the program agreed to purchase the stoves, and the remaining 129 households (30%) declined to participate. We later check whether such refusals to uptake the stoves are likely to bias our sample.

We implemented the LPG stove program in collaboration with a Saving and Credit Cooperative (SACCO) named "Women Advancement Trust" (WAT) which helped us with handling the delivery of the stoves and collection of repayment instalments for the credit treatment households. WAT-SACCO is one of the fast-growing saving and credit cooperatives that are working to provide access to micro-finance for the urban poor. So far, WAT has gained a good reputation and credibility in disbursement and handling of different types of loans, including micro-credit to finance the purchase of home appliances.[7] In order to make the loan credible and minimize the default rate, we followed all procedures for getting such loans as per the rules of the SACCO , but with a few modifications to suit to the objectives of this study. For example, we did not require households to present any physical asset other than the stove itself as collateral. In addition, all credit treatment households

[7] See "http://watsaccos.co.tz" for more information about WAT-SACCO.

were required to pay TZS 20,000 (i.e., 10% of total loan) upfront as their initial re-payment on the day of stove delivery. In addition, they were required to provide a letter of guarantee from their local government offices, which in Tanzanian context is credible.

The intervention was implemented in late May 2015. All households selected for the treatments were invited for training before they were handed the LPG stove in its full package. The training included instructions on how to safely use, clean, maintain and re-fill the LPG stoves once the startup gas runs out.[8] Households under the credit treatment were provided extra instructions regarding their specific credit scheme, including how to fill in the application forms, the required documents, how the payments will be collected, etc. All participants were allowed to ask as many questions as they wished and answers were given by the survey team. To minimize associated transaction costs and inconvenience, we required households receiving the stoves on credit to transfer the repayment instalments to a given mobile phone account managed by WAT using their mobile phone banking system. The transfers were set to be done during the working hours of either each working day of the week, every Monday or every 30th day of the month, depending on the treatment type. The complete loan repayment period was set to be six months after delivery of the stove, with repayment rates of either TZS 33,350 per month, TZS 8,350 per week or TZS 1,200 per day, depending on the treatment type. We did not charge any interest on the loans but required beneficiary households to cover minor transaction fees charged by mobile phone companies during loan repayment.

We then conducted a midline follow-up survey at the end of September 2015 - approximately four months after the stoves were distributed - to collect information on key outcome variables of interest, including charcoal consumption, LPG stove use, compliance with treatment, and satisfaction with the stoves.[9]

Finally, in order to assess the longer term impact of our interventions, we conducted a comprehensive end-line follow up survey during July-August, 2016, i.e., 15 months after the interventions. We documented detailed information on household and community characteristics, cookstove use, energy use and consumption, cooking habits, and LPG stove use and satisfaction.

3 Descriptive Stats, Randomization Checks and Attrition

Table 1 presents descriptive statistics of key household socioeconomic characteristics, cooking pattern, charcoal use and stated demand for LPG stoves at the baseline. Panel A shows that the average age of the household head is 48 years, the majority of whom (67%) are male, and the average education is 7.1 years of schooling, which is slightly higher than the standard primary school level in Tanzania (7 years). About half of the sample households live in privately owned households, but only 41% have access to a separate private kitchen, the remainder either cooking in their corri-

[8] See figure A2 in the appendix for pictures taken during training and home visits.

[9] We initially planned to conduct the mid-line survey six months after the stoves were distributed. However, the 2015 Tanzania National Election was scheduled in October 2015. In order to avoid interferences in our survey due to election related activities, we instead decided to conduct the mid-line survey in September 2015, four months after intervention.

dors or sharing a kitchen with other households. Consistent with our expectation, the majority of our sample households are low-income urban dwellers with average reported mean annual income of TZS 309,000 (about USD 172).[10] We notice, however that the reported average daily expenditure on basic consumption items is TZS 9,600, which on annual basis is nearly eleven times larger than the reported income. This overwhelming difference provides additional evidence that, compared to consumption expenditure, income in developing countries is significantly underreported (Deaton, 1997; Deaton and Grosh, 2000). In our subsequent analysis, we rely on consumption expenditure to capture economic status of households.

Table 1 about here

There is a large dependence on charcoal to meet cooking energy needs by households in urban Tanzania (Panel B). The average household cooked using charcoal for about 24 years and consumes 18.7 kg of charcoal per week, which costs about 11,000 TZS. We use insights from a recent study to shed light on the devastating consequences of charcoal use in Tanzania. Luoga et al, (2000) show that it requires one hectare of the Miombo woodland forest of Tanzania to produce approximately 3 tonnes of charcoal. Using rough computation, it is easy to show that our sample of households deplete an equivalent of 0.6 ha of forest every week. When it comes to the intra-household decision on the choice of cook stoves, only 47 percent reported that the head is the main decision maker about the type of stoves to be used by the household. This suggests that on average spouses (wives) have fairly strong intra-household bargaining power when it comes to acquisition of kitchen appliances. The type of meals cooked by the household could influence the amount and type of fuel used due to the cooking time and taste of food. During the fact finding survey, a few respondents argued that, while rice tastes better when cooked on a charcoal stove, it takes significantly longer to boil beans (the main ingredient for the complementary sauce) on the stove. Our baseline data suggests that nearly half of the sample cook rice and beans very often, with about 19 meals cooked per week.

Low adoption of LPG stoves in Dar es Salaam seems to be mainly driven by liquidity constraints. Panel C of Table 1 reports that 99 percent of the sample households knew about LPG stoves and 80 percent know someone within their close network who uses the stove.. However, 93 percent of the the sample households reported the high startup cost of the stove package as the main constraint to their adoption. Difference in taste of food cooked using LPG stoves does not seem to be an important reason for not owning LPG stoves for almost the entire sample. Only 2 percent reported it as the main reason for not owning an LPG stove. This could be partly because none of the households in our sample used an LPG stove previously so they did not experience the taste of food cooked using the stove. This number may change during the endline survey when households are asked the same question after they had experienced cooking using the LPG stove. When asked if they wish to have an LPG stove in the future, in case their economic status improves, a staggering 96% of our sample households replied “yes” but their current average willingness to pay for the stove package is only TZS 63,420, which is much lower than the market price (200,000 TZS) of the stove package in Dar es Salaam.

[10] At the time of the baseline survey, 1 USD = 1800 TZS.

8

Randomisation of treatment should insure that on average treatment and control groups have similar baseline characteristics. In order to check this, in Table 2, we present means of several key characteristics of households in both groups, as well as test results for the null hypothesis that the difference in means is statistically significantly not different from zero. For nearly all the variables presented, the difference in means is not statistically different from zero. The sole exception is that there is a statistically significant difference in the means of the variable “owning a saving account” between the credit treatment and the control group. Although this is unfortunate, we don’t think it will bias our results because the proportion of households who own a saving account in the control group is about 9 percentage points higher than in the credit treatment group.

Table 2 about here

In order to investigate whether the decision by some of the treatment households not to buy the LPG stoves resulted in a systematic difference between the treatment and control groups, we performed a simple mean comparison test for all relevant baseline characteristics. Results reported in Table 3 indicate that none of the baseline variables seem to be statistically different between the treatment and control groups. Consequently, the decision not to buy by some of the potential treatment group households is less likely to create bias in our sample.

Table 3 about here

During the midline survey conducted about 4 months after the intervention, the proportion of households we could not track was only 3%. However, the proportion increased to about 27% during the endline survey which was conducted 15 months after the intervention. It is common to encounter a larger rate of attrition in urban areas than in rural areas of developing countries (Bandiera et al. 2015, Friedman et al. 2011, Duflo et al. 2014). As shown in Table 1, about half of our sample of households reside in rented residential places. By the time of the endline survey, a number of households had moved to rented apartments in other parts of the city. While the survey team managed to track some of those who moved to new locations using their cell phone numbers, others could not be traced and thus we could not document endline information for these households.

In order to check if attrition in our sample has been systematic, we run a probit regression for the correlates of attrition and report the results in Table 4. The dependent variable is a dummy equal to one if the household attrits by endline. Column 1 controls for being treated (LPG aquisition either on credit or through subsidy). Column 2 differentiates the correlates of attrition by the type of intervention. Column 3 controls for other socio-economic characteristics in addition to the type of treatment. Results in all columns suggest that none of our interventions are statistically significant in predicting attrition. Column 3 however shows households living in own residential property are less likely to attrit and the correlation is statistically significant at the one percent level. This is consistent with our actual observation during the endline survey. We also note that households with educated heads are less likely to attrit. In the results section, we compute treatment effects, which control for the possible impacts of attrition.

Table 4 about here

4 Results

4.1 Specification

Given the randomised nature of our design, we can identify the impact of adoption of LPG stoves on charcoal consumption from the single mean differences between treatment and control groups in an OLS regression. As participation in our interventions (both credit and subsidy) are voluntary, not all households who have been assigned to the interventions take-up the offer. Consequently, we focus on intent-to-treat (ITT) impacts. Given random assignment of sub-wards to treatment, we can estimate the ITT impact of the LPG credit and subsidy programs using the following OLS specifications.

$$y_{ijt} = \alpha + \gamma treat_j + \beta X_{ij0} + \varepsilon_{ijt} \tag{1}$$

and

$$y_{ijt} = \alpha + \eta credit_j + \theta subsidy_j + \beta X_{ij0} + \varepsilon_{ijt} \tag{2}$$

where y_{ijt} is our key outcome variable of interest, charcoal consumption by household i in sub-ward j at 4 months follow-up ($t = 1$) and 15 months follow-up ($t = 2$), *treat* is a binary indicator for either credit or subsidy treatment, *credit* and *subsidy* refer to binary indicators of treatment type, X_{ij0} are control variables at the baseline, ε_{ijt} is a random error term that we allow to be clustered by sub-ward j, and γ, η and θ are the coefficients of interest, measuring the ITT impact of our credit and subsidy interventions.

In order to minimise measurement error in the outcome variable of interest during all the three surveys, households were asked to keep a record of the quantity of charcoal used during the most recent week in the local units. We visited four charcoal markets in each ward and constructed average conversion factors to standard units by measuring each available local unit using a digital scale. We then converted all local units reported by households into standard units using these conversion factors.

4.2 Charcoal Consumption

We begin with results from the simple mean comparison of weekly charcoal consumption between the treatment and control groups during the baseline, mid-line (4 months after the interventions) and endline (15 months after the interventions), as reported in Table 5. Panel A presents the results for the quantity of charcoal consumed. While the treatment and control groups reported similar amounts of charcoal consumption per week during the baseline (18.9 kg and 19.78 kg respectively), treated households consumed 3.85 kg less in a week compared to the control households during the midline follow-up survey, and 3.79 kg less in a week during the endline follow-up survey. Both these effects translate into a large reduction in charcoal use which is statistically significant at the one percent level. In panel B, we present the monetary value of the reduction in charcoal due to adoption of LPG stoves. The results reveal that compared to the control group, adoption of

LPG stoves reduced the amount of weekly charcoal expenditure for the treatment group by about 2,900TZS (USD 1.61) at midline follow-up and to about 2,300 TZS (USD 1.28) at the endline follow-up.

Table 5 about here

Table 6 provides formal empirical estimation of intent to treat (ITT) from an OLS model. Column (1) presents the results for the impact of adoption of LPG, regardless of the treatment type at the midline. In columns (2) and (3), we extend the analysis by controlling for the type of treatment (subsidy and credit), and for controls. This is very important from a public policy point of view given the ongoing debate about the idea that people tend to value and use goods less when they receive them at a lower price (e.g., Hoffman et al, 2008; Hoffman, 2009; Cohen & Dupas, 2010). Consistent with the observation in the mean comparison presented in the previous table, column 1 of Table 6 suggests that compared to the treatment group, LPG adoption reduced charcoal consumption by about 31.8 percent per week four months after the interventions. When we assess the impact by the treatment type, results in column 2 suggest a relatively larger impact (34.5 percent) for the stoves adopted through a subsidy compared to the control group than those purchased on credit (29.1 percent). The results remain robust even after controlling for other covariates (column 3).

Table 6 about here

In columns (4) - (6), we investigate the impact of adoption of LPG stoves at endline - 15 months after the stoves have been distributed. This is important given the recent finding that after stoves have been adopted, households might not continue using them for several reasons (Hanna et al. 2016). Results remain quite robust 15 months after the intervention. On average, LPG adoption reduced charcoal consumption by 27.4 percent (column 4), acquiring the stoves through subsidy resulted in 31.5 percent reduction in charcoal use, and acquiring them on credit led to a 23.6 percent reduction in charcoal use column (5). Controlling for household characteristics in column (6) reduces the treatment effects slightly, but the effects remain robust.

Both at the midline and at the endline follow-ups, we document difference in the impact of LPG stoves on charcoal consumption between the credit and subsidy treatments, which we believe can be explained by several factors. The main reason for such a difference at the midline could be the fact that we conducted our midline followup survey four months after the interventions and before households who bought the stoves on credit have paid back the full amount of the LPG loan. It is therefore plausible to expect that the credit households are still hesitant to use the stove relative to those who received the stoves through a subsidy and who actually have full ownership. This could be more pronounced by the fact that the stoves themselves are collateral for the credit. In addition, it is plausible to expect that households in the credit treatment had to pay the full cost of the stoves, while those in the subsidy treatment acquired them at a much lower subsidized price. Consequently, subsidy households might have refilled gas more frequently and reduced charcoal consumption. However, the difference seems to have persisted even at the endline follow-up, i.e., 15 months after the stoves have been distributed.

4.3 Satisfaction with LPG Stoves

In addition to identifying the impact of LPG stove adoption on charcoal use, it would be interesting to investigate how often adopter households use the stoves and whether the intensity of use differs across treatments. One could anticipate that provision of LPG stoves would encourage households to switch from charcoal to LPG. However, existing empirical evidence (e.g., Masera et al. 2000; Heltberg, 2005) suggests that households may continue to use the charcoal stove in combination with the LPG stove, a phenomenon known as "fuel stacking". During the midline follow-up survey, almost 25 percent of the treated households (i.e., 74 households) reported not to have used the LPG stove over the past one week. Table A3 in the Appendix shows the distribution of reasons for not using the LPG stoves during the midline survey among those who received the stoves.

In Table 7, we explore if stove use and intensity are correlated with the type of treatment assigned to households both at the midline and endline. Midline results reported in column [1] suggest that the number of times the stove is put to use is not correlated with the treatment category in a statistically significant manner. These results are robust to controlling for other covariates. However, results show that incomplete knowledge on how to operate an LPG gas stove and gas run out are negatively correlated with stove use. This is expected given the fact that the treated households only had about four months of experience in using the stoves by the time of the midline follow-up survey. Fifteen months after the intervention, i.e., during the endline, however, incomplete knowledge on LPG stove use is not correlated with stove use any more. This most likely suggests the presence of learning-by-doing in stove use. During the endline, we observe that gas run out remained to be an important variable in explaining stove use. But we also find education (years of schooling) to be positively correlated with the intensity of LPG stove use. Results in column [4] also suggest that household size is weakly positively correlated with intensity of LPG stove use, while the number of years a household used charcoal for cooking is weakly negatively correlated with LPG stove use.

Table 7 about here

We finally explore the extent to which households who received LPG stoves are satisfied with the different attributes. Figure 1 shows the distribution of responses to the satisfaction questions. Results suggest that the majority of households are satisfied with all features of the stove, including stove quality (80 percent), stove functioning (79 percent), gas cost (77 percent), food taste (73 percent) and cooking convenience (80 percent). These results indicate that the type of LPG stoves we distributed have a high acceptance rate by the sample of treated households in urban Tanzania.

Figure 1 about here

In order to explore the correlates of reported levels of satisfaction with the different attributes of LPG stoves, we run simple OLS models of satisfaction and report the regression results in Table 8. Two variables appear to be consistently important correlates of satisfaction with LPG stoves. These are household size and years of schooling. Households headed by educated individuals tend to be satisfied with all aspects of the LPG stoves. Larger households tend to be satisfied with all aspect of the stove except with functioning. We do not, however, find any evidence suggesting satisfaction with stove attributes is correlated with the type of treatment, as indicated by the coefficient of the credit treatment variable, which is statistically insignificant.

Table 8 about here

5 Conclusions

Charcoal, largely consumed by households in urban areas, has been documented to be one of the main causes of deforestation and forest degradation in Africa. Forest clearing for charcoal production results in loss of invaluable biodiversity and destruction of local ecosystems. One important factor that hinders transition of households from biomass energy to clean energy sources is the high start-up cost of modern cooking appliances. In order to test this hypothesis, we collaborated with one of Tanzania's largest micro-finance institutions, WAT-SACOS, and implemented an LPG gas stove program in a randomised controlled trial setup. The program involved provision of a durable and high-quality two-burner LPG stove package through a subsidy and on credit, which included different repayment arrangements. To the best of our knowledge, this is the first study to provide rigorous evidence on the causal effects of relaxing households' financial constraints on on adoption of modern cooking appliances that have a high-start up cost and the corresponding impact on charcoal consumption..

The LPG stoves we offered had a high uptake rate by urban households in Tanzania, with 70 percent adoption by those who were randomly assigned to the treatments. Our results indicate that, overall, adoption of LPG stoves reduced charcoal consumption by about 27.4 percent per week compared to the control group 15 months after the stoves have been distributed. When we assess the impact by the treatment type, estimates suggest that, compared to the control group, those who adopted the stoves through a subsidised price reduced charcoal consumption by 31.5 percent while those who adopted the stoves on credit reduced charcoal consumption by 23.6 percent. These results are robust to controlling for other household covariates. This finding is consistent with the reported use frequency by households, with those who obtained the stoves through subsidy using them more often than those who obtained them on credit. The difference in stove use and impact on charcoal consumption during the midline survey was most likely driven by the fact that the survey took place a couple of months before the full credit amount had been paid out by households, who probably did not feel complete ownership of the LPG stoves. Interestingly however, the difference remained significant between the two groups during the endline survey which took place 15 months after the stoves have been distributed.

Millions of hectares of Africa's forests are destroyed for production of charcoal and firewood each year. Given the documented high carbon sequestration potential of Tanzania's forests, targeting reduction of charcoal production is likely to provide substantial external benefits to society at large. The findings from our study provide useful insights on how to reduce charcoal consumption in urban areas of Africa. Both the descriptive statistics and results from our randomised controlled trial demonstrate that the high start-up cost of modern cooking appliances such as LPG stoves is the main factor that prohibits households from switching to modern and relatively environmentally-friendly energy. In view of this, simple policy interventions such as reducing the import duty on LPG stoves could increase adoption and use of LPG stoves and consequently reduce charcoal consumption. This is the main message of our study, which could be useful to policymakers, donors, and other stakeholders who are interested in saving the remaining forest resources of Africa.

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Figure 1: Satisfaction with different features of LPG stoves

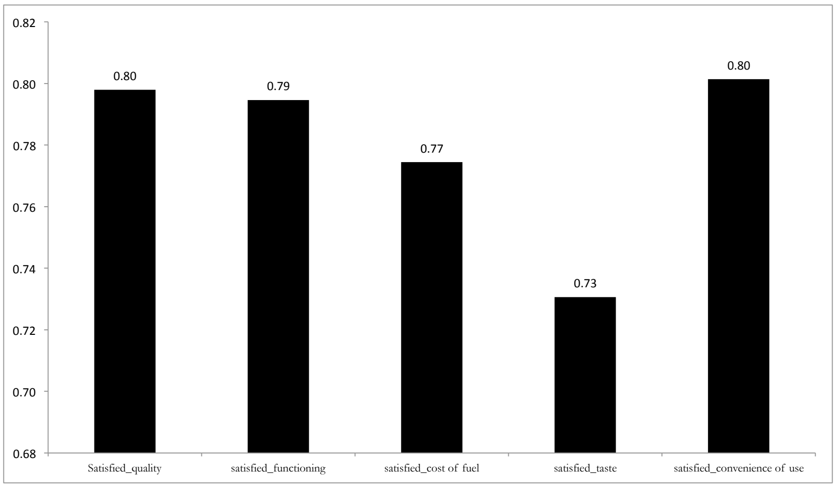

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Table 1: Descriptive Statistics at Baseline

	Mean	SD
PanelA: Socioeconomic Characteristics		
Age	48,004	13,351
Male	0,670	0,470
Household size	5,768	2,222
Annual income (TZS)	309931,000	256702,700
Years of schooling	7,165	3,076
Muslim (dummy, 1= yes)	0,793	0,405
Has access to main grid electricity in the house (dummy, 1= yes)	0,750	0,433
Average household daily expenditure	9661,586	18043,120
Access to separate kitchen room (dummy, 1= yes)	0,406	0,491
Residential house is privately owned (dummy, 1= yes)	0,505	0,500
At least one member owns a saving account (dummy, 1= yes)	0,373	0,484
Panel B: Cooking Pattern and Charcoal Use		
Number of years using charcoal stove	23,748	11,662
Head decides on acquisition of stove (dummy, 1= yes)	0,469	0,499
Distance to nearest charcoal market (in minutes)	4,349	4,224
Number of meals cooked last week	18,885	3,560
Number of meals cooked last week using charcoal	16,073	4,698
Rice, main staple for the household (dummy, 1= yes)	0,477	0,500
Beans, main sauce (dummy, 1= yes)	0,551	0,498
Amount of charcoal used last week (in Kg.)	18,719	10,049
Total expenditure on charcoal last week (in TZS)	10948,030	6107,990
Panel C: Demand for LPG stoves		
Household knows about LPG stoves (dummy, 1= yes)	0,985	0,123
Knows someone using LPG stove (dummy, 1= yes)	0,803	0,398
High start up cost is main reason for not owning LPG (dummy, 1= yes)	0,934	0,249
Difference in taste of food cooked is main reason for not owning LPG (dummy, 1= yes)	0,024	0,152
Household wishes to own LPG stove in the future (dummy, 1= yes)	0,961	0,193
Maximum willingness to pay for an LPG stove package (TZS)	63419,670	38548,520
Can afford gas refilling cost (dummy, 1= yes)	0,882	0,323
Walking distance to the nearest LPG gas dealer (in minutes)	17,757	14,102
Observations	722	

Table 2: Descriptive Statistics by Treatment Type

	[1 - Credit]		[2 - Subsidy]		[3 - Control]		[Diff. 1 Vs 3]	[Diff. 2 Vs 3]
PanelA: Socioeconomic Characteristics								
Age	47,769	12,718	47,048	11,974	47,451	12,802	0,317	-0,403
Male	0,694	0,462	0,660	0,475	0,717	0,451	-0,023	-0,057
Household size	5,644	2,039	5,799	2,236	5,997	2,258	-0,353	-0,198
Annual income in TZS (log)	12,486	0,729	12,427	0,738	12,496	0,695	-0,010	-0,069
Years of schooling	7,602	3,261	7,565	3,022	7,404	2,711	0,198	0,161
Access to main grid electricity (dummy, 1= yes)	0,745	0,437	0,809	0,394	0,811	0,392	-0,066	-0,003
Average household daily expenditure	8877,315	5968,327	10545,450	13892,930	9168,350	6438,137	-291,035	1377,100
Separate kitchen (dummy, 1= yes)	0,421	0,495	0,368	0,484	0,421	0,495	0,000	-0,052
Residential house privately owned (dummy, 1= yes)	0,472	0,500	0,483	0,501	0,515	0,501	-0,043	-0,032
Saving account (dummy, 1= yes)	0,366	0,483	0,469	0,500	0,458	0,499	-0,092**	0,011
Panel B: Cooking Pattern and Charcoal Use								
Number of years using charcoal stove	23,736	11,169	22,737	10,862	22,987	10,814	0,750	-0,250
Head decides on acquisition of stove (dummy, 1= yes)	0,472	0,500	0,435	0,497	0,421	0,495	0,051	0,015
Distance to nearest charcoal market (in minutes)	4,512	4,125	4,696	3,902	4,236	4,752	0,276	0,460
Number of meals cooked last week	19,222	3,105	19,364	3,344	19,121	3,492	0,101	0,242
Number of meals cooked last week using charcoal	16,759	4,136	16,292	4,892	16,364	4,654	0,396	-0,072
Rice, main staple for the household (dummy, 1= yes)	0,537	0,500	0,502	0,501	0,488	0,501	0,049	0,014
Beans, main sauce (dummy, 1= yes)	0,560	0,498	0,488	0,501	0,522	0,500	0,038	-0,034
Amount of charcoal used last week (in Kg.)	19,088	8,942	18,482	9,043	19,734	11,735	-0,646	-1,252
Total expenditure on charcoal last week (in TZS)	11137,440	5191,617	10804,530	4921,571	11498,890	7474,942	-361,450	-694,360
Panel C: Demand for LPG stoves								
Household knows about LPG stoves (dummy, 1= yes)	0,981	0,135	0,990	0,098	0,983	0,129	-0,002	0,007
Knows someone using LPG stove (dummy, 1= yes)	0,819	0,386	0,804	0,398	0,791	0,407	0,028	0,013
High start-up cost of LPG (dummy, 1= yes)	0,949	0,220	0,914	0,281	0,936	0,245	0,013	-0,022
Difference in taste of food (dummy, 1= yes)	0,037	0,189	0,014	0,119	0,020	0,141	0,017	-0,006
Max. willingness to pay for an LPG stove (TZS)	64199,070	37458,220	67263,160	36888,770	60148,150	40281,420	4050,920	7115,010
Can afford gas refilling cost (dummy, 1= yes)	0,889	0,315	0,904	0,295	0,862	0,346	0,027	0,042
Distance to the nearest LPG gas dealer (in minutes)	18,951	15,113	16,145	12,919	18,022	14,081	0,930	-1,876
Observations	216		209		297			

Notes: $***p < 0.01, **p < 0.05, *p < 0.1$.

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Table 3: Descriptive Statistics by Treatment Type: Accounting for Uptake

	[Treatment]		[Control]		[Diff.]
	Coeff.	SE	Coeff.	SE	Coeff.
Panel A: Socioeconomic Characteristics Age	47,236	12,183	47,505	12,812	-0,269
Male	0,661	0,474	0,721	0,449	-0,060
Household size	5,712	2,173	5,997	2,258	-0,284
Annual income in TZS (log)	12,494	0,733	12,495	0,696	0,000
Years of schooling	7,642	3,127	7,404	2,711	0,238
Average household daily expenditure	10321,920	12560,680	9168,350	6438,137	1153,570
Separate kitchen (dummy, 1= yes)	0,411	0,493	0,421	0,495	-0,010
Residential house privately owned (dummy, 1= yes)	0,466	0,500	0,515	0,501	-0,049
Saving account (dummy, 1= yes)	0,462	0,499	0,458	0,499	0,004
Panel B: Cooking Pattern and Charcoal Use					
Number of years using charcoal stove	24,007	11,516	22,987	10,814	1,020
Head decides on aquisition of stove (dummy, 1= yes)	0,466	0,500	0,421	0,495	0,045
Distance to nearest charcoal market (in minutes)	4,945	4,060	4,236	4,752	0,710
Number of meals cooked last week	19,301	3,303	19,121	3,492	0,180
Number of meals cooked using charcoal	16,356	4,596	16,364	4,654	-0,007
Rice, main staple for the household (dummy, 1= yes)	0,497	0,501	0,488	0,501	0,008
Beans, main sauce (dummy, 1= yes)	0,476	0,500	0,522	0,500	-0,046
Amount of charcoal used last week (in Kg.)	19,193	8,781	19,734	11,735	-0,541
Total expenditure on charcoal last week (in TZS)	11072,760	4821,808	11498,890	7474,942	-426,130
Panel C: Demand for LPG stoves					
Household knows about LPG stoves (dummy, 1= yes)	0,983	0,130	0,983	0,129	0,000
Knows someone using LPG stove (dummy, 1= yes)	0,818	0,386	0,791	0,407	0,027
High start-up cost of LPG (dummy, 1= yes)	0,921	0,270	0,936	0,245	-0,015
Difference in taste of food (dummy, 1= yes)	0,031	0,173	0,020	0,141	0,011
Distance to the nearest gas dealer	17,836	14,423	18,022	14,081	-0,186
Observations	296		297		

Notes: $***p < 0.01, **p < 0.05, *p < 0.1$.

Table 4: Correlates of Attrition, Baseline - Endline: Probit Regression Results

	[1]	[2]	[3]
Treatment	0,106		
	-0,142		
Credit treatment		0,0929	0,101
		-0,176	-0,148
Subsidy treatment		0,119	0,129
		-0,175	-0,173
Age			-0,00398
			-0,00508
Household size			0,0303
			-0,0264
Years of schooling			-0,0396*
			-0,0221
Male dummy (1=yes)			0,135
			-0,159
Separate kitchen (dummy, 1= yes)			-0,0763
			-0,133
Residential house privately owned (dummy, 1= yes)			-0,248***
			-0,0963
Owns a bank account (dummy 1=yes)			-0,062
			-0,0883
Number of years using charcoal stove			-0,00832
			-0,00548
Head decides on acquisition of stove (dummy, 1= yes)			0,0323
			-0,18
Number of meals cooked last week			0,00437
			-0,0135
Intercept	-0,667***	-0,667***	-0,193
	-0,0973	-0,0973	-0,437
Observations	722	722	722

Notes: $***p < 0.01, **p < 0.05, *p < 0.1$.

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Table 5: Charcoal Consumption at Baseline, Mid-line and Endline: Treatment and Control Group

	Baseline	Midline	Endline
Panel A: Amount of Charcoal in KG.			
Treatment	18,97	16,01	15,83
	(9,141)	(11,549)	(8,542)
Control	19,78	19,86	19,61
	(11,832)	(10,462)	(9,226)
Diff(Treated-control)	-0,82	-3,845***	-3.787***
Panel B: Value of Charcoal in TZS Treatment	11060,16	9328,25	9086,01
	(5081,011)	(6613,589)	(5008,947)
Control	11573,95	12241,70	11423,96
	(7667,924)	(7483,96)	(5072,572)
Diff (Treated-control)	-513,79	-2913,446***	-2337,947***
Obs	722	698	527

Notes: $***p < 0.01, **p < 0.05, *p < 0.1$.

Table 6: Impact of LPG Stoves on Charcoal Consumption

	[Midline]			[Endline]			[Mid. End. Diff.]
	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Treatment	-0,318***			-0,274***			-0,044***
	-0,0771			-0,0829			-0,0046
Credit Treatment		-0,291***	-0,278***		-0,236**	-0,190**	-0,088***
		-0,0792	-0,0699		-0,0866	-0,0676	(0,0034)
Subsidy Treatment		-0,345***	-0,333***		-0,315**	-0,288***	-0,045***
		-0,108	-0,104		-0,11	-0,0977	(0,006)
Controls	No	No	Yes	No	No	Yes	
Observations	698	698	698	527	527	527	
R-squared	0.041	0.042	0.062	0.037	0.039	0.0.122	

Notes: $***p < 0.01, **p < 0.05, *p < 0.1$.

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Table 7: LPG Stove Use: OLS Regression Results

	[Midline]		[Endline]	
	[1]	[2]	[3]	[4]
Credit treatment	0.900	0.221	-1.153	-0.618
	(1.032)	(1.125)	(1.355)	(1.045)
Age		0.0596		0.0596
		(0.0460)		(0.0469)
Household size		0.154		0.243*
		(0.235)		(0.116)
Years of schooling		0.260		0.359***
		(0.185)		(0.112)
Household monthly income (log)		0.332		-0.123
		(0.654)		(0.308)
Number of years using charcoal stove		-0.0506		-0.121*
		(0.0386)		(0.0631)
Gas run out (dummy)		-12.81***		-10.57***
		(0.980)		(0.660)
Incomplete knowledge on LPG stove use (dummy)		-11.72***		-5.190
		(0.756)		(5.389)
Distance to the nearest gas dealer		0.113		0.200
		(0.417)		(0.336)
Constant	11.38***	3.112	9.519***	8.060*
	(0.547)	(8.617)	(0.745)	(4.109)
Observations	296	296	241	241
R-squared	0.003	0.093	0.006	0.329

Notes: Standard errors clustered at the street level, $***p < 0.01, **p < 0.05, *p < 0.1$.

Table 8: Satisfaction With LPG Stoves: Probit Regression Results

	Quality	Functioning	Food Taste	Cost	Convenience
Credit Treatment	-0.273	-0.309	-0.142	-0.237	-0.250
	(0.248)	(0.228)	(0.212)	(0.212)	(0.217)
Age	-0.00510	-0.000919	0.000793	0.00441	-0.00177
	(0.00755)	(0.00751)	(0.00967)	(0.00683)	(0.00808)
Household size	0.0795*	0.0448	0.0839*	0.0416	0.0878***
	(0.0408)	(0.0379)	(0.0476)	(0.0368)	(0.0290)
Years of schooling	0.0756**	0.0800**	0.0998***	0.0718*	0.0789**
	(0.0327)	(0.0318)	(0.0327)	(0.0416)	(0.0322)
Male	-0.366*	-0.374	-0.267	-0.407*	-0.435*
	(0.205)	(0.256)	(0.262)	(0.245)	(0.247)
Separate kitchen	-0.0582	-0.0119	-0.00106	0.107	0.0527
	(0.222)	(0.234)	(0.187)	(0.229)	(0.221)
Residential house privately owned	-0.266	-0.243	-0.196	-0.286	-0.223
	(0.183)	(0.220)	(0.186)	(0.189)	(0.190)
Number of years using charcoal stove	0.00779	-0.000186	-0.00815	-0.000188	-0.00395
	(0.00818)	(0.00807)	(0.00803)	(0.00808)	(0.00809)
Head decides on acquisition of stove	0.0683	0.0123	0.119	-0.0531	0.0111
	(0.286)	(0.281)	(0.228)	(0.261)	(0.265)
Number of meals cooked last week	-0.00608	-0.00579	0.000139	-0.00231	0.0111
	(0.0267)	(0.0300)	(0.0248)	(0.0339)	(0.0315)
Intercept	0.542	0.689	-0.138	0.351	0.264
	(0.671)	(0.716)	(0.638)	(0.833)	(0.823)
Observations	296	296	296	296	296
Pseudo R^2 - squared	0.065	0.061	0.066	0.049	0.065

Notes: Robustness standard errors in parentheses, $***p < 0.01, **p < 0.05, *p < 0.1$.

Table A1 Reasons for not using LPG Stoves

	No.	%
Gas run out	5	0,07
Stove/parts mulfunction	3	0,04
Type of food cooked	2	0,03
Not confident on how to operate the stove	4	0,05
Non of the above	60	0,81
Observations	74	1,00

Figure 1: Map of Dar Es Salaam City Council Showing Municipalities

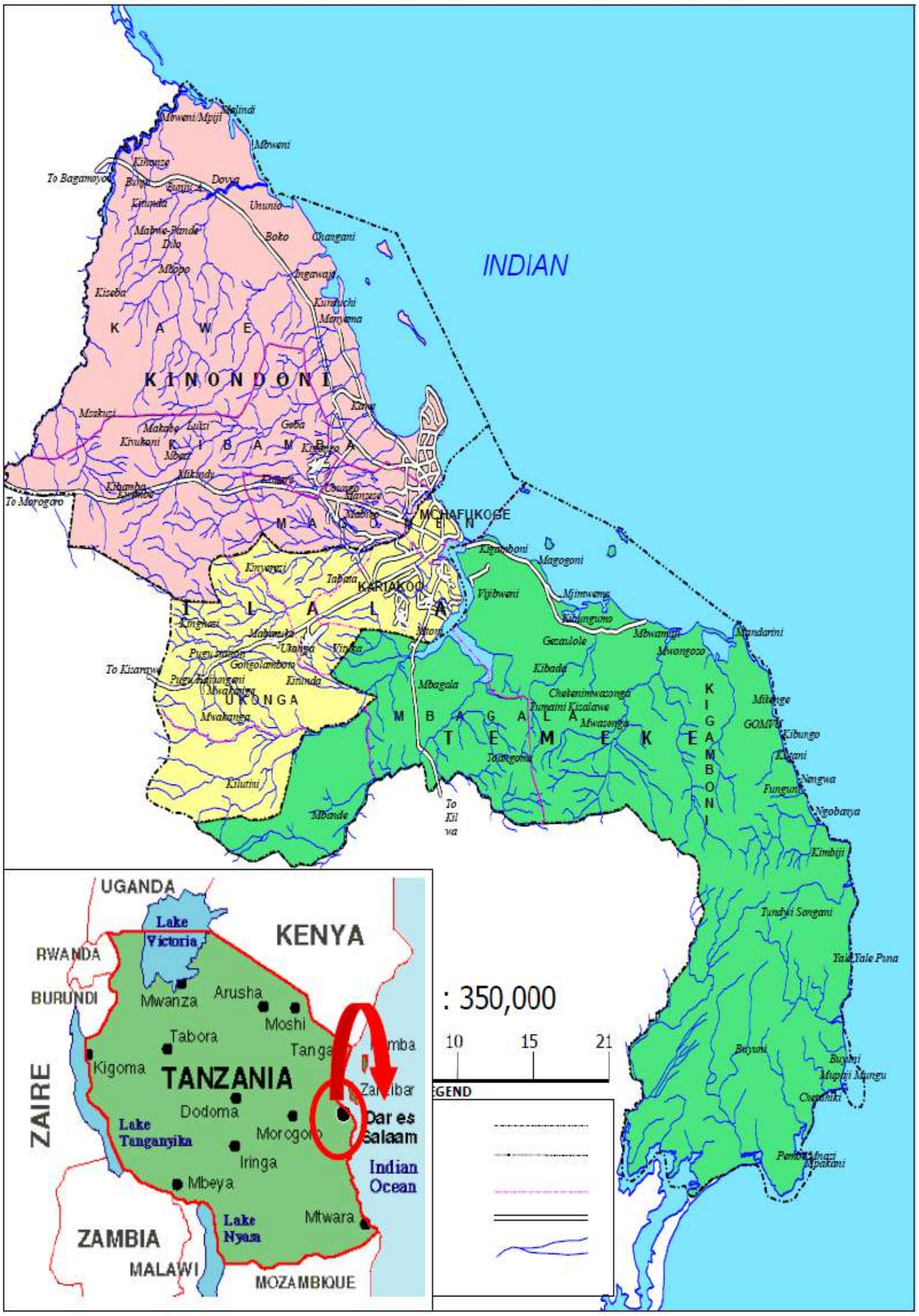

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Figure A2.
I). Subjects attending a training session.

II). Picture taken during home visits at follow-up survey.

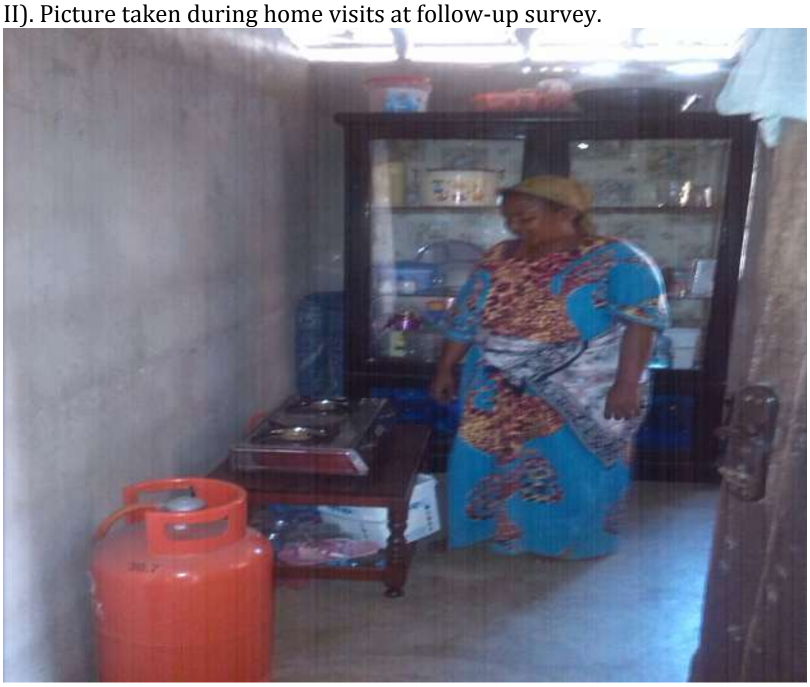

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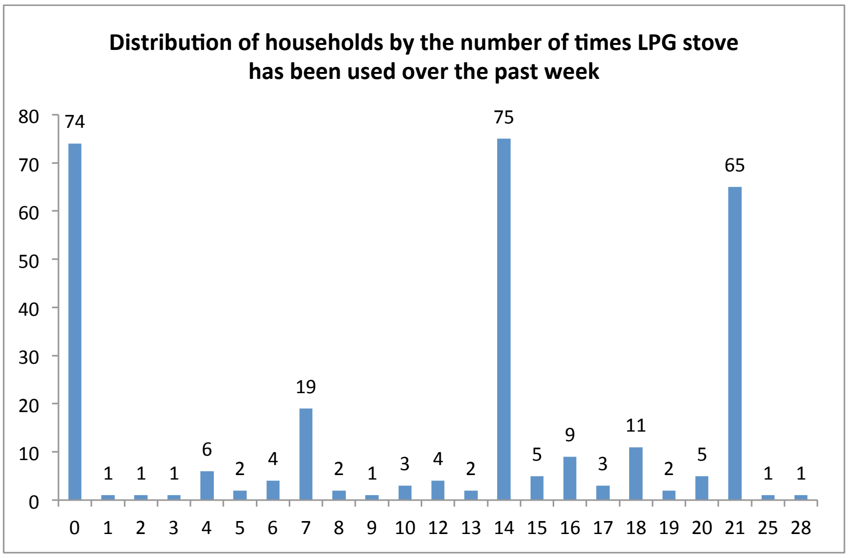
Figure A3



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Reporting and Auditing when Accounting for Sustainability:
How Far We Have Come and Framework for Continuing

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Reporting and Auditing when Accounting for Sustainability:
How Far We Have Come and Framework for Continuing

Abstract

This research responds to increasing calls for more and different forms of accounting research in accounting for sustainability. It provides background, clarifies accounting research issues, and suggests research methods. Background analysis indicates a change in focus from external sustainability issue focusing on ecological and social issues to an internal focus on sustainable companies facing a broad range of sustainability issues including ecological, social, and economic. Accounting for sustainability must go beyond supplemental reporting of ecological and social information to include such emerging issues as integrated reporting of sustainability information along with financial reporting. Additional emerging issues are needs of users of sustainability reports, auditing and other assurance of sustainability information, and sustainability implications of financial failure, accounting and auditing failures, and lack of enforcement.

Analysis of integrated reporting against traditional financial accounting theory and the postulates of going concern, reporting entity, monetary unit, and time period, indicates a need for substantial changes in the traditional financial accounting model if sustainability issues are to be integrated. The agenda concludes with five research issues and methods:

- An accounting research framework for sustainability using general systems theory approaches that have been useful for similar emerging issues.
- Reporting of sustainability information which has been the focus of most research to date, and the emerging important topic of integrated reporting.
- Users of sustainable information, their uses and perceived needs, an area that has been largely neglected.
- Auditing and assurance issues that are taking on greater importance as more users demand assurance for sustainability information. Issues include standards to be used and users' expectations and reactions.
- Financial distress and sustainability consequences of accounting and enforcement failures that are just now being recognized as sustainability issues.
- A new Sustainable Enterprise Theory and Sustainability Indicator Accounting that also allows auditability of sustainability reports.

Research methods, including content analysis, field studies, experiments, and archival, are identified as appropriate for each issue.

Key words: sustainability, accounting and reporting, integrated reporting, assurance, auditing, environment, social, going concern, financial distress

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Reporting and Auditing when Accounting for Sustainability:
How Far We Have Come and Framework for Continuing

1. Introduction

As calls for accounting involvement in sustainability issues have become stronger, more frequent, and more urgent, both practicing accountants and accounting academics have become more involved. In particular, integrated reporting of financial and sustainability information has become more widespread, accepted, with implementation attempts, but without a comprehensive analysis of the challenges and many pitfalls. Auditability of reported information has become an issue. This paper presents discusses how far we have come and some of the issues that have emerged and remain to be addressed before further progress can be made.

As discussed below, there is no common notion of sustainability, especially in accounting contexts, and notions are rapidly expanding. For this paper, we tentatively, as a starting point, draw upon the classic economist Sir John Hicks who developed the concept of consumption being what would leave a person as well off at the end of the period as at the beginning of the period. The notions of what constitutes a period is also rapidly changing. Our working notion of sustainability is that a sustainable entity is one that is as well off at the end of a period as at the beginning with respect to use of **all** resources including. environmental, human, ecological, social, financial, and technological.

Much previous research has used the definition of sustainability of Buntland (1987) given 30 years ago for the World Commission of Environment and Development of the United Nations (UN) which focuses on sustainable development ensuring that it meets current needs without sacrificing needs of future generations (quoted and cited, e.g., by Kasperiet 2011). Buntdland's definition, while innovative and ground-breaking for the time, is now obsolete for current activity in accounting for sustainability. Among other things, it focuses on external sustainability, i.e. sustainability of ecological and social systems, while the focus of current accounting for sustainability is on sustainability of an entity and entities much more broadly defined. More comprehensive definitions of sustainability and entity are needed.

Despite no common notion, the terms "sustainability" and "accountability" in environmental and social contexts are used widely. Journals have been launched to publish research exclusively or primarily on accounting for sustainability, e.g. *Social and Environmental Accountability Journal, Sustainability Accounting, Management, and Policy Journal*, and

Sustainability: The Journal of Record. A major international academic accounting conference of the International Association for Accounting Education & Research (IAAER) held in Singapore in November, 2010, featured panel discussions of practitioners and academics that called clearly for more academic research in accounting for sustainability, notably in auditing. At another recent international academic accounting conference, Asian Pacific Conference on International Accounting Issues held in Australia in November 2010, a speaker from a government pension fund agency in Australia was critical of academic accountants' lack of involvement in accounting for sustainability; she indicated if the academic accountants did not get more involved soon, other groups would.

Thomas L. Friedman, a *New York Times* columnist and award-winning author, in his book on sustainability, *Hot Flat and Crowded*, Release 2.0 (2009), has explicitly used accounting terminology (discussed in more detail below) to describe inadequacies of current accounting practice for sustainability. Major international business-oriented newspapers write about the same issues.

Dedicated research in sustainable investing has been ongoing for a few years. Notably, the Sustainability Investment Research Platform (SIRP) (www.sirp.se) in Sweden has been a world leader in such research. It is now recognized by SIRP and others that accounting for sustainability is the current major research area.

The Principles of Responsible Investment (PRI) Academic Network of the UN (http://academic.unpri.org/), among other things, publishes the RI Digest of academic research articles in sustainability. Increasingly, the RI digest has been reviewing accounting research, notably about disclosures, e.g. Solomon and Solomon, (2006), reported and reviewed in December 2010.

The Centre for Social and Environmental Accounting Research, Accountability, Transparency, Sustainability (CSEAR) (http://www.st-andrews.ac.uk/~csearweb/) has been created at the University of St. Andrews in the UK to provide information resources, sponsor workshops, and other activities to help researchers and scholars exploring social, environmental, and sustainability accounting, auditing and reporting and related topics.

One of the major issues in accounting for sustainability is lack of a common notion of accounting roles in sustainability, nor even what constitutes sustainability in an accounting context. The various notions of sustainability and accounting for sustainability, while not conflicting, and indeed complementary, reflect a need for more detailed accounting analysis to identify research issues, establish more precise concepts, definitions, and notions to provide near-term future directions. In addition, there is no common notion of reporting of sustainability. The term integrated reporting is thrown about as though there was consistency in its use and understanding. Yet there is no common notion of "integrated" and varying approaches are used under the guise of "integrated."

This paper presents continuing steps to provide structure to identifying and discussing specific groups of research issues for accounting for sustainability, along with methodologies and data sources. The remainder of this paper is organized as follows:

- Section 2 presents background information underlying issues of accounting for sustainability.
- Section 3 analyzes issues in accounting for sustainability with respect to traditional accounting practice, notably the postulates of accounting.
- Section 4 presents specific research possibilities along with research methods and sources. Some issues are better developed than others.
- Section 5 gives a concluding discussion.

2.0 Background

During the past several years, many accounting academics and accounting practitioners have viewed sustainability almost exclusively as representing environmental, i.e. ecological, and sometimes social issues, and sustainability reporting as telling how 'green' and socially responsible a company has been. This view of sustainability reflects a common view developed over 25 years ago by the Brundtland commission of the United Nations (UN) that sustainability is meeting needs of current generations without sacrificing future generations' needs (Brundtland 1987). A large number of academic publications reflect this view (e.g. Adams 2010, Gray 2010, and sources cited by them). Panelists at the IAAER conference (2010), however, were clear that current approaches to sustainability reporting are too narrow and inadequate for many reasons; especially the notion of accounting for sustainability is much broader than mere environmental (ecological) and social reporting. Therefore, the role of accounting involvement must be broader to include such activities as risk assessment and providing assurance including auditing.

It is now widely recognized, but not well documented in academic publications, that sustainability goes beyond mere environmental (ecological) and social issues, and includes sustainability of an enterprise as a business involving raw material extraction, production, sales, and marketing, disposal, and recycling, as well as being sustainable financially, legally, and in other similar ways. Also relevant are broad economic issues such as income inequality that must be resolved in order for enterprises to be sustainable both individually and collectively. Poor environmental (ecological) and social performance can indeed lead to unsustainable business activity as evidenced by consumer boycotts of large retail enterprises that were viewed as selling products made by suppliers using child labor and other socially and environmentally unacceptable practices. Users of financial information consistently indicate a desire to have more information to allow them to assess sustainability and risk related to sustainability.

Thomas L. Friedman (2009), the award-winning author, links both financial sustainability in the latest financial crisis and environmental sustainability as representing the same phenomenon: inadequate accounting that does not adequately consider risk:

> If the true risks involved in these subprime mortgages or default insurance had been priced into these products, they would never have been rated the way they were. Investors would have been much more wary and demanded much higher yields before buying them, which would have forced the mortgage brokers to be more careful in deciding to whom to give these mortgages and the banks to be more careful in choosing which ones to bundle. (Friedman 2009, pg. 15).

While pricing of products might be viewed as a marketing issue, under IFRS and accounting standards of most industrialized countries, valuation of the cost of the products sold and the inventory of buyers would require an adequate risk assessment to measure amounts in financial statements of both sellers and buyers. Furthermore, the principle of going concern applies to all valuations in financial statements and underpricing of financial risk raises serious issues of going concern. The going concern principle is essentially the same as sustainability when making financial accounting valuations. (Going concern issues are discussed in more detail shortly.) As a result, sustainability failures in the recent financial crisis related to inadequate pricing of risk in products are indeed issues of accounting for sustainability.

Then, when writing about environmental issues discussing a 2005 report of the Millennium Ecosystem Assessment of the United Nations, Friedman comments:

> Yet because most nations do not put a price on [the natural resources consumed] they too are 'underpriced' and therefore overexploited—with the profits privatized and the losses socialized. (Friedman 2009, p. 25)

Further quoting the World Wild Life Fund's Living Planet 2008 Report:

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> 'The world is currently struggling with the consequences of over-valuing its financial assets, but a more fundamental crisis looms ahead—an ecological credit crunch caused by undervaluing the environmental assets that are the basis of all life and prosperity.' (Friedman 2009 p. 25).

Under current accounting standards, IFRS and USGAAP, the value of ecological resources used would not normally be used to measure product prices or report values in financial reports; thus, Friedman advocates a new accounting paradigm for accounting for sustainability that incorporates use of environmental and social resources in accounting measurements.

In both of these situations, as well as throughout the book, Friedman, a well read, literate and articulate writer, but a non-accountant, uses accounting terminology to link both financial and ecological sustainability failures and to attribute the cause of both to the same phenomenon, underpricing of assets and products sold due to failure to consider sustainability risk. Similar calls for a new accounting model to incorporate external costs have been made by others, e.g. the Accounting for Sustainability Group (2006) and Epstein (2008).

Recent attention to so-called integrated reporting has come from the Accounting for Sustainability Project (www.accountingforsustainability.org), among other places. As discussed in more detail shortly, this project includes initiatives of the International Integrated Reporting Committee (IIRC) (http://www.integratedreporting.org/) to develop a new reporting model that will better reflect the interconnected impact of financial, environmental, social and governance factors.

There is, however, no common notion of what constitutes integrated reporting. Many believe that 'integrated' is merely including environmental and social information along with financial information, while others view 'integrated' as incorporating sustainability factors within accounting measurements.

3.0 Accounting for sustainability with respect to traditional accounting

When environmental (ecological), social, and other issues are viewed from the perspective of accounting for sustainability, many issues emerge that have not yet been addressed and need to be examined from the perspective of traditional accounting and financial reporting theory and practice.

3.1 Integrated reporting and financial accounting theory

Recent calls for integrated reporting involve reporting sustainability issues in parallel with or supplemental to financial reports, incorporating sustainability issues in accounting

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measurements in financial reports, or both. Many inconsistencies arise, though, have not been considered and should be analyzed with respect to traditional financial reporting theory. Recent studies of integrated reporting, e.g. Dumay, J., et al. (2016) and Iannou and Serafiem (2016). In these studies, there is not even a common notion of what constitutes “integrated” some believing that “integrated” merely means sustainability information beside financial information or sustainability information supplemental.

Among the inconsistencies is the orientation, especially in Anglo-Saxon countries, of financial reports towards investors and prospective investors. Even though the conceptual framework of the IASB states the objective of financial reporting is to provide information useful to a wide variety of users in making economic decisions (paragraph 12 as cited by Deegan and Unerman, 2008 p. 179), it has an obvious orientation towards investors and analysts. Frameworks of other countries, e.g. that of the FASB of the US., are essentially the same. Among other things, the framework (cited by Deegan and Unerman above) states that the objective is ‘to provide information about the financial position, performance, and changes in financial performance of an enterprise’. This type of financial information is not consistent with the sustainability information envisioned by integrated reporting on sustainability except to the extent that sustainability failures affect financial performance and position, e.g. as in the BP debacle in the Gulf of Mexico.

Also, significantly, the IASB conceptual framework explains that economic decisions should be based on an assessment of an enterprise’s future cash flows (Deegan and Unnerman, 2008, p. 179). Other conceptual frameworks have similar language. This language clearly implies that accounting measurements should be ultimately related to cash flows. The theory adds, though, that future cash flows are best assessed by accrual accounting. Many of the suggestions to include sustainability into accounting measurements would not involve direct future cash flows, such as use of environmental resources, unless for some limited circumstances when a carbon tax or carbon permits might be involved. Therefore, it would be difficult to include such sustainability measurements without changing a major aspect of traditional financial reporting theory.

Financial accounting theory specifies fundamental postulates of accounting and financial reporting. These postulates predate both IFRS and US GAAP conceptual frameworks and are included in them. Terminology varies, but theory includes the following four postulates (e.g. see

Riahi-Belkaoui, 2004 pp. 211-214). These postulates with respect to sustainability are discussed in Fagerström, et al. (2017) and presented here.

- Going concern
- Reporting entity
- Monetary unit
- Time period

Some would add a fifth postulate, exchange price**s** (e.g. Kam, 1990 pp 46-47).

The **going concern** postulate for financial reporting assumes an entity will be in business for the foreseeable future and will be able to realize its assets and complete its financial obligations. This concept affects valuation bases for measurements of many items on financial reports. It is also the basis for auditors' reports on financial statements.

With respect to sustainability, the concept of going concern has additional implications because lack of sustainability implies lack of a going concern and a sustainable entity must necessarily be a going concern. As discussed in more detail shortly, well-known going-concern failures such as Enron and sub-prime mortgage collapses have resulted massive social costs and clearly represent lack of environmental and social sustainability. In addition, the need to complete all sustainability obligations can extend over a much longer time period than the period to complete financial obligations. The time period postulate is discussed further below. It is conceivable, though, that there could be two different notions of going concern, one financial and one sustainability based among other reasons on different time periods for completion of obligations. Accounting practice and research has not yet dealt with this issue.

A major part of going concern is the availability of technology to achieve the necessary recycling and disposal of products that are manufactured or used in providing services. Such technology must be available or expected to be available in the foreseeable future.

The **reporting entity** postulate defines the entity for which financial reports are prepared. Traditionally, financial reports are prepared for an economic entity, usually defined as a consolidated group in which one dominant entity controls a group. With sustainability reporting, the appropriate reporting entity for sustainability reporting may differ considerably from the reporting entity for financial reporting purposes. As two examples: First, recent publicity about retail companies that sell clothes made by child labor, and similar situations in other industries, indicates that transparent and informative reporting should include the entire supply chain as part of the entity for sustainability reporting. Second, the environmental impact of a company's products, e.g. automobile emissions, is also a significant element to be considered in assessing a company's sustainability for reporting purposes. Similarly, for many goods and services, disposal and recycling requirements must be considered as part of the sustainability reporting entity, even if separate companies are involved just as companies in the supply chain must be considered.

Traditional financial reporting is based on **monetary units** in which all non-monetary items are reported as an equivalent monetary amount. Almost all sustainability information in reports to date are in narrative and or non-monetary terms. Under some notions of sustainability reporting, environmental and social information would be incorporated into accounting measurements. Also as discussed above, Friedman (2009) and others imply a new accounting in which environmental risk, including financial risk, is incorporated into product pricing.

Under the costs-attach principle of traditional financial accounting, costs are included in product prices and similar measurements if there is a payment (or similar actual use of resources owned). There has been no measurement method to incorporate use of "free" environmental resources nor potential damage to environmental resources, e.g. through greenhouse gases. Carbon trading schemes are in their earliest stages of development in Europe and some other places, but so far, no accounting measurement has been proposed to include the cost of carbon emission purchases into products and similar accounting measurements.

Figge and Hahn (2004) in their Advance project have developed the Advance Model (see also http://advance-project.org) in which, among other things, sustainable value added is computed in monetary terms for various types of emissions. These sustainable values, though, are not incorporated into accounting measurements, but could conceivably be reported in integrated reports.

Recent studies by Fagerström, et al. (2017) and Hartwig and Homayoun (2017) have developed Sustainability Accounting Indicators which provide quantifiable, auditable, non-monetary indicators discussed below.

Under the **time period** postulate, traditional financial reporting is based on specific time periods, almost always one year, based on perceived users' needs for timely information covering discreet time periods of optimal length to make meaningful decisions. Two approaches of accounting measurements have traditionally been used: First the revenue-expense approach measures revenues earned and costs incurred to earn those revenues during a year to derive a profit for the year; assets and liabilities are residuals. Second, the asset-liability approach measures assets and liabilities at the end and the beginning and of a year, subtracting the difference as profit for the year, divided into revenues and expenses.

The asset-liability approach has been adopted by IFRS and US GAAP, but the revenue-expense approach remains in some countries, notably Finland.

The asset-liability approach is more compatible with sustainability reporting because it focuses on consumption of resources that would leave a company as sustainable at the beginning as at the end. Nonetheless, both approaches are problematic for sustainability reporting because of the rigid notion of financial reporting in discrete annual increments. Many issues of sustainability relate to long-term consequences for the environment, for example, consequences from past environmental damage as in the oil fields of Nigeria and coal mining regions of the U.S, and damage from emissions over the life cycle of products like automobiles.

In a very recent issue of *The Economist* (2017), discussion of nuclear waste disposal in Finland by a company jointly owned by two utilities indicates that nuclear waste must be kept safely buried tens of thousands of years. While it is bizarre, maybe even ridiculous, to imagine a time period of tens of thousands of years for sustainability reporting, the facts remain that disposal of nuclear waste is indeed a sustainability issue, the company is spending billions of euros, and there must be accountability and reporting of the activity both financial reporting and sustainability reporting.

The **exchange price** postulate indicates accounting data are based on measurements of actual past, current, or future exchange prices. As indicated above, some of the information anticipated in sustainability reports does not involve specific exchange transactions, e.g. the use of “free resources” like air. Further, many times periods are of such extremely long time periods in the future that determining exchange prices is virtually impossible. As sustainability reported progresses, much more attention must be devoted to these issues.

In summary, there are fundamental conflicts between traditional accounting theory for financial reporting and aspects of sustainability reporting. These conflicts must be resolved, at least partially, before sustainability reporting can progress beyond mere supplemental reporting which is hardly integrated.

3.2 Auditing and other assurance

The panel discussion at the IAAER conference (November 2010) clearly calls for accounting researchers to be involved in additional roles in reporting sustainability, notably auditing or other assurance. Users of financial information, notably investors, it is claimed, need, almost demand, increasing levels of assurance on sustainability information, notably assurance of information in management commentaries and environmental reports. The anecdotal statements claim that investors require such assurance to make proper risk assessments of sustainability, especially because of documented false environmental statements in annual reports. In the Massey Coal case in the US, as part of a legal settlement, Massey agreed to provide audited statements of workplace safety and protections of the environment (Harris and Cunningham 2012).

The call for auditor assurance of sustainability reports is also reflected in personal interviews with international accounting firms. Some countries, e.g. Sweden, allow auditors to offer both positive and negative assurance on environmental reports, i.e. positive assurance in which auditors examine evidence as in a financial audit and give a professional opinion about its reliability and negative assurance in which the auditor states there is no reason to suspect the information is not reliable. Companies choose to provide environmental and social information, it is claimed, to obtain reputational benefits not necessarily related to risk. Assurance, if any, would be used to achieve greater reputational benefits; few companies are willing to pay for positive assurance because of limited perceived benefits.

Calls for greater assurance of sustainability information, however defined, are based on anecdotes, assertion, conjecture, etc. Interests of investors and creditors in assessing sustainability risk in making decisions have been largely ignored. As a result, there is a need for accounting research to assess investors' and creditors' perceived needs for assured sustainability information, how they use it, market reaction to the information, etc.

In order for there to be effective audits or other assurance, there should be standards against which to perform such assurance. Some sources, e.g. Dumay et al. (2016), Hahn and Khünen (2013), Comyns et al. (2013), indicate that for many companies, especially those with mandatory reporting requirements, standards of the Global Reporting Initiative (GRI) have become the de facto standards. GRI standards, however, are not comprehensive and provide at best limited bases for audit and other forms of assurance. Very recently, Fagerström et al. (2017) based on sustainability enterprise theory developed in Fagerström and Cunningham (2017)

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propose develop the notion of sustainability indicator accounting (SIA) with quantifiable reporting measurements that can be audited. Hartwig and Homayoun (2017) develop comprehensive indicators to accomplish this result. These efforts provide bases for continued research and development.

3.3 Financial failures, reporting and auditing failures, and enforcement

Yet another set of accounting-for-sustainability situations within the past few years is the well-known financial sustainability failures and near failures of companies like Enron, WorldCom, Parmalat, Ahold, and Lehman Brothers and other financial institutions. These financial sustainability failures resulted not only in investor and creditor losses, but also massive losses for society. They are clearly social and environmental sustainability issues as well. The sustainability failures were directly related to non-compliance with accounting standards, audit failures, and enforcement failures. In addition, the going concern concept implies financial sustainability and these organizations clearly were not going concerns.

While there has been extensive research and publication about the high-profile cases, little research has been conducted in the context of accounting for sustainability. Research has shown, however, continued lack of compliance with accounting standards and apparent lack of enforcement, especially in Europe (e.g. Carrara et al. 2010; Fagerström et al. 2009, 2007a, 2007b). It is also recognized that lack of adequate enforcement of accounting standards within the EU is contributing to lack of reliability of published accounting reports and thus the ability of users of financial reports to assess sustainability risks. As widely reported in the business media, in October 2010, the European Commission announced its intention to examine compliance with accounting standards, the role of auditors, and enforcement. It is too soon to assess the consequences of this action by the European Commission, but it is clearly an issue within accounting for sustainability.

3.4 Value Creation

Almost all the research and writing to date has taken the perspective that companies account for and report sustainability out of necessity due to mandatory requirement or external pressure. Even though sustainability, in various forms, is said to be voluntary, there is usually some pressure. Very recent research by Dumay et al. (2016) indicates that increased shareholder value as measured by Tobin’s Q is associated with sustainability reporting.

In addition, the recent essay developing Sustainable Enterprise Theory (Fagerström and Cunningham 2017) builds a good case for value creation through sustainable activities and reporting them. Clearly more research is needed on value creation through sustainability and reporting thereof, avoiding the implication that sustainability accounting is done under duress.

4. Research Issues

With the analysis above of accounting for sustainability in the context of traditional accounting theory and practice, and recent events, this paper now develops specific research issues along with research methods and data sources.

4.1 A Research Framework for Accounting for Sustainability

A conceptual framework to guide researchers in accounting for sustainability is an essential first step for ongoing research because of various notions of sustainability and roles of accounting in accounting for sustainability that exist, and lack of a common language. Such frameworks have been successful in guiding emerging areas of accounting research in the past. In the 1970s, when the phenomenon of multinational companies became sufficiently large to warrant ongoing accounting research, a seminal study, *An Accounting Research Framework for Multinational Enterprises* (Cunningham 1977) facilitated accounting research for multinational enterprises for coming decades. A similar but less elaborate framework also facilitated research into accounting research for performance reporting and accountability in governmental entities (Cunningham and Harris 2005) when this issue emerged as an issue for accounting research.

Such a framework in accounting for sustainability would, among other things, identify, explore, and analyze systematically:

- Various notions of sustainability to assess which ones represent roles for accounting and to what extent.
- Groups and individuals who are or potentially could be involved in accounting for sustainability including preparers of reports; users of such information, e.g. banks and investment analysts; assurers of such information, i.e. auditors or similar groups; regulators; other organizations, e.g. the United Nations and its PRI academic network; and policy makers such as the European Commission.
- Different forms and levels of accountability, e.g. financial reporting and assurance thereof; integrated reporting of financial and other sustainability accounting information; reporting sustainability information outside the financial reports and assurance thereof; incorporating sustainability risk and use of resources in accounting measurements; other elements of accountability for sustainability risks; managerial accounting; management control systems; etc.
- Identifying and describing various notions of a sustainable entity that would be the object of accountability.

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- Matching the interests of groups and individuals with regard to sustainability with different forms and levels of accountability.
- Developing a common language to discuss and guide future research.

Similar to *An Accounting Research Framework for Multinational Enterprises* (Cunningham 1977, pg. 1), such a research framework facilitates continuing research in accounting for sustainability by describing gaps in current knowledge, specific issues that require research, factors to be considered when conducting the research, and suggesting research approaches. One important aspect is to identify failures in past research and means to overcome the failures. It also provides a common taxonomy and language for continuing research.

Following Cunningham (1977 pp. 31-61) and sources cited by him, such a framework uses a general systems theory approach as the primary methodological and analytical tool (described in more detail shortly). General systems theory is especially well suited to develop conceptual frameworks in business contexts and especially for accounting research because it allows researchers to explore such relevant aspects as:

- The scope of the agenda and which systems are included in this scope.
- System boundaries, i.e. what is included in a system and what remains outside in the environment. **It is important to note** (as discussed below) **that the word "environment" has a different meaning than is commonly used in the literature on accounting for sustainability so far.** For this framework, boundary considerations are important for such issues as defining sustainability in accounting contexts; what is inside systems of accounting for sustainability and what remains outside in the environment; and whether sustainability reporting and financial reporting are separate systems or can become integrated into a single reporting system.
- System regulation and control. For this framework, regulation and control factors deal not only with such obvious issues as standards and enforcement, but also what type of outputs from accounting for sustainability are to be produced and for whom.

4.1.1 Methodology

A research framework uses general systems methodology discussed in Cunningham (1977 Chapter 2). General systems theory is not a theory *per se* but instead an approach to guide analysis and development of specific research approaches. It is also a first step in grounded theory approaches which represent back and forth analyses of a system and its environment to build a theory.

Under general systems theory, each system is viewed as part of a larger system and each system can be viewed as having one or more subsystems. The objective is to identify the system of interest for the research issue at hand and the boundaries of that system. Thus, the system of interest can be defined in different ways for different research purposes. As discussed above, from a sustainability perspective, the system of interest can include a company and its supply chain as well as users of its products during the product life cycle and companies that dispose of and recycle it products and residue of services. In defining the boundary of the system of interest, everything that remains outside the boundary is considered to be the environment. **As noted above, this definition of "environment" is different from the term "environment" used in the research literature to date which typically views environment as representing ecological resources.** Among other things, the analysis considers properties of the system of interest, properties of subsystems, and properties of the environment, including influences of each on the other.

Other important aspects of general systems theory are the notions of regulation and control. Control is generally defined as setting expectations, monitoring outcomes against those expectations, and taking actions if necessary to make necessary changes to achieve desired outcomes. Thus control typically occurs outside a system in the environment and depends on how the boundary between a system and its environment is defined. Regulation represents activities and subsystems incorporated within a system to achieve the desired outcomes automatically without explicit intervention. Notions of what constitutes regulation and control differ depending on how the system of interest and the environment is defined. The concepts of regulation and control have obvious implications for accounting for sustainability. One example is establishing standards for sustainability reporting, a control function, and the steps taken by an entity to assure compliance with standards, a regulation function.

4.2 Reporting sustainability information

In some countries, e.g. Sweden, a form of integrated reporting is required for certain companies, e.g. those with state ownership, following the triple bottom line of the Global Reporting Initiative (GRI) (www.globalreporting.org/Home). In addition, several other companies have been voluntarily reporting environmental and social information for some years.

Recent attention to so-called integrated reporting has come from the Accounting for Sustainability Project (www.accountingforsustainability.org). This project includes initiatives of the International Integrated Reporting Committee (IIRC) (http://www.integratedreporting.org/)

to develop a new reporting model that will reflect the interconnected impact of financial, environmental, social and governance factors. The IIRC includes, among others, representatives from the major international accounting firms, securities exchanges, the Financial Accounting Standards Board (FASB) of the US, and the International Accounting Standards Board (IASB). As mentioned, though, there is no common notion of what constitutes integrated reporting.

Also as mentioned above, anecdotally, companies report so-called sustainability information and sometimes seek assurance of such to achieve reputational benefits. Research is needed to identify what type of reputational benefits companies expect to achieve.

A further issue is establishing standards for sustainability reporting. The Global Reporting Initiative (GRI) (www.globalreporting.org/Home), a network-based organization based in the Netherlands, provides standards for voluntary reporting of supplemental sustainability disclosures. GRI reporting standards are required in Sweden for companies that are required to report the triple bottom line. The IIRC as part of the UN PRI is also establishing reporting standards. Research could determine the criteria by which companies, accounting firms and others choose reporting standards.

4.2.1 Research Methods

The primary research methods for this set of issues would be content analysis and field studies. With respect to content analysis, because of different notions of what represents integrated reporting, it would be useful to examine actual reports under the different approaches to learn differences and their impacts. Content analysis could also be used to examine reports of different companies that use different types of reporting standards to assess different impacts. A further analysis of the groups promulgating the standards to determine their intentions and desired results would be useful.

Content analyses can be complimented by field studies of companies that currently report sustainability information to determine difficulty or ease of implementation and extent of compliance. Field studies are a form of grounded theory in which researchers engage with the field to discover phenomena of interest to be used to develop a theory. Field studies by Fagerström et al. (2009, 2007a, 2007b) have examined similar issues and provide a model for this research agenda. Field studies can be useful to assess the reputational benefits companies seek to achieve from reporting environmental and social information.

Field study research by Cunningham and Harris (2005) on a similar topic was a significant contribution to accountability research for governmental entities and is also a model.

4.3 Users of Sustainability Information.

As mentioned, research and discussion of accounting for sustainability so far have almost exclusively focused on companies that prepare and present sustainability information. There is very recent recognition that needs of users of the information must be considered as well. The research framework described in 4.1 would necessarily address these issues. Research is also needed to address directly users' needs and reactions to them.

Anecdotal evidence suggests financial analysts, one major user group, routinely discard supplemental sustainability disclosures. Instead, anecdotally, analysts want information that allows assessment of risk. Somewhat contradictory research, though, has shown financial analysts do consider sustainability risk information when making recommendations to their clients (H. Nilsson et al. 2008). Other research reported by the SIRP (www.sirp.se) indicates a market reaction to sustainability risk under certain situations thus suggesting some recipients of sustainability information do use it. Research is needed not only to assess whether sustainability risk information is desired and used but the form in which sustainability risk incorporated in accounting reports, e.g. in integrated reports, in product prices as suggested by Friedman (2009), and in other accounting measurements.

4.3.1 Research methods.

Field study research methods like those discussed above (Fagerström et al. 2009, 2007a, 2007b, Cunningham and Harris 2005) are useful to learn more about potential users of integrated reports, what they expect, different formats they prefer, and similar items. The primary research method for this issue could be experimental research along the lines used by Baker and Cunningham (1993) when assessing the perceptions of bankers about different sets of assurance standards on their loan decisions.

With respect to experiments, persons in each treatment group would be *a priori* viewed as essentially identical and making the same types of decisions following the approach of Cunningham and Baker (1992). In their study, subjects attended training and education classes sponsored by a professional bankers' association; the association supported the type of research and virtually all participants voluntarily chose to participate. The subjects for similar issues in this research agenda could be similar, not necessarily in educational classes, but groups of professionals who use reports of sustainability information. In addition, or alternatively, students could be used as surrogates for users of sustainability accounting information. Numerous accounting-related experiments using students as surrogates have been conducted and published by Michael Shields and Graeme Harrison, among others; these studies are too numerous to cite here, but can be readily located and examined. Similarly, experimental studies in sustainability under the auspices of the SIRP (www.sirp.se) have used students as surrogates for professionals who use sustainability information. These studies cite evidence that students perform as well as actual subjects in these types of experiments.

4.4 Auditing and Other Assurance of Sustainability Information

As mentioned, a major emerging issue is the extent to which users of sustainability information expect assurance; at what level, negative or positive; and in what form, supplemental or incorporated in financial measurements. A further issue is establishing both standards for sustainability reporting and standards against which assurance is given. As mentioned, the Global Reporting Initiative (GRI) provides standards for voluntary reporting of supplemental sustainability disclosures. The IIRC as part of the UN PRI is also establishing reporting standards. Studies by Fagerström et al. (2017) and Hartwig and Homayoun (2017), cited and discussed above, have provided sustainability accounting indicators (SIA) to make auditing possible.

For assurance, as one example, major accounting firms in Sweden use assurance standards published by Föreneningen Auktoriserade Revisorer (FAR) (www.far.se) (http://www.far.se/pls/portal/docs/PAGE/FAR_2010/FAR_TYCKER/INFORMATIONSMATERIAL/GRANSKNINGAVHALLBARHETSREDOVISNING.PDF), although use of such standards is apparently voluntary. FAR RevR6 is taken from (essentially a translation of) the International Standard on Assurance Engagements 3000 (ISAE 3000) (http://www.accountability21.net/uploadedFiles/Issues/ISAE_3000.pdf) developed in the Netherlands. A competing set of assurance standards, though, has been developed by AccountAbility (http://www.accountability.org/) in its AA1000 AS. Despite the organization's claim of wide-spread acceptance, there is no indication such standards are in fact widely used.

Yet another set of standards is incorporated in the Greenhouse Gas Protocol Initiative (http://www.ghgprotocol.org/).

These sets of assurance standards, while not always in direct competition because they relate to different types of sustainability information, overlap sufficiently to create uncertainty and complexity in accountants' roles of providing assurance. Because of multiple sets of standards for both reporting and assurance, yet another research topic in this agenda is criteria by which companies and organizations providing assurance voluntarily choose standards to use in reporting and in assurance engagements.

When sustainability information is included in accounting measurements, e.g. pricing products to include external resource costs and including sustainability risk in financial products, additional issues of reporting standards and assurance standards are apparent. Similar issues are presented in integrated reporting when environmental and social concerns would be included in accounting measurements. Current accounting standards in almost every country do not permit such accounting measurements; likewise auditing standards for measurements are not available.

4.4.1 Research methods

Previous research by Baker and Cunningham (1993), discussed above, is an ideal model for research on assurance levels in this research agenda. In their experiment, bank loan officers were asked to make decisions based on financial statements prepared using, among other things, different levels of audit assurance and different accounting standards. Field studies like Fagerström et al. (2009, 2007a, 2007b) and Cunningham and Harris (2005) are grounded theory approaches which are useful models to examine auditors' perceptions of different levels of assurance and standards.

4.5 Financial distress, non-compliance with financial reporting standards, and lack of enforcement

Despite the fact that past financial failures, notably Enron and sub-prime mortgage crises, have resulted in massive social costs, there is only recent recognition that financial distress, often related to failure to consider different types of sustainability risk, non-compliance with financial reporting standards, and enforcement of accounting standards, is an issue of accounting for sustainability. Friedman (2009) views ecological risk and financial distress as integrally related through inadequate accounting for risks.

Even though financial and other sustainability risks are recently receiving attention, the going concern concept has been essential in financial reporting and auditing for many years. Research would be useful to assess the extent to which users of financial information, notably banks, investment analysts, and financial analysts, view the link between financial distress risk and ecological risk as being integrally related as does Friedman (2009).

Non-compliance with financial reporting standards has been an accounting research topic for at least the last 10 years in which wide-spread non-compliance was discovered along with apparent lack of enforcement (e.g. Carrara, et al. 2010, Fagerström et al. 2009, 2007a, 2007b; and sources cited by them). Such research, though, focused on detecting non-compliance without implications for sustainability. As indicated in those studies, non-compliance with accounting standards and lack of enforcement are readily apparent to users of financial reports. Research could assess the impact on apparent non-compliance with accounting standards on users of the information, notably bankers and bank investment analysts.

A very recent study by the publishers of the Asset 4 data base has indicated that companies that report sustainable information also have abnormal returns, suggesting that investors and/or analysts do not consider sustainability information in their decisions. By implication, failure to consider sustainability risk could lead to abnormally low returns or loss through financial failure. Research is useful to assess any relation of negative or lack of reported sustainability information on low returns or failure.

4.5.1 Research Methods

This line of research could follow an approach by Baboukardos (2011, 2010) which involves content analysis of publicly listed European companies to identify lack of compliance. Examination of stock market reaction to the lack of compliance and other faulty financial information could then use the well-known value relevance model and other well-known models that assess market reactions to accounting information. Among others outputs, the well-known measurement of Tobin’s Q gives an indicator of risk.

Similar research methods can be used to assess the value relevance of negative sustainability information. In addition, the well-known bankruptcy prediction models can be used to assess the ability of negative sustainability information to signal financial failure. The existence of the Asset 4 data base now facilitates research methods using large samples and more sophisticated quantitative methods.

5.0 Concluding discussion

This purpose of this paper is to give structure to the diverse, disjointed area of research into accounting for and reporting sustainability, providing background, including identifying research issues, and methods. The introduction and background present the following premises:

- A change in focus in research and practice from external sustainability, i.e. ecological and social sustainability in the environment to a sustainable company, which can include external sustainability. Such external sustainability covers a large range of social and societal issues, some of which likely have not been imagined yet.
- Including financial sustainability as an integral part of being a sustainable company, especially with respect to risk.
- Assurance of sustainability information is essential, including audit. A change in focus from assurance for the benefit of the reporting company to assurance for the benefit of users of information is apparent.
- Postulates of financial reporting provide bases for sustainable reporting but are very inadequate for a number of reasons, including the need to report sustainability over and entire supply chain and disposal activities.

From these premises, research needs are identified:

- Inherent conflicts exist between integrated sustainability and financial reporting that must be resolved. Efforts toward integrated reporting are advancing, but no effort has occurred to resolve conflicts that must be resolved before integration can occur.
- Despite strong calls and effort towards assurance of sustainability information, there is no one set of accepted standards; a need to consolidate and develop standards is apparent. A change of focus from companies' seeking assurance to users' demands for assurance is also apparent.
- Research indicates widespread lack of compliance with accounting standards and audit failures that have led to financial failure as well as serious social consequences. Research to identify ways to overcome such failures is apparent.

The agenda then describes specific projects and methods:

- A research framework using general system methodology that, among other things, identifies and clarifies notions of sustainability, accounting roles, interested parties, and a language for analysis.
- Assessing nature and uses of sustainability information using content analysis and field studies.
- Assessing perceptions of potential users of sustainability and integrated reported through experimental research with actual subjects or surrogates.

- Assessing market reaction to sustainability information using archival and content analysis methods.

Because this is a research agenda, not a conventional research paper as such, it has many limitations. The agenda, while ambitious, gives structure and indicates a substantial change in traditional view of accounting, reporting, and auditing in a new era of sustainability and related research.

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Construction and application of Bayesian networks to support decision-making in the water, sanitation and hygiene sector: A case study of SIASAR initiative in Central America

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Abstract

The 2030 Agenda includes a dedicated goal on water and sanitation (SDG 6) that sets out to "ensure availability and sustainable management of water and sanitation for all". SDG 6 expands the MDG focus on drinking water and sanitation to cover the entire water cycle. A clear lesson from the MDGs is that we cannot manage what we do not measure, and there is little doubt about the role of monitoring and evaluation data in providing the evidence base for decision-making. Against this background, a number of composite indicator frameworks have been implemented to make water and sanitation quality services available and accessible to all, particularly to those most in need. Despite their significance in sector monitoring, indicators are not completely adequate to provide an insight into the complex cause and effect relations within water, sanitation and hygiene (WaSH) issues. The flexibility of Bayesian Networks (Bns) have been exploited to integrate multiple and simultaneous cause-effect or dependence relationships and unravel the linkages between poverty and WaSH services. In consequence, Bns have proved to be effective in project planning and monitoring support. Three major weaknesses however hinder a wider use of this monitoring approach in sector planning: i) an increased data demand, ii) software availability to run the networks, and iii) lack of a systematic methodology to deal with networks generation. In this study, open-databases are exploited and free software "R" is applied. One monitoring initiative is selected as initial case study due to its increasing relevance in Latin America in monitoring the WaSH sector: the Rural Water Supply and Sanitation Information System (SIASAR). On the basis of SIASAR's conceptual framework, a simple Bn model has been applied to reflect the main issues that determine access to WaSH services. Data from Nicaragua is processed and analysed, since the Government has already carried out and completed a national baseline. The paper discusses about i) the proposed methodology to construct the networks, and ii) the potentiality of BNs in terms of evaluation and planning. It concludes that the proposed methodology represents a contribution to facilitate the use of this tool and that Bns are able to accommodate the complexities of WaSH-related issues. Additionally, they emerge as an effective management tool to support decision-makers in formulating and making informed choices between alternative actions.

Keywords: Bayesian Networks, WaSH, decision-making, planning, SIASAR

1. Introduction

Despite the efforts made towards the Millennium Development Goals (MDGs) targets during the last decade, , it is estimated that 663 million people worldwide still use unimproved drinking water sources and 2.4 billion people globally still use unimproved sanitation facilities (Joint Monitoring Programme, 2015). Undoubtedly, much effort lasts to be done. In this context, and during 2015, the MDGs set by the United Nations gave way to a new formulation of international action, based on Sustainable Development Goals (SDGs). The SDGs seek to complete the unfinished business of the MDGs and respond to new challenges. In this way, it was adopted the 2030 Agenda for Sustainable Development to end poverty and promote prosperity for all while protecting the environment and addressing climate change. This new Agenda also has water and sanitation at its core. The agreement of a SDG target of universal and equitable access to water, sanitation and hygiene (WaSH) by 2030 requires a fundamental change in the way the sector is assessed, and multi-sectoral and system-wide approaches to monitoring and evaluation are needed.

Indicators and indices have been widely used to provide sound decision-making, and much effort has gone into the development of alternatives to evaluate WaSH issues from many disciplinary perspectives and conceptual frameworks. Thus, it is possible to find focused-approaches that tackle independently water-related (Cohen and Sullivan, 2010; Sullivan, 2002; WHO/UNICEF, 2006), sanitation-related (Giné-Garriga et al., 2011) or hygiene-related issues (Webb et al., 2006). On the other hand, more integrated approaches have been developed. WaSH-related issues have been evaluated from a Human Right perspective (Flores Baquero et al., 2013) and from a more sectoral-focused one (Giné-Garriga et al., 2015; Giné-Garriga and Pérez-Foguet, 2013; Requejo-Castro et al., 2016). Nevertheless, these approaches do not describe the increasing interdependency of the reality. For this reason, appropriate instruments are required to support decision-making with adequate information to define strategies that are efficient, effective and sustainable.

In this context, Bayesian networks (Bns) appears as a means to provide an insight into the complex dependence relations within WaSH issues. Bns are a type of model-based Decision Support System (DSS) based on the concept of conditional probability. Briefly, they are made up of three different elements (Bromley, 2005); i) a series of nodes representing a set of variables that are relevant to the problem at hand, ii) the links between these variables which represent the existing dependency among them, and iii) the conditional probability tables (CPTs) behind each node that are used to assess the extent to which one variable is likely to be affected by the others. Among its strengths, Bns allow incorporating data and knowledge from different sources and domains, and they are especially helpful when there is scarcity or some degree of uncertainty in the data (Bromley et al., 2005; Castelletti and Soncini-Sessa, 2007; Henriksen and Barlebo, 2008). Although Bns have been successfully applied for many years in fields such as medicine and artificial intelligence, it is relatively recently the application to environmental issues (Bromley et al., 2005). There are recent examples where the focus is on water resource management (Mohajerani et al. 2017; Molina et al. 2009; Castelletti and Soncini-Sessa, 2007; Henriksen and Barlebo, 2008) but there are limited examples where WaSH issues have been tackled (Dondeynaz et al., 2013; Giné-Garriga et al., 2009; Kumar and Mazumdar, 2002). In this sense, three major weaknesses hinder a wider use of Bns in WaSH sector planning: i) an increased data demand, ii) software availability to run the networks, and iii) lack of a systematic methodology to deal with networks generation.

This study aims to provide a systematic methodology for Bayesian networks construction while exploiting the potentiality of this tool to support decision making in WaSH sector. The selected case study is briefly described in Section 2. A step-by-step explanation of the proposed methodology to deal with networks generation is conducted in Section 3. Main results regarding networks structure and usefulness are presented and discussed in Section 4. Major findings are highlighted in Section 5 to conclude the study.

2. Case study

In Latin America and Caribbean (LAC) countries, a regional sector information system has been developed, namely the Rural Water and Sanitation Information System (SIASAR; Sistema de Información de Agua y Saneamiento Rural). SIASAR is a country-led monitoring initiative launched in 2011 by the governments of Nicaragua, Honduras and Panama, with the support of the World Bank and other strategic partners. Since then, this initiative has grown up rapidly and, today, it is in use in eleven countries. The main objective of SIASAR is to support decision-making of a variety of stakeholders involved in the sector (such as policy makers, national and local planners and sector practitioners). It is important to stress that this entire initiative, from the organizational to the functional levels, has been created ad hoc by the SIASAR community itself. It is not dependent on any organization or international structure and it represents a public tool and an open-database available for interested stakeholders.

The first remarkable aspect of SIASAR is its focus on those aspects that address the quality and sustainability of water and sanitation service delivery. This core idea led countries to design a set of survey instruments to analyse mentioned aspects from different perspectives: i) the community; ii) the water system; iii) the service provider; and iv) the technical assistance provider (Requejo-Castro et al., 2016).

One salient aspect of SIASAR is the manner that collected data are organised and analysed throughout its conceptual model. This is defined by six aggregated dimensions and three additional indices to assess water and sanitation services from different and complementary points of view (Requejo-Castro et al., 2016). Nevertheless, only an important amount of data is available for four of the six dimensions, and a simplification of the conceptual model is considered in this study (see Table 1).

Table 1. *General index, partial indices, dimensions and components of the SIASAR simplified conceptual model. Source: Requejo-Castro et al., 2016.*

Water and Sanitation Service Performance (WSP) index	
Water, Sanitation and Hygiene Service Level (WSHL)	**Water Services Sustainability Index (WSSI)**
Water Service Level (INSAc)	**Water System Infrastructure (IEIAc)**
Accessibility (ACC)	System Autonomy (AUT)
Continuity (CON)	Production Infrastructure (INF)
Seasonality (EST)	Water Catchment Protection (ZPA)
Quality (CAL)	Treatment system (STR)
Sanitation and Hygiene Service Level (INHS)	**Service Provision (IPSEc)**
Sanitation Service Level (NSS)	Organizational Management (GOR)
Personal Hygiene (HPE)	Operation & Maintenance Management (GOM)
Household Hygiene (HHO)	Economic Management (GEF)
Community Hygiene (HCO)	Environmental Management (GAM)

As explained in detail by Requejo-Castro et al. (2016), each dimension comprises four components, which are fed by a short list of single indicators. As collected data are frequently represented on different scales, these indicators are normalized prior to their analyses. A score between 0 and 1 is assigned for each parameter, whereby 1 represents the best performance and 0, the worst-case scenario. Components are then defined by simple and easy-to-use multi-attribute utility functions. Finally, the achieved results are made more understandable for final users and stakeholders by linking components, dimensions and index values to a defined set of categories (A, B, C or D, whereby A represents the best result and D, the worst). Although, in practice different intervals are used, in this study equal intervals are employed. Specifically, these intervals are defined as follows: A, [1–0.75], with both limits included; B (0.75–0.5]; C (0.5–0.25]; and D (0.25–0]. This aspect is especially important as they represent the states of the variables (nodes) or, in other words, the way they are parameterised.

In particular, the case study of Nicaragua has been selected, where a baseline of all rural communities (6,863), water systems (4,792) and service providers (2,585) was carried out. Nevertheless, the total number of communities which counts with values associated to all components detailed in the conceptual model is reduced to 3,495 (data available at http://doi.org/10.5281/zenodo.804010). It is noteworthy that this still represents an important amount of data that addresses one of the weaknesses introduced previously.

3. Methods

As mentioned previously, one of the aspects that hinders a wider use of Bns is the lack of a systematic methodology to deal with networks generation. First, there is an important amount of both free and commercial software available. Furthermore, existing software employ one of the three types of structure learning methods, namely constraint-based, score-based and hybrid approaches (Liu et al., 2017; Madsen et al., 2016), which increases the range of selection and the need of highly qualified people to use available options. Second, and in addition to this, it exists little guidance on how to deal with the combination of expert knowledge and data for Bns development (Nicholson et al., 2001; Oniśko et al., 2001; Pollino et al., 2007). In this context, one of the aims of this study is to provide a step-by-step methodology to address, to some extent, the existing difficulties.

3.1. Initial settings

In first instance, it is proposed the use of R free software and its package “bnlearn” developed by Scutari (2010). In this case, constraint-based and score-based methods for network structure learning are available. Briefly, the former learns the network structure by analyzing the probabilistic relations with conditional independence (CI) tests and the latter assigns a score to each candidate Bayesian network and try to maximize it with some heuristic search algorithm (Scutari, 2010). Further details of these algorithms are not provided in this study, but have been extensively described recently by Liu et al. (2017). As large amount of data is needed to guarantee the reliability of the CI tests, the database of Nicaragua is suitable for applying the constraint-based algorithm. On the contrary, score-based algorithm might be an alternative.

3.2. Networks construction

Once the initial settings have been introduced, the proposed methodology for networks generation is illustrated in Figure 1 and is specified as follows:

- Step 1: Network skeleton provision

“bnlearn” package implements the following constraint-based learning algorithms (Scutari 2010): grow-shrink (gs), incremental association (iamb), fast incremental association (fast.iamb), interleaved incremental association (inter.iamb) and max-min parent and children (mmpc). Additionally, the CI tests must be chosen regarding data typology. In this case, all values are discrete and several CI tests for discrete values are available. Regarding computing time, CI tests selection is reduced to mutual information (mi) and Pearson’s X^2 (x2) tests. By applying the combination of both algorithms and CI tests to the database, ten primary networks are obtained. It is of standing out that the network structure is learnt from data (data-driven).

- Step 2: Network selection (structure learning algorithm and conditional independence test)

In order to select the final primary network, several measures are proposed:

i) Select those primary networks which do not leave isolated an important number of nodes (variables);

ii) Provide functionality to the remaining networks. To do this, some important aspects should be taken into consideration. First, objective variables should be identified. In this study, for example, node “WSP” (general index) is considered as the objective one. Second, all variable relationships (edges) must be defined as directed links. Third, all edges pointing the objective node must be inversed. As a result, a functional network with several inputs nodes, direct links and output nodes is obtained. It should be noted that different network configurations (i.e. input nodes and links) might be elicited.

iii) Introduce evidences to compare inferred node distributions with real node distributions provided by data. Once networks are functional, one option is make a “direct use” of them. In this case, variable “A-B-C-D” (states) distributions obtained from the database of Nicaragua are assigned to the corresponding input nodes. Then, inferred results of “WSP” node can be compared with the real “A-B-C-D” distribution provided by the data;

iv) Final selection of the structure learning algorithm and CI test. To do this, an evaluation of each network inferred results must be completed. The one providing a lower bias (lower difference between inferred and real “A-B-C-D” distributions) should be selected. In those cases where results are similar, it is proposed to select that primary network which detects automatically that or those objective nodes.

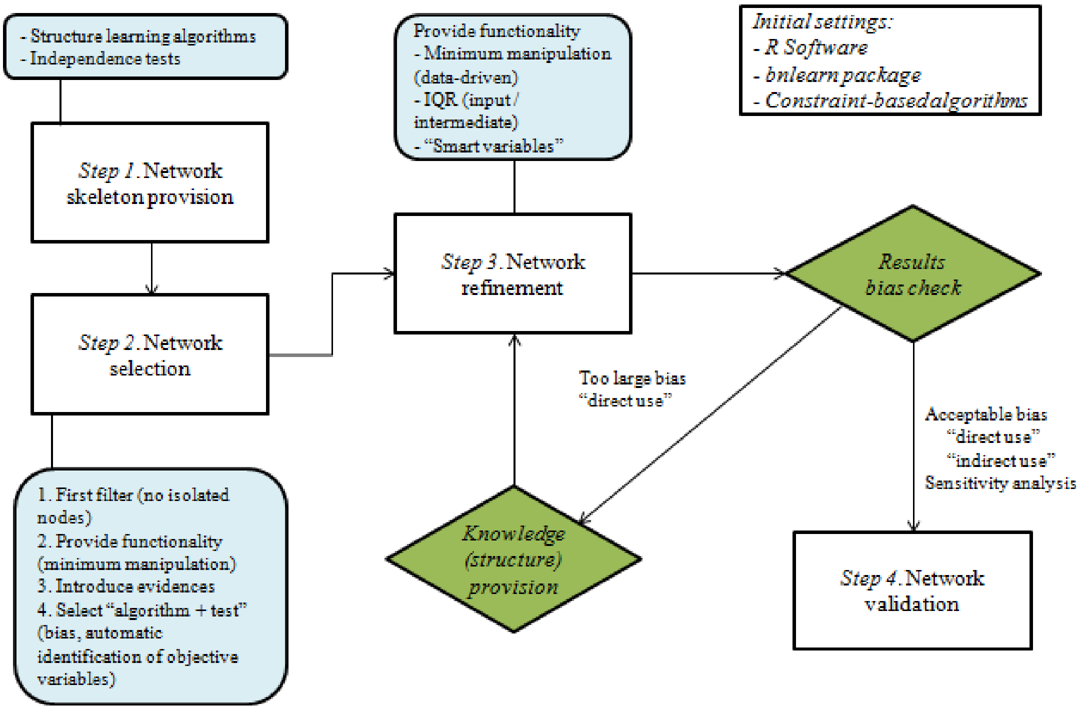

Figure 1. *Step-by-step methodology for Bayesian networks construction.*

- Step 3. Network refinement

Once the network is selected, it might occur that the bias obtained is not acceptable when inference is carried out. In order to address this drawback, it is proposed to provide structure to the network. In this case, structure is related to the conceptual model of SIASAR which, in other words, represents expert knowledge. As an illustrative example, previous steps were carried out by setting a first scenario employing those sixteen components of the conceptual model and the general index. As this bias was too large, a second scenario was simulated introducing the two partial indices as new nodes (WSHS and WSSI), complementarily to the sixteen components and general index. At this point, it should be noted that when introducing additional nodes, the processes to provide functionality to the network must be repeated (i.e. transform undirected links and inverse some edges). A third scenario was set due to the undesirable bias. Other four nodes were integrated to the network representing the four dimensions of the conceptual model (INSAc, INHS, IEIAc and IPSEc). In this way, the network gained more structure and acceptable bias was achieved.

A further refinement of the network might be done at this point. In this study, three alternatives are proposed that affect the final selection of the network input nodes. First, a “data-driven approach” is put forward. In this case, inputs nodes are selected by providing a minimum manipulation to the network (input nodes proposed by the learning algorithm and CI test). Second, an “interquartile range (IQR) approach” is proposed. Here, input nodes are associated to those variables with highest IQR (resulted from a descriptive statistic analysis). Third, a “smart variable approach”, whose input nodes are selected according to their facility for data collection in field (expert knowledge). Again, it should be noted that each alternative brings a further manipulation of network links. Finally, the alternative which provides an acceptable bias is selected.

- *Step 4. Network validation*

A final step for network validation is proposed by making an “inverse use” of it. To do this, the “A-B-C-D” distribution provided by the database is assigned to the objective node. Then, inferred results of input nodes can be compared with the real “A-B-C-D” distributions provided by the data. Again, in this case, a threshold bias between 0% and 5% established for network validation. A further step relies on the application of a sensitivity analysis. This is carried out by evaluating changes in the network in response to changes in its inputs.

4. Results and Discussion

4.1. Testing proposed methodology

According to the proposed methodology, different structure learning algorithms and CI tests were applied to the database of Nicaragua. A first scenario considered those sixteen components and the general index (WSP) of SIASAR conceptual model. From the ten different primary networks obtained in first instance, six networks provided a structure where there was a high amount of isolated nodes. Thus, only the remaining four networks were considered suitable for selection (see Figure 2).

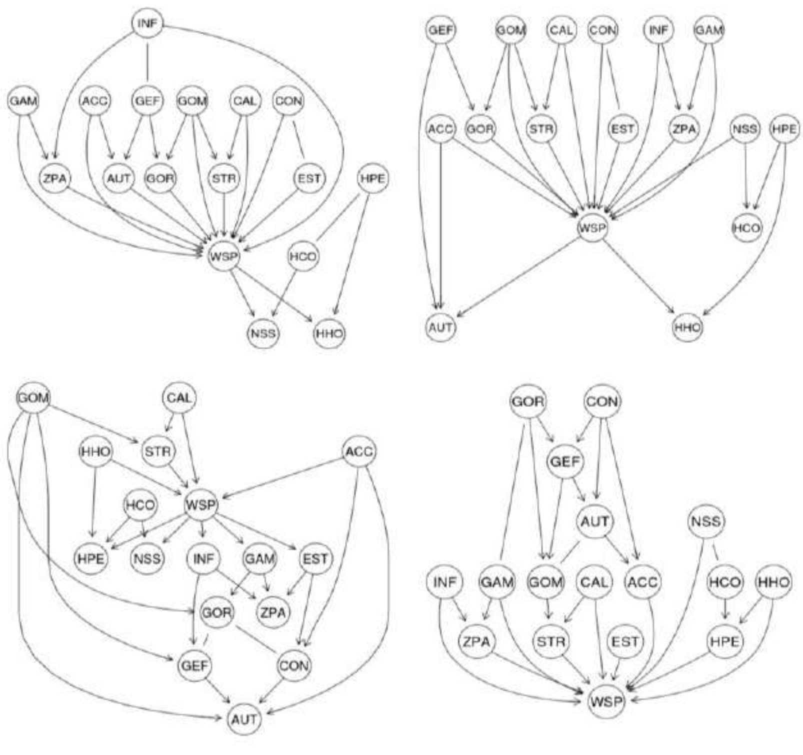

Figure 2. *Primary networks resulting from the application of different structure learning algorithms and CI tests. Top-left: fast.iamb (x2); top-right: fast.iamb (mi); bottom-left: inter.iamb (x2); bottom right: inter.iamb (mi).*

In Table 2, result biases, corresponding to the four candidate networks, over the real "A-B-C-D" distributions of objective node "WSP" are presented. As described in previous section, functionality to the networks was provided a priori (see Figure 3). Considering the network "fast.iamb (mi)" as an example, results presented in Table 2 show that, when inferring "WSP" states distribution by providing input nodes' "A-B-C-D" distributions, the model establishes that 18% and 8% less of the communities will reach an "A" and "B" grade, respectively. These biases affect, on the other hand, "C" and "D" inferred results. Note that the sum of negative and positive errors is equal. A first comparative assessment of the results shows that both "fast.iamb" networks provide a systematic unacceptable error. This is, they consider a high percentage of communities in state "C", when in reality their state is "A". This fact gives an insight to discard these networks as candidates. On the other hand, "inter.iamb" networks provide similar results. As pointed in previous section, a proposed criterion for network selection falls on the automatic identification of objective nodes. In this case, the network "inter.iamb (mi)" is chosen in last instance (see Figure 1).

Table 2. *Resulting biases over WSP node A-B-C-D distribution. Results are obtained by subtracting the values provided by the database to those provided by the model (i.e. WSP_{model} - $WSP_{database}$)*

	Bias over A-B-C-D grade system (states) of WSP node			
Network	A (0.0804)	B (0.5436)	C (0.3570)	D (0.0289)
fast.iamb (x2)	0.1727	0.1120	-0.2583	-0.0289
fast.iamb (mi)	0.1811	0.0866	-0.2388	-0.0289
inter.iamb (x2)	0.0212	0.1599	-0.1533	-0.0277
inter.iamb (mi)	0.0366	0.1756	-0.1840	-0.0282
In brackets, real "A-B-C-D" distributions of node WSP obtained from Nicaragua database				

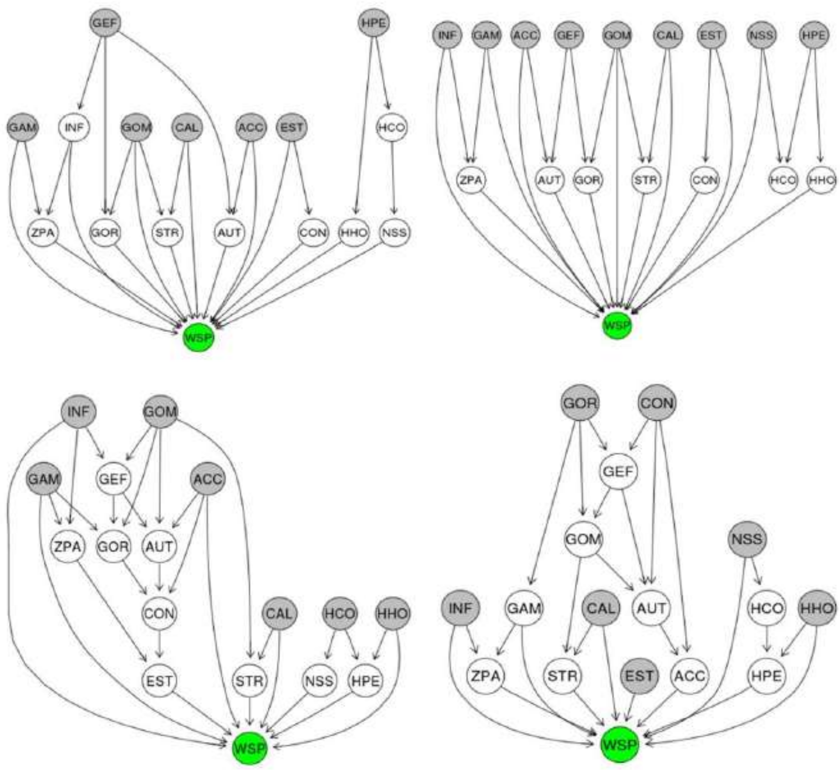

Figure 3. *Functionality provision to networks. In grey, input nodes. In green, objective node (output node). Top-left: fast.iamb (x2); top-right: fast.iamb (mi); bottom-left: inter.iamb (x2); bottom right: inter.iamb (mi).*

However, resulted biases are considered too large. Thus, expert knowledge (in terms of structure) is provided to the selected network. In this case, expert knowledge is related to the provision of structure according to the conceptual model of SIASAR. As shown in Figure 4, a second scenario is tested by integrating WSHS and WSSI nodes, which represent the partial indices of the conceptual model. As acceptable biases were not reached yet, a third scenario was set out by including those nodes representing the four dimensions of the conceptual model (INSAc, INHS, IEIAc and IPSEc). At this point, it should be highlighted that in both cases same input nodes were maintained for the comparison. In parallel, it should be noted that the more expert knowledge is provided to the network (defined structure), the more manipulation must be done to the network.

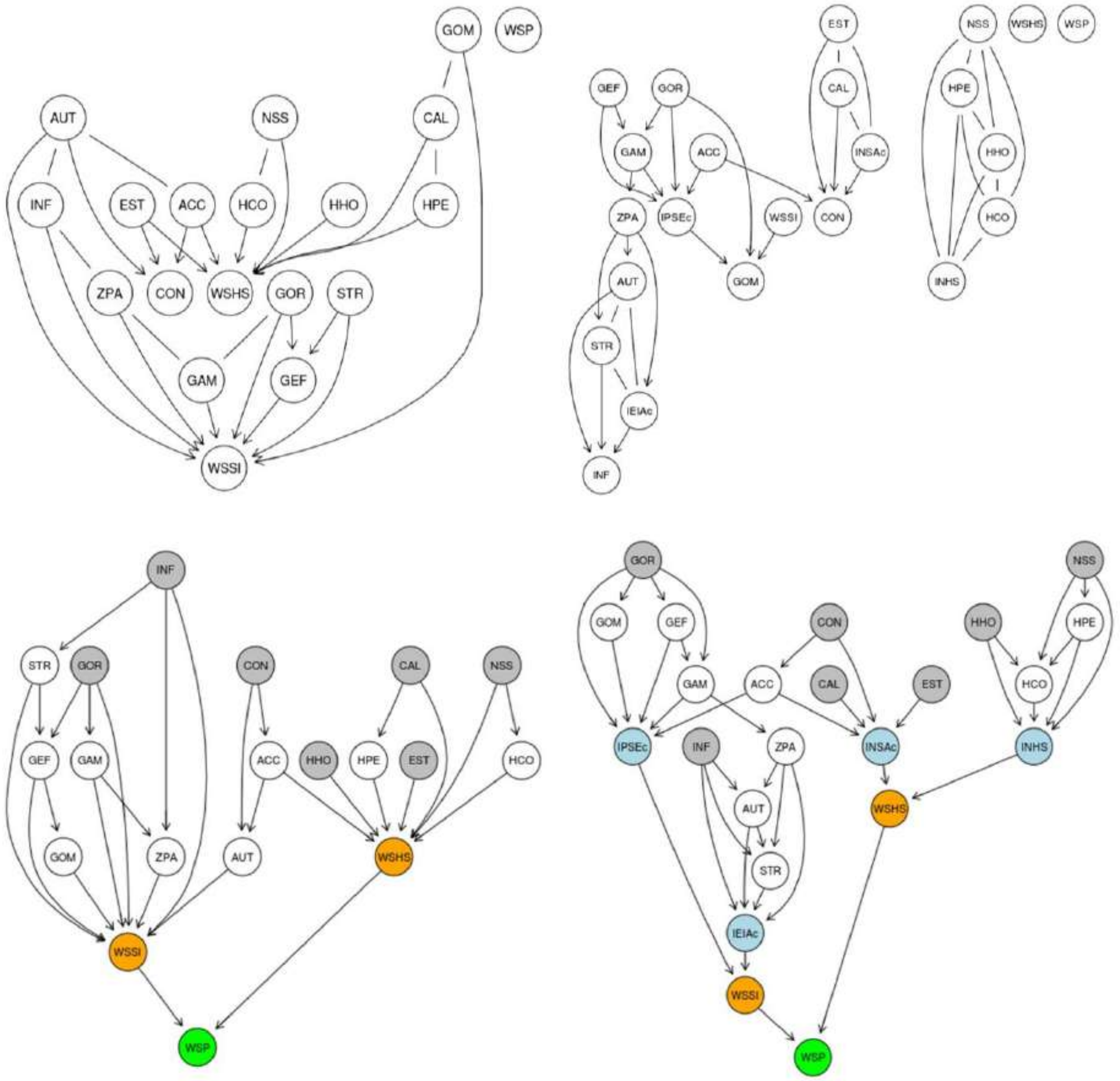

Figure 4. *Expert knowledge (structure) provision to networks. In grey, input nodes. In blue, nodes representing SIASAR conceptual model dimensions. In orange, nodes representing SIASAR partial indices. In green, objective node (output node). Top-left: primary network of scenario 2; top-right: primary network of scenario 3; bottom-left: manipulated network of scenario 2; manipulated network of scenario 3.*

The network, generated from the third scenario tested, provided acceptable results regarding resulted bias. This fact provides an insight of how expert knowledge (in terms of structure) improves model inference capacity. Until this stage, it should be reminded that a "direct use" of the network has been done. The next step was to validate the model by applying to an "inverse use" of the network. This is, checking the inferred values of the input nodes, given the "A-B-C-D" distribution of the output node of "WSP". In Tables 3 and 4, results from both direct and inverse use of the network are presented. From the three proposed alternatives for network refinement (i.e. "data-driven", "IQR" and "smart-variables" approaches), data-driven network (minimum manipulation) provided better results. When applying the "direct use" of the network, few cases reach an error over 5%. This might be considered unacceptable when envisaging important investments at national scale. In order to counteract this error, it is proposed a simple action when new evidences (new "A-B-C-D") distributions are provided to the network. Considering the real distributions as "x" and the inferred values as "y", the difference "x - y" (bias) is provided in Table 3. When new evidences are provided, new inferred values "z" are obtained. In this way, a correction of the results should follow the operation "z - (x - y)". On the other hand, results obtained when applying the "inverse use" of the network are acceptable. A final step, regarding a sensitivity analysis is also carried out. However, due to its pertinence with the potential use of Bns, it will be introduced in the next Section.

Table 3. *Resulting biases over network node's A-B-C-D distributions ("data-driven approach").*

	Bias over A-B-C-D grade system (states)			
Nodes of interest	A	B	C	D
WSP	-0.0379	*0.0577*	-0.0032	-0.0166
WSHS	-0.0313	*0.0659*	-0.0236	-0.0110
WSSI	-0.0439	*0.0694*	-0.0107	-0.0075
INSAc	-0.0289	*0.0694*	-0.0227	-0.0178
INHS	-0.0428	*0.0660*	0.0005	-0.0238
IEIAc	-0.0161	0.0264	-0.0038	-0.0065
IPSEc	-0.0125	0.0151	-0.0030	0.0005
In Italics, those errors higher than 5%.				

Table 4. *Resulting biases over network input node's A-B-C-D distributions ("data-driven approach").*

	Bias over A-B-C-D grade system (states)			
Input nodes	A	B	C	D
CON	-0.0020	0.0009	0.0018	-0.0008
EST	-0.0068	0.0003	0.0029	0.0035
CAL	-0.0078	0.0037	0.0050	-0.0009
NSS	-0.0063	0.0010	0.0035	0.0017
HHO	-0.0048	-	0.0038	0.0009
INF	-0.0031	0.0039	-0.0001	-0.0007
GOR	0.0137	0.0059	-0.0061	-0.0135
Note that HHO node states are only A, C and D.				

At this point, it emerged the question to which extend this network might be used in other contexts. In order to answer this query, network input nodes were populated with the data of Honduras (3,869 communities, 3,123 water systems and 3,373 service providers). Following the same considerations than the case of Nicaragua, only those communities that count with values associated to all components detailed in the conceptual model are employed for the analysis. Thus, 3,608 communities fulfil this requirement (data available at http://doi.org/10.5281/zenodo.804010). Results reached too large biases (up to 13%). However, the proposed step-by-step methodology was applied for this country. In this case, "fast.iamb (x2)" was the final selection of structure learning algorithm and CI test. Accordingly to the case of Nicaragua, lower biases were obtained when providing expert knowledge under a "data-driven" approach. In Table 5, final results (in terms of errors) are provided. It can be seen that in few cases the bias reaches the value of 8%. In these cases, the proposed actions for error correction should be applied. On the other hand, when "inverse use" of the network was enforced, acceptable biases up to 1% were achieved. In this way, it is demonstrated the applicability of the proposed methodology for network construction. As it can be seen in Figure 5, this methodology might provide different network adapted to each county context.

Table 5. *Resulting biases over network node's A-B-C-D distributions for the case of Honduras ("data-driven approach").*

	Bias over A-B-C-D grade system (states)			
Nodes of interest	A	B	C	D
WSP	0.03963	*-0.07949*	0.03413	0.00573
WSHS	0.01845	-0.04564	0.02330	0.00388
WSSI	0.04954	*-0.08673*	0.02497	0.01222
INSAc	0.00658	-0.01247	0.00308	0.00281
INHS	0.03813	*-0.08755*	0.03539	0.01402
IEIAc	0.02088	-0.03521	-0.00263	0.01695
IPSEc	0.03762	*-0.05430*	-0.00109	0.01777
In Italics, those errors higher than 5%.				

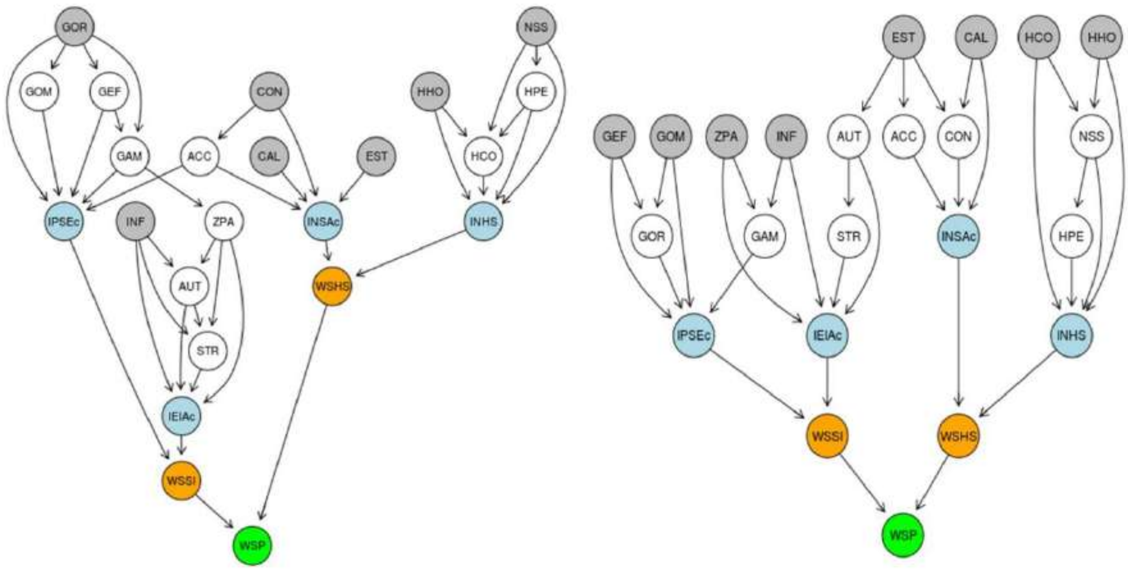

Figure 5. *Final networks obtained due to proposed methodology application. On the left: the case of Nicaragua; on the right: the case of Honduras.*

4.2. Testing the potentiality of Bayesian networks

4.2.1. "Direct use" of networks

During the process of network construction, a direct use of the networks was applied to infer distributions of the objective node (i.e. "WSP") from the provision of the "A-B-C-D" distribution of input nodes. This application might be expanded to evaluation processes where, for example, the impact of the implementation of different actions or scenarios is to be assessed. In this study, an illustrative example is provided bringing all inputs nodes (individually) to the state "A" at 100% and analysing the impact on the output node "WSP" (see Table 6). In parallel, the correction of the bias has been carried out following the results shown in Table 3. As to facilitate results understanding, in Table 7 "A-B-C-D" distributions obtained from Nicaragua database are presented. Two main observations can be made from these results. First, those inputs nodes with lower qualifications (higher frequencies of "C" and "D" states) induce a greater impact on the output node. For example, an optimal sanitation and hygiene service level (NSS) would increase in around 3% and 6% of the total of those communities qualified by "A" and "B", respectively. At this point, it should be pointed that the general index of SIASAR is calculated at community level. Even if the entities are measured independently (i.e. water system and service provision), they are projected to the community. Another example shows that if the organizational management of the service providers is brought to optimal conditions, around 18% of the total communities would pass from "C" and "D" states to "A" (6%) and "B" (12%) states. The second main aspect to highlight is the robustness of the model when testing such a scenario. Only in the case of an extreme change in a node (i.e. "GOR"), the model experiments a remarkable impact. It should be highlighted that this sensitivity analysis is recommendable to place it in the validation process. However, it was suitable to present it this Section due to its relationship with impact evaluation.

Table 6. *Impact on node WSP brining input nodes to state "A" at 100%. Proposed method to counteract the systematic bias has been applied.*

	Impact over A-B-C-D grade system (states) of WSP node			
Input nodes ("A" = 100%)	A (0.0804)	B (0.5436)	C (0.3570)	D (0.0289)
CON	0.0122	0.0244	-0.0344	-0.0021
EST	0.0076	0.0224	-0.0278	-0.0022
CAL	0.0106	0.0333	-0.0409	-0.003
NSS	0.0267	0.0576	-0.0791	-0.0052
HHO	0.0245	0.057	-0.0754	-0.0061
INF	0.0102	0.0376	-0.0461	-0.0016
GOR	0.0582	0.1181	-0.1649	-0.0115
In brackets, real "A-B-C-D" distributions of node WSP obtained from Nicaragua database. Note that HHO node states are only A, C and D.				

Table 7. *Input nodes distribution obtained from Nicaragua database.*

	Node states distribution			
Input nodes	A	B	C	D
CON	0.5688	0.1450	0.1170	0.1690
EST	0.6469	0.1914	0.0469	0.1147
CAL	0.6329	0.0695	0.0120	0.2855
NSS	0.3665	0.2312	0.1488	0.2535
HHO	0.3920	-	0.4707	0.1373
INF	0.5450	0.3256	0.0781	0.0512
GOR	0.1202	0.2426	0.2638	0.3734
Note that HHO node states are only A, C and D.				

Finally, it is noteworthy to mention the importance of designing strategies that embraces actions in all dimensions, as improving service delivery is not only a business of implementing isolated actions such as providing new water and sanitation infrastructure. For this reason, Bns is suitable to deal with more complex problems. For simplicity, in this study the focus was not on the assessment of a wider range of scenarios or the interlinked impact among nodes, but it should be pointed out.

4.2.2. "Inverse use" of networks

This manner of using the network was applied when dealing with the validation process. However, this possibility might be useful for planning purposes. In this sense, desirable results might be established over the objective node "WSP" and new values for the input nodes would be obtained. Thus, these results might be useful to optimize the interventions in order to achieve the expected results. In this study, it is presented two alternatives to deal with the inverse use of networks. The first one refers to the provision of "hard evidences", while the second one deals with the so called "soft evidences". When providing hard evidences to a node, this is brought to one specific state. In the example shown in Figure 6, node "WSP" is considered at "A" state and the required values in input nodes are obtained. Considering current situation of "WSP" node (8% A; 54% B; 35% C; 3% D), it is logical that all nodes need to be improved drastically. As mentioned previously, in order to reach an overall upgrade of the water and sanitation performance (WSP), simultaneous measures should be taken place. In this case, an average of 20% gain in all nodes in relation to "A" state is needed. This is associated to the importance and the complexity to address aspects regarding continuity of service (CON), quality of water (CAL), sanitation coverage (NSS), water infrastructure (INF) or organizational capacities of the service provider (ORG).

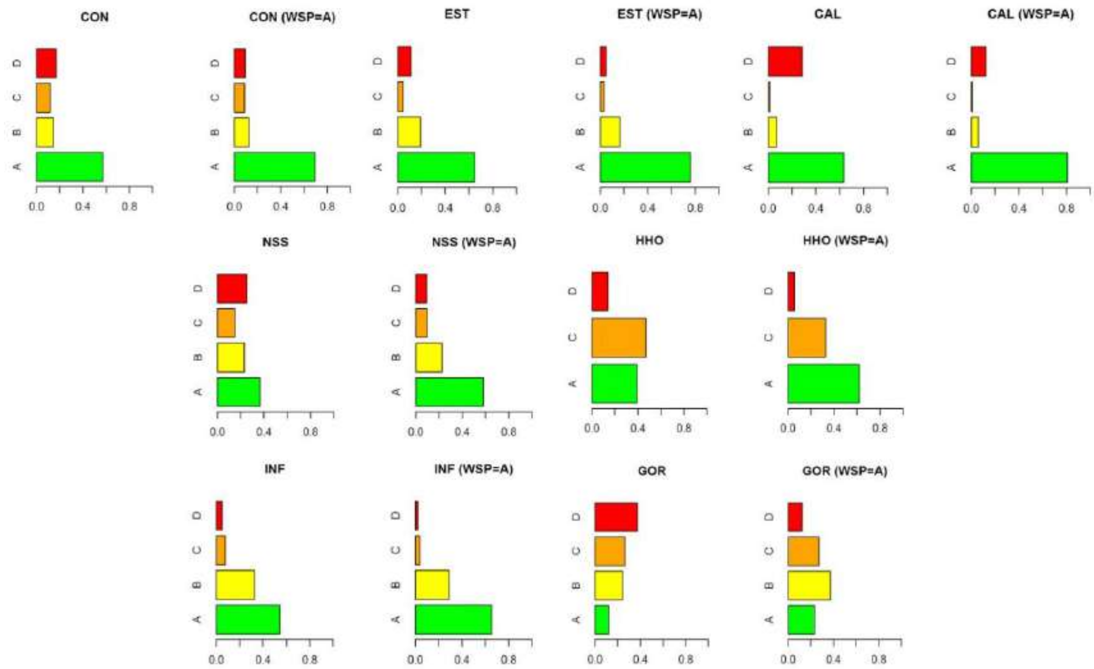

Figure 6. *Improvements required in input nodes setting WSP node to "A" state.*

On the other hand, a more realistic approach is to provide soft evidences. This is related to the assignment of different percentages to the different states. As an example, it might be established a goal of reaching a 15% of communities at "A" state and 85% at "B" state, as presented in Figure 7. However, any other configuration is possible. At this point, it must be mentioned that the "bnlearn" package does not facilitate to deal with soft evidences. Nevertheless, this drawback is easily tackled by recalling the second axiom of the conditional probability. This axioms states that "for any two mutually exclusive events "a" and "b", the probability that either "a" or "b" occur is the sum of their probabilities" (see eq. 1). In this case, a community cannot be at two states simultaneously. Then, the procedure is to separate the calculations. First, "WSP" is set at 100% of "A" state and second at 100% "B" state. Finally, results of input nodes are multiplied by the proposed configuration (15% "A" and 85% "B") and the sum is carried out.

$$P\ (\text{"A" or "B"}) = P\ (\text{"A"}) + P\ (\text{"B"}) \quad \text{(eq. 1)}$$

From Figure 7, it can be seen that, for reaching desirable goals, those aspects regarding sanitation coverage (NSS) and service provider organizational management (ORG) require a higher improvement. While other nodes need a progress as well, these results might provide an insight to develop specific interventions in order to achieve the expected results.

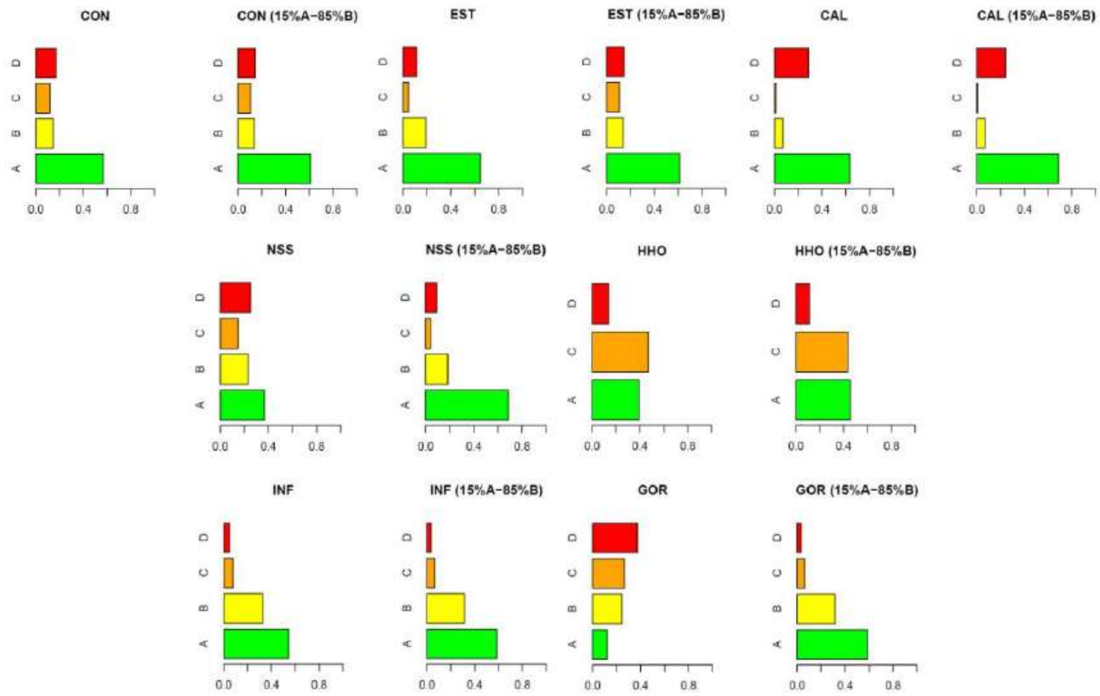

Figure 7. *Improvements required in input nodes providing WSP node with soft evidences (15% "A" and 85% "B").*

5. Conclusions

This study aims to provide a systematic methodology for Bayesian networks construction while exploiting its potentiality to support decision making in WaSH sector. To do this, the Rural Water and Sanitation Information System (SIASAR) initiative has been selected as an initial case study. Furthermore, SIASAR open-database has been exploited for the case of Nicaragua by applying the free software "R" and its specific package "bnlearn". On the basis of SIASAR's conceptual framework and supported by a proposed methodology for networks construction, a simple Bn model has been applied to reflect the main issues that determine access to WaSH services.

As a far as the proposed methodology to deal with networks generation, it is concluded that it provides a useful contribution to facilitate a wider use of this tool in order to accommodate the complexities of WaSH-related issues. This step-by-step method has been applied successfully to two different contexts and it has been demonstrated the robustness of the model obtained. Although slight undesirable biases are provided by the model, it has been provided a mechanism to counteract this drawback.

In parallel, it has been demonstrated the potentiality of Bns. First, the "direct use" of the networks has been applied. This utility supports decision-makers in evaluating and making informed choices between alternative actions. Second, by exploiting the "inverse use" of Bns, it has been shown the advantages in sector planning. When dealing with important investments, it is presented as a useful management tool to optimize the interventions in order to achieve the expected results.

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Integration of habitat quality index with physicochemical and ecological models oriented to the ecosystem recovery in the Meléndez River, Cali-Colombia

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Abstract

The ecological quality water in Meléndez River at the medium and low basin was evaluated through the application of water quality and pollution indexes in the ecosystem by using physiochemical parameters and its association with aquatic macroinvertebrates. In addition, a pollution control scenario was evaluated by the application of a simplified dissolved oxygen model of Streeter Phelps, in the most critical loads into the river. This study was performed in the winter period of the last quarter of the year 2016. The aim of this project was to find the actual ecological situation in the river in order to create a baseline study necessary for the future environmental improvement of the city. In general, the ecological water quality index showed a significant alteration of the riverside forest at the middle basin and an extreme degradation at the lower part. On the other hand, the physiochemical parameters results showed high dissolved oxygen levels (7.21 mg / L at the middle basin and 6.63 mg / L at the low basin), pH very close to neutrality in all stations, BOD5 and COD with values that did not exceed 12 mg/L, whereas fecal coliforms presented high levels at the low basin (up to 66000 CFU) showing a certain degree of contamination in the lower river basin. A total of 22041 macroinvertebrates individuals from 7 different families were obtained by the catching methods which indicates according to the BMWP-Col index that the river presents very polluted waters due to the discharges of domestic wastewaters. The measured physicochemical parameters and the macroinvertebrates species presented good correlations according to the canonical correspondence, whit strong associations in the X axis with pH (0.940) and OD (0.919), while in the Y axis a strong correlation with the BOD (0.819). This project contributes to explore new issues to discuss about our ecosystem´s resources and how our environmental authorities can improve their care through the use of ecological indices, models and its correlation with the aquatic macroinvertebrates providing a frequently tracing spatial and temporal in our Rivers.

Keywords: aquatic macroinvertebrates, ecological quality, sustainability indicators, Streeter Phelps model, Meléndez River.

1. Introduction

The aquatic ecosystem qualities are characterized by the continuous and rapid flow of its waters; these generate special conditions for the organization of structures in which life and basic ecological processes such as: flows of energy, matter, information, biodiversity and succession (Universidad Nacional de Colombia, 2010).

After the conference in Rio de Janeiro on the decline of biodiversity in tropical ecosystems, the governments of the United Nations (UN) countries made every effort to preserve the oceans and dry tropical forests. However, in such efforts, ecosystems as fragile and important as those developed in rivers have never been taken into account before (Segnini, 2003).

The diversity of life forms that integrate aquatic communities is related to the variety of physicochemical attributes of water bodies and their banks. The topographic heterogeneity within the river favors habitat diversity, which in turn is often related to greater biological diversity at each site (Sanchez et al., 2007). In relation to the above, several studies have argued that the recovery of an aquatic ecosystem in a river should not only be based on the evaluation, monitoring and control of the physicochemical parameters of water as has traditionally been done in Colombia. In order to improve the traditional monitoring that has been used in Colombia, the environmental authorities need to adopt complementary strategies that allow an easy and effective evaluation of the necessary conditions to recover or preserve these water sections (Luna, 2009).

The Project “Corredor verde de Cali”, moving by the urban renewal in favor of the qualitative and quantitative recovery of the environmental quality in the city, proposes the study of the quality of the rivers by which the project will be traced. These studies found that the water quality of the Meléndez River, which is one of the most important in the city of Cali, with a length of 25 km (Secretaria de Salud de Santiago de Cali, 2010) crossing the city from west to east, is in a state of marked deterioration and needs an immediate restoration process in their ecosystem.

This research was achieved in order to present a prefeasibility study in the use of bio indicators of water quality as a complement to the physicochemical monitoring of water currently accomplish by the environmental authorities in Cali, Colombia. This study of the aquatic ecosystem in the river is carried out under the concept of "ecological status" proposed by the EU Water Framework Directive (Directiva Marco del Agua, S.F)

2. Methods

2.1. Study area

The middle basin of the Meléndez River is located in the western slope of the rural territory in Cali, Colombia. This study covered about 13 km of course starting in the middle basin and ending in the vicinity of its mouth in an artificial collector canal (Collector Sur Canal). A total of five stations were used for riverbank forest monitoring and four stations for physicochemical, hydrobiological and microbiological monitoring like Figure 1 shows.

Figure 1. Monitoring stations evaluated in Meléndez River.

Meléndez River has an extension of 25km from west to east with altitudes ranging between 2800 and 1000 meters above sea level (m.a.s.l) (DAGMA, 2014). The middle basin of this river presents altitudes from 1800 m.a.s.l with very soft slopes that end when it arrives to Cali at about 994 m.a.s.l; In this zone a bush vegetation and erosion problem predominate. At first glance, water at the beginning of the middle basin present a good quality that is deteriorating little by little in its downstream path due to the wastewater discharges of the hillside population, the deforestation of its riverside forest and the Recreational misuse of its waters by the settlers

2.2. Physico-chemical, microbiological and hydrobiological parameters checked in this monitoring

Samples of one liter (river water) were taken in zones of the canal where the stream of water will not carry a turbulent flow in each one of the four selected stations; In situ, the water temperature and flow rate was measured. Subsequently the water samples were taken to the laboratory to measure physico-chemical parameters such as BOD5, COD, total alkalinity, conductivity, dissolved oxygen, pH, total suspended solids, total and fecal coliforms, in order to evaluate quality and pollution indices.

At the same time, a hydrobiological sampling was carried out to determine the quality of the habitat through the use of qualitative and quantitative biological indices. This type of sampling is not currently used in the city of Cali to evaluate water quality, so this prefeasibility assessment evaluated the benthic macroinvertebrate species that inhabit the Meléndez River (related to the specific sample day).

In a second course, the riparian forest quality was analyzed, taking into account parameters such as forest density, native species, and their connectivity, as Munné et al. (2003) had explained in the QBR index.

Due to the limited monetary resources in this study, only a spatial monitoring was performed (a single sample without repetitions), for this reason the results obtained in this work should be supported with more monitoring campaigns that strengthen the statistics with which it currently counts.

2.2.1 Quality index for River waters. In this work we chose to apply the calculation of the Water Quality Index developed by the United States National Sanitation Foundation (WQI-NSF) which is commonly used by expert's panels (University of Pamplona, S.F). This index was calculated by the mathematical expression of the WQI aditive shown below:

$$WQI_a = \sum_{i=1}^{n} I_i W_i$$

Where: I= Subscript value of each parameter**, i=** Quality parameter that is being evaluated**, W=** Relative Weight of each parameter.

The subscript value depends on the curve that describes its function with each parameter. (The graphs can be reviewed in the study of the Universidad de Pamplona, (S.F)). In these graphs the subscript is a variable dependent on the value of each physicochemical parameter. The relative weight of each parameter in the total value of the index depends on the number of variables selected (in this case nine variables like table 1 shows). Likewise the value of this subscript can be calculated mathematically as was done in this study with the ICATest v.1.0 software.

Table 1. Variables and weights for the case of nine parameters

Parameter	measurement (units)	Relative weight (%)
Dissolved Oxygen (DO)	% saturation	17
fecals Coliforms	CFU	16
pH	pH units	11
BOD_5	mg/L	11
phosphates	mg/L	10
Nitrates	mg/L	10
Temperature	°C	10
Total Solids	mg/L	7
Turbidity	NTU	8

Finally the water quality in each station is given by the values that table 2 shows.

Table 2. WQI-NSF rating ranging (Universidad de Pamplona, 2003)

WQI-NSF Value	Classification
90-100	Excellent quality
70-90	Good quality
50-70	Medium quality
25-50	bad quality
0-25	Extremely bad quality

2.2.2 Pollution indices in Rivers waters. The pollution indices (PI) allow to measure the water quality problems with more precision and less subjectivity compared to WQI indices, showing specific pollution parameters. The pollution indices applied in this study and the water quality values (look at table 3) are shown below; these indices can be calculated mathematically as was done in this study with the software ICATest v.1.0.

- Mineral Contamination Index (MIPI)
- Contamination Index by Organic Matter (PIOM)
- Contamination Index by suspended solids (PISUS)
- Contamination Index by pH (PIpH)

Table 3. Pollution rating ranging (Luna, 2009)

Pollution level	values	Colour
Nothing	0-0,2	Blue
Low	0,2-0,4	Green
Medium	0,4-0,6	Yellow
High	0,6-0,8	Orange
Extremely High	0,8-1	Red

2.2.3 QBR Index. The characterization of the riparian forest state was carried out on 80m trajectories, which is within the range recommended by Munné et al. (2003), which proposes that it must be between 50m and 100m. This index is applied on both River banks and taking into account all riparian vegetation as well as its connectivity with the studied forest path.

After applying the index, the quality of the riparian forest is evaluated according to the criteria shown in table 4.

Table 4. QBR index rating ranging (Munné et al. 2003)

Score	Quality	Colour
≥90	Bank without alterations, natural state	Blue
71-90	Bank Slightly disturbed, good quality	Green
51-70	Start of a significant alteration, acceptable quality	Yellow
30-50	Strong Alteration, bad quality	Orange
0-29	Extreme degradation, really bad quality	Red

2.2.4 Qualitative and quantitative ecological indices. BMWP Biological Index. Is a method of assessing water quality using the families of insects - e.g. mayflies and stoneflies - and other aquatic invertebrates such as freshwater shrimps present in a river. Species are allotted points to rank their importance in the ecosystem, the less tolerant a group of invertebrates is to pollution the higher the points they are allotted.

The organisms identified at each monitoring station are assigned a rating, ranging from 1 to 10 according to the family which it belongs as can be seen in table 5. The points obtained are summed by each monitoring station and its quality is established through the criteria shown in table 6

Table 5. Scores assigned to aquatic macroinvertebrate families for the BMWP/Colombia index (Torres, 2007)

Families	Score
Perlidae, Oligoneuridae, Helicopsychidae, Calamoceratidae, Ptilodactylidae,Lampiridae, Odontoceridae, Blepharoceridae, Psephenidae, Hidridae, Chordodidae, Lymnessiidae, "hidracáridos", Polythoridae, Gomphidae	10
Leptophlebiidae, Euthyplociidae, Leptoceridae, Xiphocentronidae, Dytiscidae, Polycentropodidae, Hydrobiosidae,Gyrinidae	9
Veliidae, Gerridae, Philopotamidae, Simulidae, Pleidae, Trichodactylidae, Saldidae, Lestidae, Pseudothelpusidae, Hebridae, Hydrobiidae	8
Baetidae, Calopterygidae, Glossossomatidae, Corixidae, Notonectidae, Leptohyphidae, Dixidae, Hyalellidae, Naucoridae, Scirtidae, Dryopidae, Psychodidae, Coenagrionidae, Planariidae, Hydroptilidae, Caenidae	7
Ancylidae, Lutrochidae, Aeshnidae, Libellulidae, Elmidae, Staphylinidae, Limnychidae, Neritidae, Pilidae, Megapodagrionidae, Corydalidae	6
Hydropsychidae, Gelastocoridae, Belostomatidae, Nepidae, Pleuroceridae,Tabanidae, Thiaridae, Pyralidae, Planorbidae	5
Chrysomelidae, Mesovelidae, Stratiomidae, Empididae, Dolicopodidae, Sphaeridae, Lymnaeidae	4
Hirudinea (Glossiphoniidae, Cyclobdellidae), Physidae, Hydrometridae, Hydrophilidae, Tipulidae, Ceratopogonidae	3
Chironomidae, Culicidae, Muscidae	2
Oligochaeta (Tubificidae)	1

Table 6. Types of water quality according to BMWP (Torres, 2007)

Type	Quality	BMWP/COL	Meaning	Colour
I	Good	>150 101-120	Very clean, uncontaminated or poorly altered waters	Blue
II	Acceptable	61-100	Slightly altered water	Green
III	Doubtful	36-60	Moderately contaminated water	Yellow
IV	Critic	16-35	Very polluted waters	Orange
V	Very Critic	<15	Strongly contaminated water	Red

The Jaccard dissimilarity or affinity index (1908). With the application of this index it is possible to evaluate the similarity of the species between sampling stations by means of the following expression:

$$\mathbf{A} = \frac{\mathbf{C}}{(\mathbf{A} + \mathbf{B} - \mathbf{C})}$$

Where: C= Number of common species for A and B**, A=** Number of present species in the evaluated area **A, B=** Number of present species in the evaluated area B.

These results will be between 0 and 1 where zero will correspond to the stations where there are no species in common and 1 when there are a large number of species in common.

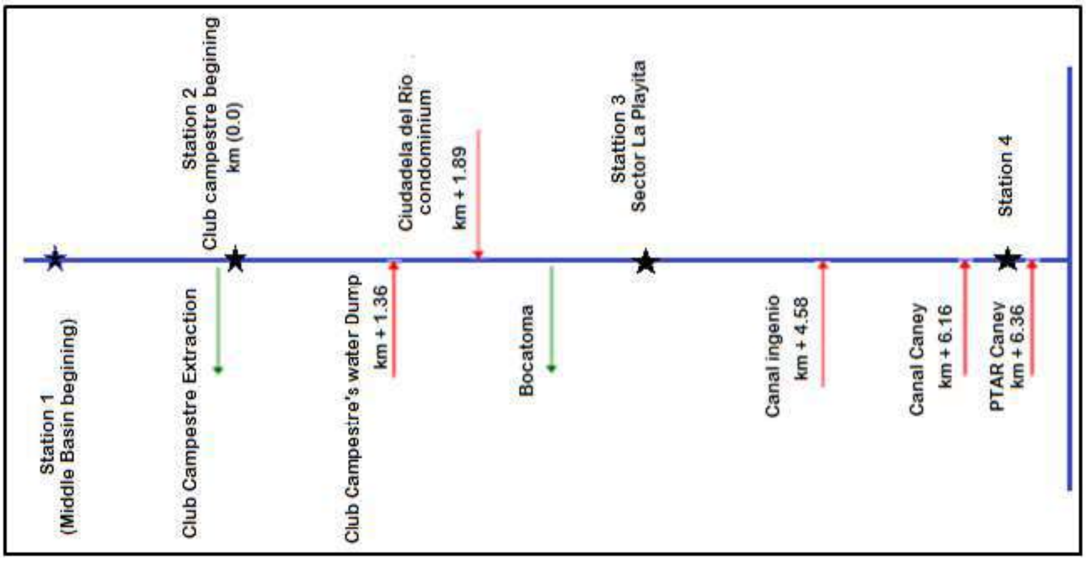
2.2.5 Association between physicochemical and biologic parameters Due to the magnitudes of the physicochemical and biological variables are notoriously different, they were transformed into the Log_{10} (X + 1) form in order to approximate and simplify the possible association between these variables and to perform the canonical correspondence analysis; all this was done in the free software PAST v. 2.16. Two dimensional axis are plotted by the software PAST, where positive or negative correlations between the environmental variables and the presence of the families of macroinvertebrates are found.

2.2.6 Dumping sewage reduction model. Given the conditions and availability of information, in this study we choose to perform a water quality modelling in the lower basin of the river through the mathematical model of multiple point sources proposed by Streeter-Phelps, which describes the change of the organic matter concentration and the dissolved oxygen deficit (OD) according to the saturation oxygen specific to the section evaluated.

The secondary information available show the impact of 4 dumps and two extraction points in the studied section of the river Meléndez. Due to the short budget, the deoxygenation coefficient k_d was estimated under the conditions of a river with medium-low pollution where the values are in a range between $0.10d^{-1}$ and $0.12d^{-1}$ according to the document Of Suarez, (2008). On the other hand, the coefficient of sedimentation k_s was assumed under the values recommended by the study of Kannel et al. (2007), which oscillate between 0 days $^{-1}$ and 5 days $^{-1}$.

The removal scenario showed in the figure 2 proposed in this model, two discharges with the greatest negative impact on the river will be eliminated through a treatment with removal efficiency in the organic load of 80%.

Figure 2. Modelling scenario (red arrows= Dumping, Green arrows=extraction). Adapted of (DAGMA and Universidad del valle, 2004)



3. Results and discussion

The results for the measured parameters of the physicochemical and microbiological quality in the Meléndez River for a day of high precipitation in the second winter season (November 2016) are shown in Table 7 and Table 8.

Table7. Chemical and biological parameters results.

S	pH	Hardness	S.S	NO_3-	Cond	DO	COD	Sat. O.	PO_4^{-3}	Alk.	T. Col.	F. Col.	BOD_5
1	6.88	112.10	2	6.7	48.1	7.21	1.0	84.42	0.65	56	60*	280*	0.33
2	6.96	184.16	9	7.2	82.8	7.34	11.4	95.69	0.28	92	14800	21200	1.84
3	6.92	224.20	7	8.4	98.6	7.03	5.5	91.65	1.41	112	8800	29600	0.98
5	6.79	244.22	8	9.2	109.7	6.63	2.1	86.44	0.48	122	VOR*	66000	1.67

Where: S= Station, Hardness= Hardness (mg CaCO3/L), S.S = suspended solids (mg/L), NO_3^- = Nitrates (mg/L), Cond = Conductivity (µS/cm), DO = Dissolved Oxygen (mgO2/L) COD = Chemical Oxygen Demand (mg/ L), Sat. O = Saturation Oxygen (%), P = total phosphorus (mg/L), Alk = alkalinity (gCaCO3/m3), T. Col. = Total coliforms (CFU/100mL), F. Col. = Fecal Coliforms (CFU/100mL), T. Col.* and F. Col.* = analyzed sample without dilution (CFU), BOD_5 = Biological Oxygen Demand (mg/L), VOR* = Value out of range, it takes the value of 200000 CFU/100Ml (IDEAM,2007).

Table 8. Physical parameters results.

Station	Turbidity (NTU)	Temperature (°c)	Flow (L/s)
1	8.20	18.0	388.32
2	8.88	22.4	294.00
3	11.20	23.0	238.35
5	7.10	23.4	245.35

The results obtained were comparing with the reference values of contaminated water shown in Table 9, according to these references it is important to mention that alkalinity and turbidity exceed the reference limits in all monitoring stations, and phosphates only exceed the reference at the station 3. On the other hand all the variables associated to oxygen in the water are in good condition since they do not exceed the reference in any station of this monitoring

Table 9. Reference values to contaminated water (IDEAM, 2007; DAGMA 2012)

Parameter	Reference Values
Alkalinity (mg CaCO3/L)	<50.0 0
BOD5 (mg/L)	≤10.00
COD	<250.00
Phosphates (mg PO4/L)	≤1.23
Nitrates (mgNO3/L)	≤44.26
DO (mg/L)	≥3.00
pH	5.00-9.00
TSS (mg/L)	≤50.00
Turbidity (NTU)	≤2.00
Total coliforms (CFU/100mL)	0
Fecal coliforms (CFU/100mL)	0

3.1 Water quality in Meléndez River

3.1.1 WQI-NSF Determination. The temperature delta was taken as zero due to the temperature was not evaluated 50m upstream of each sampling site. A summary of the results obtained for each monitored stations is shown in Table 10 below.

Table 10. WQI-NSF Results

Station	WQI-NSF Value	Rating
Station 1	77.17	Good Quality
Station 2	72.09	Good Quality
Station 3	66.99	Medium quality
Station 5	68.1	Medium quality

3.1.2 Determination of PIs. With the application of the mathematical expressions of these indices, the effects in each studied sections on Meléndez River were calculated directly. According to the values obtained in the WQI-NSF, the parameter with the greatest negative environmental impact is the high presence of fecal Coliforms. Table 11 shows the type of pollution in the river waters according to the application of PIs.

Table 11. PI results in each monitored Station

	Station 1	Station 2	Station 3	Station 5
	0.05	0.35	0.36	0.38
PIOM	Nothing	Low	Low	Low
	0.376	0.471	0.52	0.55
MIPI	Low	Medium	Medium	Medium
	0	0	0	0
PISUS	Nothing	Nothing	Nothing	Nothing
	0.01	0.01	0.01	0.02
PIpH	Nothing	Nothing	Nothing	Nothing

3.1.3 Quality evaluation of the riverside forest. The application of this index showed a decrease in the forest quality as the river approaches to the urban perimeter of Santiago de Cali, even in the upper part of the middle basin, the riverbank forest is dense, with low connectivity but has a great variety of native tree species. Downstream the variety of native species is diminishing; the presence of introduced species is evidenced like water containment structures in the river´s channel. The table 12 shows the results of the QBR shore quality index

Table 12. Riverside forest quality

	mid-high Basin	Mid Basin		Low Basin	
	Station1	Station2	Station3	Station4	Station5
Index Content					
1. Coverage Degree	5	0	0	0	0
2. Coverage Structure	5	0	0	10	5
Geomorphological type	I	I	II	I	I
3.Coverage Quality	22	15	21	0	1
4. Natural River channel degree	25	10	5	15	10
Final Score	57	25	26	25	16

3.1.4 Determination of qualitative ecological indices. In the route traveled were found 5 orders and 6 families of benthic macroinvertebrates communities. In general the species found are indicators of water with oligotrophic, mesoeutrophic and well oxygenated waters, which is in accordance with all the results obtained previously in the physicochemical sampling.

BMWP-Col Index.

Station 1: the results at this station show a biological quality of contaminated water; only three individuals from three different families were identified at this station (see Table 13), The Hydropsychidae family was the one with the greatest apparent dominance (see Figure 3), and it has a tolerance rated 5.

The three individuals founded are indicators of well oxygenated waters and from here it begins to mark a pattern that could be seen in the rest of stations where the presence of oligomesotrophic waters to eutrophic waters is observed, thus following the trends shown by the physicochemical parameters .

Table 13. BMWP-Col Station 1.

Family	BMWP-COL Score	Classification
Hydropsychidae	5	Very polluted waters
Elmidae	6	
Gerridae	8	
Final Score	19	

Figure 3. Found Individuals from Hydropsychidae family

Station 2: The results at this station show a biological quality of strongly contaminated waters (see Table 14). Results in this station were actually poor due only three individuals were found, where two of them belong to the family Megapodagrionidae whose tolerance has a value of 6 (see figure 4).

An individual belonging to the family Philopotamidae (Figure 5) was found whose tolerance is very low and due to the contamination that has received the river at this height it is possible that this individual has been dragged by the strong currents that generate the rains.

Table 14. BMWP-Col Station 2

Family	BMWP-COL Score	Classification
Megapodagrionidae	6	Strongly contaminated waters
Philopotamidae	8	
Final Score	14	

Figure 4. Found Individuals from Megapodagrionidae family

Figure 5. Found Individuals from Philopotamidae family

Station 3: The results at this station show a biological quality of strongly contaminated waters as well as station 2 (see Table 15). At this station only individuals from the Hydropsychidae family were identified (see figure 6) which has a tolerance rated 5.

This family is an indicative of transitional waters from oligotrophic to eutrophic waters, which is in accordance with the physicochemical indices found in station 3, due to phosphates are above quality levels and nitrates have an increase but still be below from the quality levels

Table 15. BMWP-Col Station 3

Family	BMWP-COL Score	classification
Hydropsychidae	5	Strongly contaminated water
Final score	5	

Figure 6. Found Individuals from Hydropsychidae family

Station 5: The individuals found in this station show a biological quality of strongly contaminated waters (Table 16), which is contradictory to what was found with the application of WQIs and PIs indices, but showed the same as QBR index, with a poor ecological quality that can be perceived immediately when we visiting the Meléndez River.

Only two individuals were identified at this station, these belonged to the Chironomidae family (Figure7) and the Tubificidae family (Figure 8). These families have a very high tolerance to organic matter rated 2 and 1 respectively.

Table 16. BMWP-Col Station 3

Family	BMWP-COL Score	Classification
Chironomidae	2	Strongly contaminated waters
Tubificidae	1	
Final Score	3	

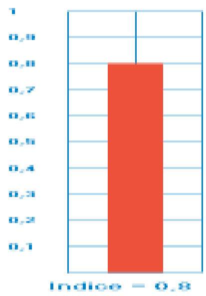
Jaccard´s Index. This index evaluates the similarity of species between two sites from individuals that have been found in both sampling areas. Taking into account the above, the only stations that present similar individuals are station 1 and station 3, therefore this index was only applied on these two sampling sites as shown below.

$$\mathbf{A} = \frac{\mathbf{1}}{(\mathbf{4}+\mathbf{1}-\mathbf{1})} = \mathbf{0.25}$$

Between station 1 and station 3 there is a 25% similarity between its macroinvertebrate species, which indicates that 75% of the species present in habitat conditions more favorable to these orders are lost between the upper and lower basins.

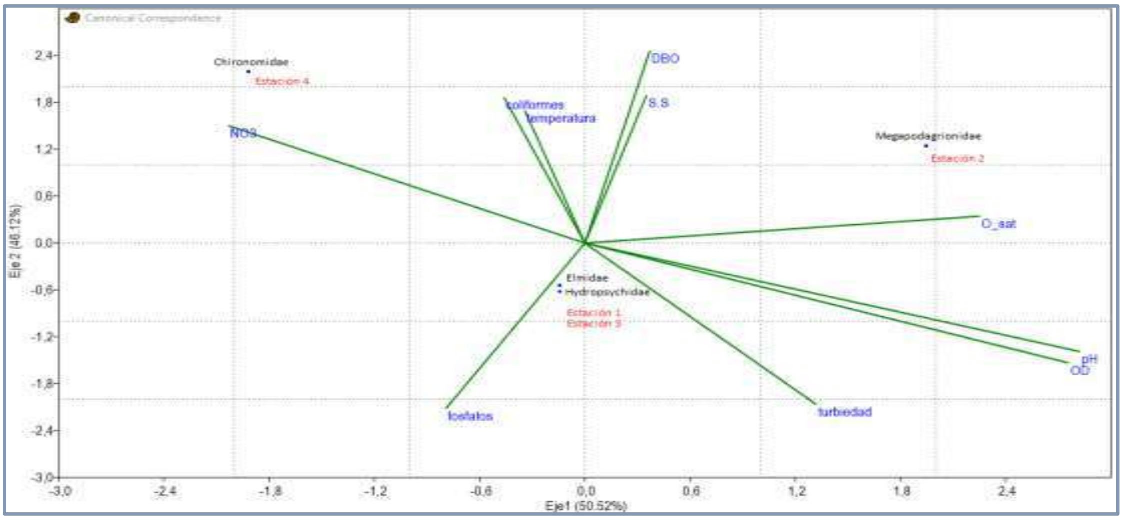
The analysis of these results was also analyzed through the Biological Pollution Index (BPI) which yielded a high contamination value as shown below in graphic 1

Graphic 1. BPI between stations 1 and 3



3.2 Relation between the physicochemical and biological parameters measured in the Meléndez River. The results of the Canonical Correspondence Analysis (ACC) are presented below in figure 9.

Figure 9. Ordering Diagram of Canonical Correspondence Analysis



The ACC captured 96.64% of total data´s variability in the first two axes. The first component (X axis 50.52%) was positively associated with a high correlation at pH (0.940) and OD (0.919) while it was negatively correlated with nitrates (-0.677).

The second component (Y axis 46.12%) was positively associated with a high correlation to BOD (0.819) while it was negatively correlated with turbidity (-0.687).

The found macroinvertebrate families in this study according to the environmental variables evaluated (pH, NO3, OD, BOD, temperature, phosphates, turbidity, coliforms, SS and Saturation oxygen), only Hydropsychidae, Chironomidae, Elmidae and Megapodagrionidae had a correlation while the other families do not present apparent associations with these variables.

As can be seen in figure 9, the strong positive correlation in the X axis shown by the ACC analysis between the Megapodagrionidae family and station 2 is linked to oxygen saturation; it shows a good relation with the reality remembering that at this station were found the best oxygen conditions in this study, which indicates that this macroinvertebrate´s family needs very high oxygen conditions to be present in rivers. On the other hand the Chironomidae family positively correlated in the Y axis with station 4 shows that the coliforms and the temperature have some correlation degree, this shows the strong influence of domestic wastewater discharges with the presence of this family in the last station.

3.3 Simplified Dissolved Oxygen Model. The information of all parameters used for the simplified dissolved oxygen model in each station and dumps is presented in table 17 while the data used for the quality evaluation in each section is shown in table 18.

Table 17. Model parameters used in each place

Model Station	BOD_U (mg/L)	Temperature (°c)	DO (mg/L)	F (L/s)	Abscissa (km)
S1 (begin)	2.2	22.4	7.21	294.0	1.2
club campestre	2.5	25.0	2.5	20.9	1.1
ciudadela río	563.4	22.5	7.2	0.6	1
canal ingenio	26.9	24.5	4.2	3.5	0.9
canal caney	153.7	28.5	2.5	3.5	0.9
PTAR Caney	9.3	25.0	7.7	13.5	0.9

Table 18. Model parameters used in each section

Section	Water speed (m/s)	River deep (m)	River width (m)	Flow (L/s)	Extractions (L/s)
S1. E1-Club Campestre	0.09	0.54	5.6	294.0	0
S2. Club camp-Ciu.río	0.09	0.52	6.23	314.9	0
S3. Ciu.río-C.inge.	0.08	0.5	5.8	238.3	77.2
S4. C.ingen.-C.caney	0.08	0.53	5.6	241.8	0
S5. C.caney-PTAR	0.07	0.56	6.3	245.3	0
S6 PTAR-C. Sur	0.07	0.56	6.3	258.8	0

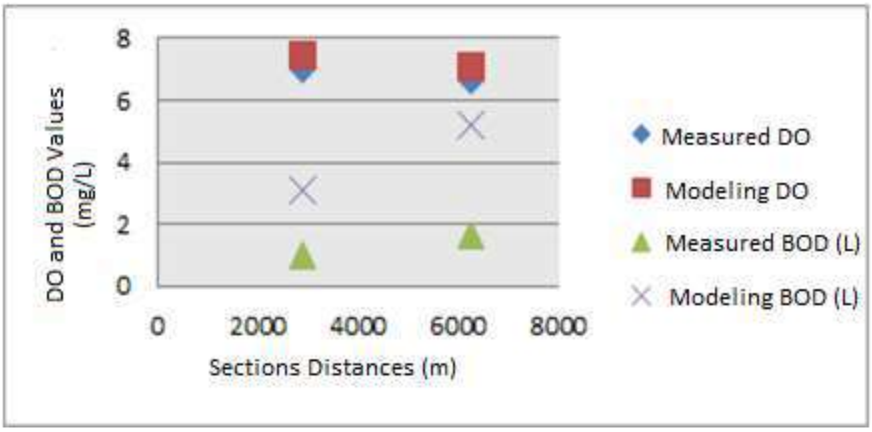
According to the evaluated sections in the model (see table 19), a dissolved oxygen deficit is presents up to the Ciudadela del Río station, from there the dissolved oxygen in water presents a recovery but its levels are below the 4mg/L quality objective proposed by the Cali environmental authority (DAGMA) for the year 2016. It should be emphasized on this point that this model does not necessarily represent an approximation of water quality in the river due to this model was made with many assumptions considering the lack of current information.

Table 19. Model Results

Parameters	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6
Mix BOD (L0) (mg/L)	1.84	2.16	3.19	3.32	5.30	5.46
Mix DO (mg/L)	7.21	7.25	7.41	7.37	7.11	7.11
Mix Temperature (°c)	22.4	22.57	22.57	22.60	22.68	22.80
Saturation O Corrected for height in S2 (mg/L)	9.22	9.22	7.68	6.91	6.91	6.91
Ka Churchill (d-1)	1.37	1.46	1.31	1.18	0.92	0.97
ka corrected by T° (d-1)	1.45	1.55	1.40	1.26	0.98	1.04
Section deep (m)	0.54	0.52	0.50	0.53	0.56	0.56
Width section(m)	5.60	6.23	5.80	5.60	6.30	6.30
Speed section (m/s)	0.097	0.097	0.082	0.08	0.07	0.07
Speed section (m/d)	8400	8399.7	7101.1	7040.4	6008.6	6339.4
Travel time (d)	0.16	0.06	0.31	0.22	0.03	0.08
BOD (L) just before the discharging (mg/L)	2.13	2.13	2.98	3.15	5.25	5.36
Initial deficit before the discharging (mg/L)	2.00	1.97	0.26	-0.45	-0.19	-0.20
Deficit just before the discharging (mg/L)	1.63	1.80	0.27	-0.26	-0.16	-0.12
DO just before the discharging (mg/L)	7.59	7.41	7.41	7.17	7.08	7.04

Figure 2 shows the calibration of the model, which was performed by reviewing the measured values of the dissolved oxygen and the biological oxygen demand versus the values obtained in the model.

Graphic 2. Model calibration



The validity of the model was reviewed by comparing OD and BOD values measured at stations 3 and 4; The OD has a good correlation value where the model value has a 5.4% error for station 3 and 6.9% in station 4 following the same downward trend as in the measured values. On the other hand, the BOD values for both stations have a high error rate that exceeds 100% but presents similar growth trends

3.3.1 Reduction Scenario. Table 20 shows the results of a prospective scenario in which the waters from the dumping of the place "ciudadela del río" (place where the highest deficit according to the Streeter Phelps model occurs) goes through a treatment train Of septic tank with a posterior step by anaerobic filter where 80% of the organic matter is removed, on the other hand it is proposed that the waters of the "canal ingenio" are taken to a treatment in WWTP with later discharge in Cauca River.

Table 20. Model prospective scenarios results,

Parameters	Section 1	Section 2	Section 3	Section 4	Section 5
Mix BOD (L0) (mg/L)	1.84	2.16	0.88	2.99	3.30
Mix DO (mg/L)	7.21	7.25	7.42	7.45	7.43
Mix Temperature (°c)	22.4	22.6	22.6	22.7	22.8
Saturation O Corrected for height in S2 (mg/L)	9.22	9.22	7.68	6.91	6.91
Ka Churchill (d-1)	1.37	1.46	1.32	0.91	0.96
ka corrected by T° (d-1)	1.45	1.55	1.40	0.97	1.02
Section deep (m)	0.54	0.52	0.5	0.56	0.56
Width section(m)	5.6	6.23	5.8	6.3	6.3
Speed section (m/s)	0.10	0.10	0.08	0.07	0.07
Speed section (m/d)	8400	8399.7	7101.2	5922.8	6253.7
Travel time (d)	0.16	0.06	0.53	0.03	0.08
BOD (L) just before the discharging (mg/L)	2.13	2.13	0.78	2.97	3.24
Initial deficit before the discharging (mg/L)	2.01	1.97	0.27	-0.53	-0.52
Deficit just before the discharging (mg/L)	1.63	1.80	0.16	-0.50	-0.44
DO just before the discharging (mg/L)	7.59	7.42	7.52	7.42	7.35

Even with this prospective scenario of reduction in the load discharged by the place “Ciudadela del Río” and eliminating the “Canal Ingenio”, it would not be possible to reach the goal proposed by the DAGMA. In this model omitted for lack of information some waste water discharges, reason why the situation in the river could present lower values.

5. Conclusions

It is important to remember that due to the limited resources in this project the idea of a space and temporary project had to be reduced to a single spatial sampling. The results of this study and its conclusions, although with a high degree of satisfaction in the ecological description of the Meléndez River, still require a greater statistical rigor, which can only be strengthened by carrying out more monitoring campaigns.

The physicochemical quality of the water shows high levels of oxygenation, typical of mountain rivers with great turbulence and some affectations as to the nutrients as much by deficits as by excess of these compounds in the analyzed stations. The organoleptic conditions of the river also provide very important information about the river quality; in the first station the waters are clear and no aggressive smells of contamination are perceived, as regards to the lower parts, the odors of organic matter in decomposition process give an idea of the high presence of waste water discharges that are present in the middle and lower basin of the river.

The riverbank forest quality indices show that the problem of illegal settlement on the slopes of the river and activities such as coal mining, small-scale farming and livestock farming are having a strong impact on the variety and density of the tree and shrub species along the Meléndez River. The variety of species diminishes considerably in the urban perimeter of Santiago de Cali, which is due to the urban development; this deterioration becomes more noticeable at the lower basin, where there is a low variety of native species and a dominance of certain tree species.

On the other hand, the macroinvertebrate communities’ evaluation found it in Meléndez River (in this first revision) shows adequately the physicochemical characteristics evaluated in the river. This would be a complementary study that can be done more frequently to determinate the water quality in our rivers. Now a days, only two monitoring campaigns are carried out on the rivers in Santiago de Cali by the environmental authority DAGMA, and these are not sufficient to carry out a rigorous monitoring with a future view on possible recovery scenarios based on quality criteria.

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A New Conceptual Perspective on Circular Economy: preliminarily confirmation of the 7R Principle by a descriptive Case Study in Eastern China

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Abstract

The purpose of this study is to outline and demonstrate an innovative conceptual framework on circular economy. Research questions arise from the background literature review and are further developed into the proposed 7R principle model. Its preliminary confirmation is pursued by a descriptive case study of Suzhou Industrial Park (SIP) in Eastern China, which is located neighbouring to Shanghai and extensively recognized as one of the most initial Eco-Industry Parks (EIP) in China and as one of the most successful EIP. To begin with, traditional 3R principle is introduced and, then, the evolvement into 5R is discussed. After that, a proposal for a conceptual framework promoting a 7R principle is put forward. Its components are reduce, reuse, recycle, recover, rethink, resilience and regulate. The descriptive case study based on secondary data provides instances to illustrate that every aspect of the 7R framework is properly embodied by a serial of SIP practices.

Keywords: Circular Economy, Eco-Industrial Park (EIP), Suzhou Industrial Park (SIP), 3R, 5R, 7R principle model proposal.

1. Introduction

1.1 Motivation and background

It is widely admitted that China witnessed rapid economic growth over past three decades. However, it has been suffering a high cost of resource wastage and environmental deterioration.In 2012, China took the lead as the world's champion in terms of industrial output, surpassing the United States, and became the true "world plant"(Shi & Yu, 2014). On the other hand, at present, circular economy and sustainable development are increasingly getting of public concern.In the 30-year economic miracle transition, industrial parks have played a great role as "policy pioneers"(Shi & Yu, 2014).In fact, more and more researchers and industries both in China and foreign countries are interested in such themes as circular economy and Eco-Industrial Park (EIP).

According to the definition in the "Law to Promote Circular Economy in People's Republic of China", from January 1st, 2009, circular economy is the integration of activities of reduction, reuse and recycle during producing, exchange and consumption (Shen & Qi, 2012). Thus, Circular Economy is essentially an ecological economy, which requires human economic activities in line with 3R principle, namely Reduce, Reuse and Recycle(Ying & Zhou, 2012).Circular Economy changes the traditional one-way linear economic model of “resource – product - waste” into the feedback circular economy mode of “resource – product – waste – renewable resource”, which conforms to the concept of sustainable development. It also utilizes resources and protects environment more effectively, so as to gain maximal economic and social benefits with minimal resource consumption and environment cost (Ying & Zhou, 2012).

In order to promote Circular Economy, some other hot topics like industrial symbiosis, industrial parks and Eco-Industry Parks (EIP) have drawn extensive attention rapidly. Industrial symbiosis is to engage traditionally separate entities in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and by-products (Chertow, 2000). Eco-Industry Parks (EIP) is a new type of industrial park which is designed and constructed according to cleaner production requirements, Circular Economy concept and Industrial Ecology Theory. Thus, EIP also obey to the3R principle of Circular Economy (Paper & Chunyou, 2009).In China, industrial development was promoted, firstly in the form of Economic and Technological Development Areas (ETDA) in 1984, and then, as High-Tech Parks (HTP) in 1988. Up to the end of 2013, China had around 300 national industrial parks, including 210 ETDA and 113 HTP (Shi et al., 2012).Chinese Government initiated an ambitious national demonstration EIP programme, in 2001, and some trial EIP programmes later on (Shi et al., 2012)to increase environment awareness in harmony with industrial growth. With the quick development of urbanization in China over the past decade, it is getting urgent to create a win-win relationship between economy and environment during urbanization in an industrialized town (Yu et al., 2015a). A common definition presents the EIP as “a community of businesses that co-operate with each other and with the local community to efficiently share resources (information, materials, water, energy, infrastructure and natural habitat) leading to economic gains, gains in environmental quality and equitable enhancement of human resources for the business and local community”(Popescu, 2008).

A conceptual proposal is developed from this background and motivations, and tested in a descriptive study. The literature review starts by analysing the connotation of 3R and 5R related to circular economy. Then, an attempt to propose an innovative conceptual framework coined as the*7R principle* is made. The research questions that arise from the literature review are the following:
RQ1: What is the 3R principle, and what is its meaning?
RQ2: What is the 5R principle, and what is its meaning?
RQ3: Could these principles be developed into a more updated conceptual framework related with circular economy?
RQ4: Does Suzhou Industrial Park practices embody the principles of this new proposal, as a preliminary check?

1.2 Research methodology

In this study, a *?R* updated conceptual framework related with the circular economy is expected to come out from a literature review. Then, a descriptive case study will conceptually apply and test the deducted framework within the scope of the Suzhou Industrial Park (SIP). Thus, the performance of SIP in applying ideas and methods of circular economy is preliminarily appreciated. When conducting the case study, secondary data from the official website of SIP (www.sipac.gov.cn) are used to check if the SIP practices follow the principles established by the innovative conceptual framework for circular economy that is being proposed. For the sake of the convenience of this preliminary qualitative analysis, only a very few representative organizations in SIP are introduced, as instances.

2. Theoretical background

2.1 Meaning of 3R

The principle of reducing waste, reusing and recycling resources and products is often called the "3Rs".As far as these three keywords are concerned; many researchers have contributed with their understanding and explanations. For example, Dhaka(2010) argues that (i)*reducing* means choosing to use things with care to decrease the amount of waste generated; (ii) *reusing* involves the repeated use of items or parts of items, which still have potential for use; and, (iii) *recycling* means the use of waste itself as a resource. Ying & Zhou(2012) explains that (i) *reduce* means reducing the amount of substance in the process of production and consumption; (ii) *reuse* is involved in extending the time intensity of product and service; and, (iii) *recycle* focuses on the regeneration of renewable resources after use. The 3Rs is sometimes called the waste hierarchy(Dhaka, 2010), because it sets an approach to address waste in order of importance. The waste hierarchy classifies waste management strategies according to the desirability of each R. Waste minimization can be achieved in an efficient way by focusing primarily on the first of the 3Rs, "reduce," followed by "reuse" and then "recycle." The waste hierarchy has taken many forms over the past decade, but the basic concept has remained the cornerstone of most waste minimization strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste (Environment & Foundation, 2006).

A basic connotation behind the first R (reduce) is to limit the amount of energy consumption, the number of purchases or the amount of waste generated. The core meaning of the second R (reuse) involves the repeated employment of items, or of usable parts of them, as much as possible, before replacing them, and the third R (recycle) means ensuring the circular utilization of products and components, or transferring waste into resources and energy by the adoption of new technology and techniques.

There are some methods to achieve the goals of 3R and fulfil circular economy, in order to decrease the amount of natural resources used and, to cut down the amount of waste generated and disposed. This kind of measures can be efficient. Examples are as follows: changing the design of the product or the production process, extending the product life cycle by improving repair and maintenance technologies, or decreasing the volume of waste discharge. Reuse can be achieved by repeatedly using products with proper maintenance and storage. At the same time, Recycle can be fulfilled by appropriate share and also, by integrated industrial symbiosis. One product or parts of a manufactured component could be the resource or raw material of another one; this means to achieve recycle by exchanging physical materials, energy, water, and by-products among a serial of companies, as it happens, for instance, in the Kalunborg Eco-Industrial Park in Denmark, the first EIP in the world. The three keywords of 3R principle are correlated rather than separated. A simple illustration, in Figure 1, shows their circular and dynamic relationships.

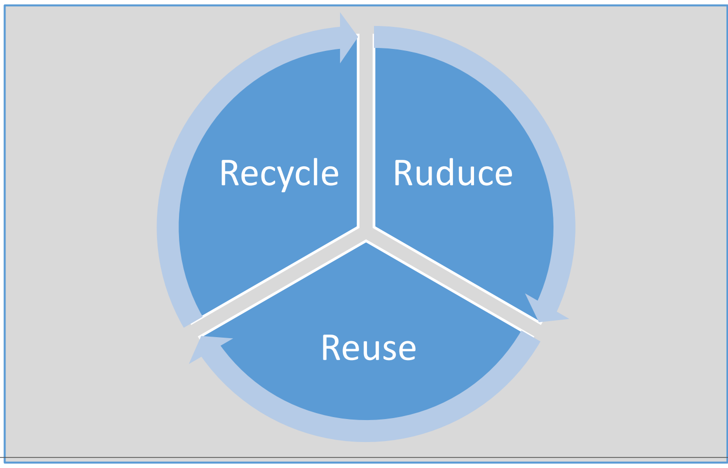

Figure 1.*The illustration of 3R principles*

2.2 Meaning of 5R

In addition to the basic 3R principle, there are some other keywords contributing to circular economy such as rethink, recover, rescue, or repair. Shen & Qi(2012)hold a view that 5R principle appears with the addition of "to rethink towards the maintenance of ecosystem" and "to repair the destructed ecosystem". Liet al. (2015) regard 5R spirit in the life-cycle of the production process, as “Recycling, Reducing, Reusing, Recovery of Energy, and Reclamation of Land”. Generally speaking, besides the 3R principle, the remaining two Rs in 5R refer to "recover" and "rethink". Recover refers to the practice of putting waste products to use. Rethink, which is the last R, is sometimes added to the front of the waste hierarchy, meaning that people should consider their options and think about their impact on the environment. For example, decomposing garbage produces methane gas (one of the greenhouse gases), which some landfill sites recover and burn for energy rather than letting it dissipate. Felicio & Amaral(2013) suggest that EIP have been seen as an opportunity for companies to reduce their waste, recover values and achieve economies of scale, in their production processes, in which, recover means to recover values. Nevertheless, some researchers refer the fifth R as to rescue, and argue that the recycling-based technologies should be promoted and implemented in EIP (Li et al., 2015). Figure 2 is an illustration of 5R principle (reduce, reuse, recycle, recover and rethink).From an innovative perspective, rethink is not a parallel keyword with others, because rethink means not only being aware of the impact any human behavior on the environment, anytime and anywhere, but also making sure to reconsider all other Rs. That is why the area of rethink in this figure is a little bit overlapped to each of other keywords. To be more specific, Reduce can imply decreasing any physical items and curtail inefficient production activities, as well as, high energy consumption; Reuse can imply utilizing products and sharing goods at their most; Recycle refers to material recycle, substance recycle, energy recycle, application recycle and data recycle, etc.; Recover alludes to the resilience that we will analyze in our innovative proposal. So, among the 5R principle, the most important is to rethink holistically in an all-around way.

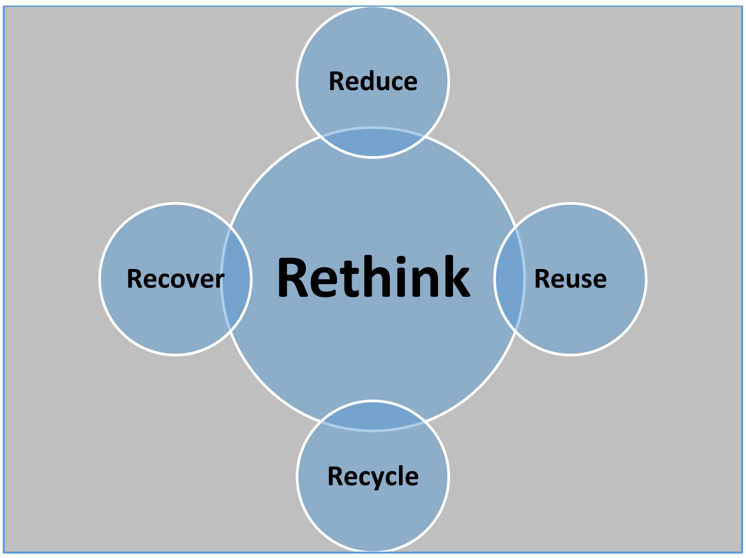

Figure 2.*The illustration of 5R principles*

2.3 Conceptual proposal of the 7R Principle

Circular Economy is essentially an ecological economy, which requires human economic activities in line with 3R and 5R principles. It is Circular Economy that further strengthens the consciousness of both resources conservation and environmental protection, thus promoting the implementation of the strategy of green supply chain management and the popularization of EIP.EIP is designed based on the requirements of clean production, principles of circular economy and industrial ecology. It is composed of the enterprises inside the EIP, and the material flow and energy flow among the enterprises maintaining industrial symbiosis by means of shared resources and exchanged by-products. The goal of an EIP is to seek: (i) loop-closing circulation of material, (ii) multi-level energy utilization and (iii) waste minimization, by simulating the natural ecological system and establishing "producers-consumers- decomposers" circulation path in the industrial system (Li & Xiao, 2017). So, in this sense, 5R is still not enough. As is shown in Figure.3, the illustration of 7R principle proposal, two more Rs are introduced, i.e. resilient and regulate, respectively.

Resilience is the ability of a system to respond to change. Indeed, comprehensively analysing the possible perturbation process is crucial for developing adaptive capacity in an EIP from topological structure and ecological feature. To track the resilience progress in an EIP, not only snapshot analysis, but also time trend need to be followed, in order to develop novel mechanisms to avoid disruptions, improve the resilience of EIP and safeguard(Li & Xiao, 2017).As it is shown in "Transforming our world: 2030 Agenda for sustainable development"(Zachariah et al., 2016), the9th goal from17 sustainable development goals, addresses the development of a resilient infrastructure, the promotion of inclusive and sustainable industrialization and fostering innovation. The literal meaning of "resilient" is returning to the original form or position after being bent, compressed, or stretched. So, in the context of circular economy, "resilient" means the internal capacity of recovering from the depletion situation of resources and energy. "Regulate" refers to the necessary management, adjustment or control from the government. For example, some laws and regulations from the state and local government, some conventions and proposals from trade associations, some suggestions and supports from non-profit sectors and some supervision and urges from mass media.

As it is shown in Figure 3, regulate or regulation is seating in the centre of the schematic diagram, and it causes an impact to all other Rs, because in our opinion, regulation is a pivotal driver to exert the efficiency of an EIP and circular economy as well. Especially in developing countries, all other Rs can be a failure if regulation is absent. EIP do work more efficiently under proper regulation and management from a holistic perspective. The proposed framework of 7R principle will be analyzed and demonstrated by the following case study on Suzhou Industrial Park, one of the most successful EIP, in China.

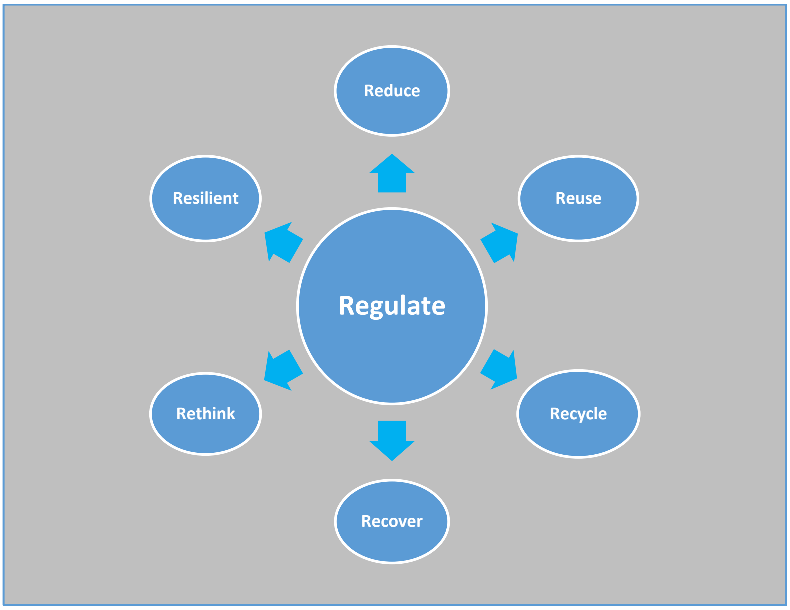

Figure 3.*7R principle model proposal*

3. Preliminary Confirmatory Descriptive Case Study

3.1 Introduction to the Suzhou Industrial Park (SIP)

TheSuzhou Industrial Park (SIP) was established in 1994 and is a flagship of the economic cooperation project between Chinese and Singapore governments. It is located in the eastern part of Suzhou, a city known as "the paradise on earth". Suzhou is also a traffic hub, about only 200 km of Nanjing, and around 100 km of Shanghai. It takes only 20 minutes to arrive in Shanghai and 45 minutes to Nanjing by high-speed train. With an advantageous transportation network, it appeals to more and more big enterprises and global talents. SIP covers a total jurisdiction area of 288 km^2, among which, 80 km^2area belongs to China-Singapore Cooperative Zone.SIP is recognized as a pilot zone of reform and opening-up, a successful model of international cooperation, and one of China's fastest-growing development zones with the most international competitive edges. In SIP, the total number of permanent residents reached over 700,000 in 2012, including registered and non-registered population. Currently, approximately 25% of the land is industrial, and 30% is residential and commercial. The remainder is green space and water (Yuet al., 2015b). Nowadays, the development goals of SIP are to develop into a hi-tech industrial park with international competitiveness and, into an innovation eco-township of internationalized, modernized, information-based happy district of Suzhou (www.sipac.gov.cn).

3.2 Achievements of SIP

Concerning the performance in environment protection, SIP obtained the label of ISO 14000 National Demonstration Zone, in 2001. As the national EIP program was launched, SIP was approved as a pilot in 2004 and started to implement EIP planning in accordance with the national EIP development guideline. In 2008, SIP passed the evaluation and obtained the label as one of the first three National Demonstration EIPs. Currently, the energy consumption per GDP is 61% lower than the national level. The discharge amount of Chemical Oxygen Demand (COD)and SO_2 are only one-eighteenth and one-fortieth of the national average, respectively.SIP is among the first national IRP (Integrated Resource Planning) demonstration parks, among the country's first demonstration eco-industrial parks, and among the first new-type industrial demonstration bases in China(www.sipac.gov.cn).

With respect to annual economic growth in SIP, 30% annual average growth occurs in key economic indicators, ranking second among national development zones in comprehensive development indexes. It accomplished four "Hundreds of Billions" of achievements, as follows: RMB 133 billion of GDP, RMB 165 billion of accumulated taxes, USD 18.9 billion of accumulated utilized foreign capital and RMB 197.2 billion of accumulated registered domestic capital. Besides that, there also are remarkable achievements in economic transformation and upgrading, as follows: RMB 147.2 billion of output value from new emerging industries in 2010, accounting for 45.4% of scale industries and ranking the first in Suzhou and, ranking the first, for years, in using foreign capital, among China's development zones(www.sipac.gov.cn).

As far as sustainable development is concerned, SIP achieved many awards. For example, it was recognized as China's only new-tech innovation & industrialization base, as China's only demonstration base of service trade innovation, as China's only national demonstration area of business tourism, no.1 among most competitive development zones, as China's first service outsourcing demonstration base and, as China's first experimental area on preferential policies for technologically advanced service enterprises (www.sipac.gov.cn).

3.3 7R principle application in SIP

When observing SIP, there are a large amount of exemplary enterprises, which conduct very good practices, in environmental protection and sustainable development, corresponding to each component of 7R principle, namely reduce, reuse, recycle, rethink, recover, resilient and regulate. Here we provide some supportive examples, analysis and beneficial implications.

3.3.1 Reduce

In SIP, it is obvious that there is a great amount of reduction on energy consumption.According to the official website of SIP, currently, the energy consumption per GDP is 61% lower than the national level.SIP learns from the experience of Singapore and adopts high standards in promoting energy-saving circular economy. In 2012, SIP recorded 0.28 ton of standard coal for producing 10,000-yuan GDP, with 0.149 kg COD, releasing 0.07, 0.008, and 0.151 kg of sulfur dioxide, ammonia, and nitrogen oxides, respectively. These are above national averages and made SIP the leader among national development zones, for four consecutive years, in the main indicators of environmental protection, energy conservation, and emission reduction (www.sipac.gov.cn).

3.3.2 Reuse

The SIP management has organized some representatives to learn from companies with outstanding performance in practicing Corporate Social Responsibility (CSR). For example, Fuji Xerox Eco-Manufacturing (Suzhou) shared with the participants the company's experience in recycling and reusing resources. From its establishment in January 2008, the company has been recycling the waste, copying machines, printers, and consumables as printing drums and powders from Chinese mainland, to make full use of resources and reduce their impacts on environment. The company, therefore, won the honorary title of SIP CSR Company 2013 (in the category of "Environment Responsibility") and was named "Model Company of Circular Economy" by Suzhou Economic and Information Technology Commission in 2014 (www.sipac.gov.cn).

3.3.3 Recycle

Green production has been part of corporate culture among most manufactures, in SIP. Nitto Denko (Suzhou), which is a member of Suzhou Industrial Park, since its founding in 2001, launched a clean production program, investing in energy-saving and emission-cutting projects. Their aim was bringing down energy consumption and waste water discharge. The company renovated the entire AC system and, as a result, saves2.35 million kw annual use of electricity power and 8,000 tons of steam, which equals to 1,716.1 tons of standard coal. In order to save the water resource, the company recycles steam condensate and reclaimed water. Every year, the steam reused amounts to 420 tons (47 tons of standard coal) and the water recycled totaled 27,000 cubic meters (2.3 tons of standard coal) (www.sipac.gov.cn).

3.3.4 Recover

In order to optimize the regional environmental to build a beautiful SIP, for years, SIP has kept investing in environment-related infrastructure to improve the monitoring system and to use energies to their full potential. With 100% coverage of sewage pipe network, it manages to achieve Grade-1, a standard for all the waste water discharged. Moreover, the waste water treatment plant, the sludge drying plant, the thermal power plant, and the heating & cooling center create an integrated system maximizing the use of public amenities, resources, and energies as well as minimizing the discharge of pollutants. The efforts include the protection of Yangcheng Lake, the source of potable water, 45.8% coverage of green grounds, surveys on biological diversity and ecological environment with 131 bird species being confirmed around the year, the river dredging projects, and the restocking of aquatic organisms in Jinji Lake (www.sipac.gov.cn).

3.3.5 Rethink

Taking Nitto Denko (Suzhou) as an example, the company introduced a lot of programs to stimulating rethink, among which "Green Design Action", which encourages employees to build up the belief that environment protection should become a part of its corporate culture. With the "Light Down" program, the employees are required to turn off their computers during lunch break. The company also regulates the AC (air-condition) temperature and arranges people to be in charge of lights and AC. The workshops should follow the plans and turn off the production equipment not in use. The company also participates in the "MOTTAINAI Campaign", a program aiming to promote environment awareness and to cultivate sense of responsibility among employees. The survey shows that the average awareness increased from 73.1% to 80.2%, which is transformed into a reduction of 11,557 kg of carbon dioxide emission (www.sipac.gov.cn).

3.3.6 Resilient

The Administrative Committee of the Suzhou Industrial Park has been calling on companies to work together to build SIP into a model of ecological civilization through Learning and Innovation. The committee often organizes all kind of forums. For example, there is a forum, which is part of the agenda for China International Green Innovative Products & Technologies Show (CIGIPTS). Enterprises are encouraged to contribute in building ecological industrial parks through international cooperation, and to demonstrate their achievements in exploring a new path of industrialization through technological innovation and low-carbon environment-friendly circular economy.

3.3.7 Regulate

Chinese Governments (both state and local) play an essential role in improving the performance of EIPs, especially when it comes to the integration and balanced development of industrialization and urbanization.In order to secure economic sustainability and optimize industrial structure to promote sustainable low-carbon economy, SIP authorities have vetoed down more than 400 projects totaling approximately 3-billion-dollar investment, which posed potential high hazards to surrounding environment.SIP government carried out energy auditing on 74 companies and set a record of 310 million RMB Yuan from local enterprises invested in technological renovation projects, cutting down energy consumption by 100,000 tons of standard coal. The enterprises are also encouraged to reuse water and wasted heat, to conform to standards on clean production, to invest in upgrading and renovating technologies and equipments, and to make a constant goal to reduce pollutant discharges. Meanwhile, SIP Eco-Science Hub and Suzhou Environmental Protection Sci-tech Industrial Park have contracted over 100 energy conservation and environmental protection companies, including Sujing and Great, with total output of 30 billion Yuan.SIP has three air monitoring stations and other two under construction, as well as three stations monitoring water quality and one under construction, which make possible to achieve real-time online monitoring and the releasing of PM2.5, PM1, and ozone, among 135 other atmospheric factors. 62 companies, including all key companies in the area, have installed 72 sets of automatic devices in total for online monitoring of pollution sources (www.sipac.gov.cn).

4. Conclusions

In order to maintain the three bottom-line pillars, namely economic, social and environmental, holistic balance and sustainable development is getting more and more critical. When retrospect the evolvement of these principles from 3R (reduce, reuse and recycle) to 5R (reduce, reuse, recycle, recover and rethink) and then, to the innovative conceptual framework of 7R principle (reduce, reuse, recycle, recover, rethink, resilient and regulate), it is safe to conclude that 7R principle is essentially pivotal to practice circular economy and sustainable development. That is to say, all participants including enterprises in the supply chain, governments from different levels, local trade associations and consumers can get involved and shoulder responsibility by applying the 7R principle.Both Corporate Social Responsibility (CSR) and Consumer Social Responsibility (another CSR) should be attached to pursuing economic growth, social progress, and environmental sustainability, as well. As a matter of fact, individuals can vastly contribute to protect the earth by consistently practising 7R in many aspects and in a variety of ways.

To sum up, this preliminary confirmatory study tries to be inspiring to current research in the area of circular economy. In fact, the conceptual 7R principle proposal can be an adventurous try for pursuing theoretical efforts in the *?R* domain (e.g. 3R and 5R). For researchers, this is also a nice attempt to stimulate more systematic thinking. Finally, for practice, Suzhou Industrial Park is just an exemplary model among hundreds of EIP all over the world. Moreover, it will be significantly desirable if there is an increasingly number of industrial parks to introduce 7R principle. Of course, there are some obvious limitations during this study, such as the lack of primary data and a more detailed and structured field study. Nevertheless, future research on the theme of EIP and in-depth theoretical exploration is worthy of much more effort, research directions could be to conduct more exemplary case studies, quantitative analysis on connotative value of 7R, and comparative analysis on EIPs from different countries and areas.

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Title: Sustainable Program Management: Hierarchical Causal Systems

Abstract
Keywords: Pyramid, Hierarchical Causal Systems, Sustainable, Program Management and Strategic Development Goals.
Problem Statement:
Donors, Multi and Bi-lateral agencies charged with distribution of development funds to primarily low and medium income countries (LMICs) have been guided by universally accepted goals, agreements and conventions. In a significant number of cases, adherence remains inadequate. Effective sustainable program management systems remain inadequate. These limitations call for a need to design an inclusive and standardized program management framework. And given the introduction of the Strategic Development Goals (SDGs), donors and implementing agencies can now concentrate on more focused, mid/long term strategies that would enhance the implementation process and more effectively deliver potential and robust intended results.

Hierarchical Causal Systems:

Aim and Methodology:
To Strengthen and Standardize Program Management Protocols and mitigate nuances, duplication and redundancies.
Seven components that facilitate the achievement of sustainable management of development program are embodied in a conceptual framework the 'CARROT-BUS' model. CARROT is for Capacity, Accountability, Resources, Results, Ownership and Transparency – all driven by an enabling environment and BUS stands for 'Bottom Up Strategy'. The holistic, inclusive pragmatic and causality model is conceptually synonymous with Abraham Maslow's Hierarchy of needs. In this framework, each step of the ladder has a well-defined description including a corresponding, comprehensive and relevant strategy and case study to facilitate user understanding.

Findings:
Many beneficiaries continue to live in squalid conditions; poverty remains ubiquitous despite reports to the contrary and improved quality of life in vulnerable populations remains a distant dream. Above all, Western countries have woefully failed to meet their own pledges of donating 0.7 % of their GDP to (LMICs). Only four countries have achieved this objective.

Conclusion:
Designing and implementing sustainable development programs remains complex. The systems presented in this abstract are a way of

addressing these complexities. They serve as an option aimed at mitigating gaps and nuances that are an integral component of development aid. An urgent need for a compelling and effective paradigm shift is required. CARROT-BUS is one attempt to address many of these challenges. Its contributions include refining, and streamlining current and potential frameworks designed to effectively achieve the SDGs.

Program Indicator and Screening Matrix: A Composite Score Model

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Abstract

Over the years, funding Agencies and National governments in developing countries have spent substantial amounts of money in developing and implementing programs. During the last decade, donors have been frequently faced with establishing sustainable and effective programs. This demand has generated a compelling need for reliable and cost-effective results. These dynamics have been motivated by frequent demands from donor-country-tax-payers for more accountable and results-based programs. The model comprises a set of deterministic criteria collectively applied in an attempt to identify the most effective set of indicators in any thematic program area. The criteria include: specificity, reliability, sensitivity, simplicity, utility and affordability. As a quality control measure, all the team outcomes are finally evaluated to establish the degree of intra-team and inter-team concordance. And it is only after this level of concordance is established that the final indicators are selected. The indicators are all evaluated against a priori gold standard by experts and categorized based on a binary (0, 1) outcome.

Keywords: indicator screening, Results-based, gold standard, concordance, criteria

Introduction

Overview:

Historically, development program implementation has been plagued with a complex set of challenges. These vary from the program design stage to implementation and sustainability. A key element of program design and implementation has been a relevant indicator selection process and ability to optimize its robustness and mitigate the prevalence of bias. These challenges continue to influence effective program management initiatives. Attempts to address some of these issues vary from program to program. For example, what is sometimes identified as “low-level indicators” end up in practice representing “higher-level results”. Such a scenario, without doubt, misrepresents the effective potential results.

The model described below and presented in table 1, is an attempt to technically map the initial program indicators with their corresponding higher-level results. With log-frame-based frameworks, these levels are: from the output level, outcome and goal. From a strategic objective framework, the levels will start with intermediate results and evolve to strategic objectives.

The model is a culmination of several years of experience and global scope of program implementation by the author.

Program Definition

In this paper, the author defines a program as follows:

A Program is defined as the different thematic and complementary subsets or projects (micro) designed to effectively contribute, in tandem, to a common set (macro).

And if there is ONLY one Project funded and implemented, then

Project is equal to Program

The graphic presentation of the definition is presented in figure 1

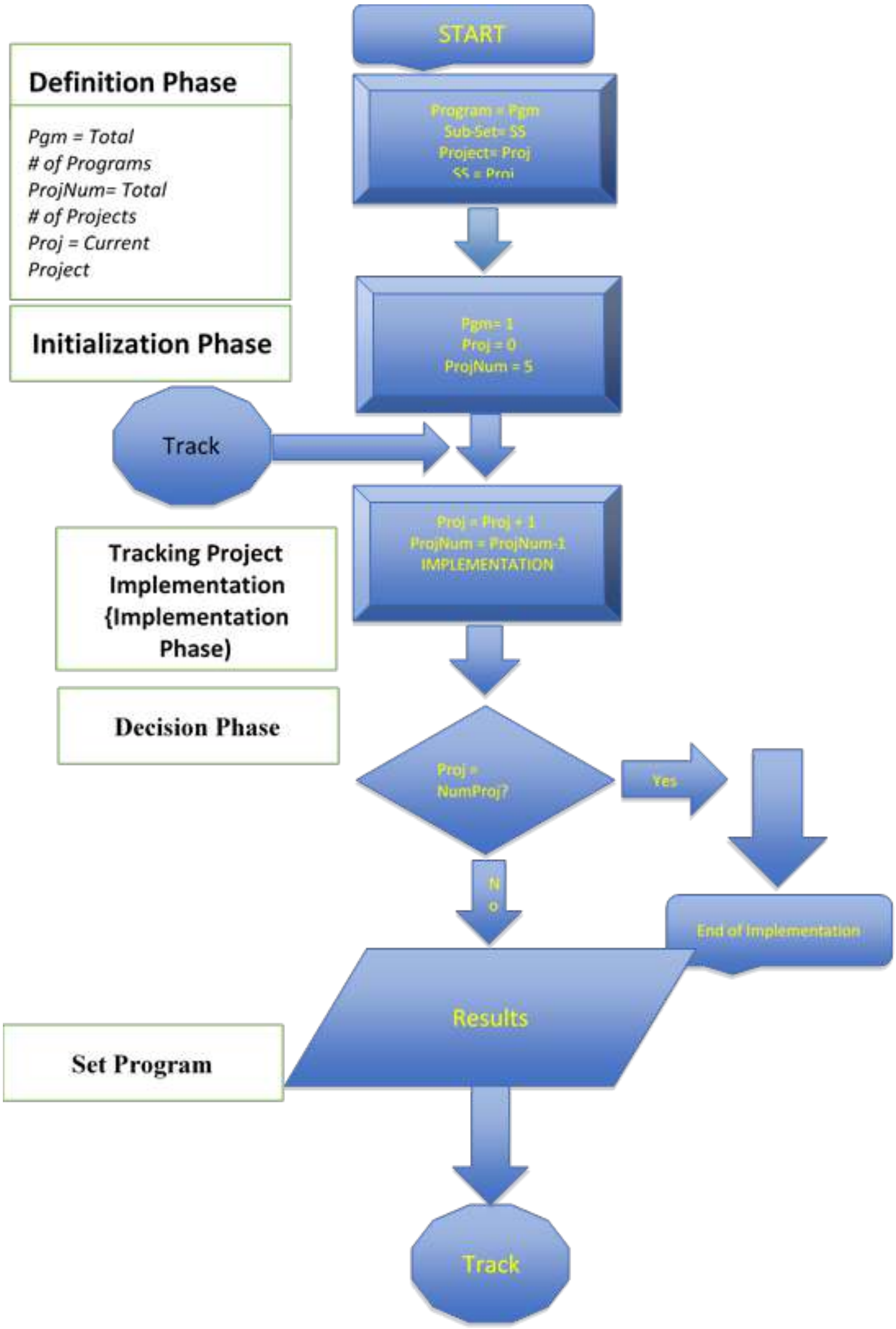


Fig 1: Algorithm of Program Tracking Process

Note: If there is ONLY one Project funded and implemented, then Project is equal to Program

Methods

The PRISM tool is a table aimed at extensively analyzing each indicator. This effort is executed by a team of experts, selected and grouped based on their relevant and appropriate expertise. An initial attempt is made to clearly describe the matrix, its limitations and how it assists in addressing some of the challenges faced by program-implementing partners in establishing meaningful indicators. The final outcome of this exercise is a consensus or degree of concordance (discordance) among the team members.

General Objectives

To strengthen the knowledge of Program implementing Agencies, Program Managers and other key stakeholders and emphasize sustainable engagement in program management and implementation processes.

To address existing nuances, highlight the synergies that exist among the different result levels of the Strategic Frameworks and hence facilitate a common ground between potential evaluators and different interested parties.

Specific Objectives

Streamline monitoring plans by improving indicator causal links at all result levels;

Mitigate duplication of indicators;

Establish authentic contributions between different result levels;

Establish meaningful synergies among different result levels with emphasis on: no lower level result can contribute to more than one upper-level result;

Strengthen the program design;

Promote a common understanding among key actors; and

Minimize cost and optimize the number of indicators included in the program.

Relevance of the PRISM

Improve intended and unintended intervention results and make funding more focused with evidence-based results;

Establish more effective, continuous and sustainable synergies among frontline forces, Implementing Partners (IPs), Funding Agencies, Stakeholders and Beneficiaries.

Target Audience

- Funding Agencies;
- IPs;
- Program Managers;
- Program Administrators;
- Holders of PMP Certification;
- Relevant Stakeholders;
- Program Evaluators;
- Academic Institutions.

Figures 2 and 3 are illustrative graphic and narrative demonstrations of the implementation processes respectively.

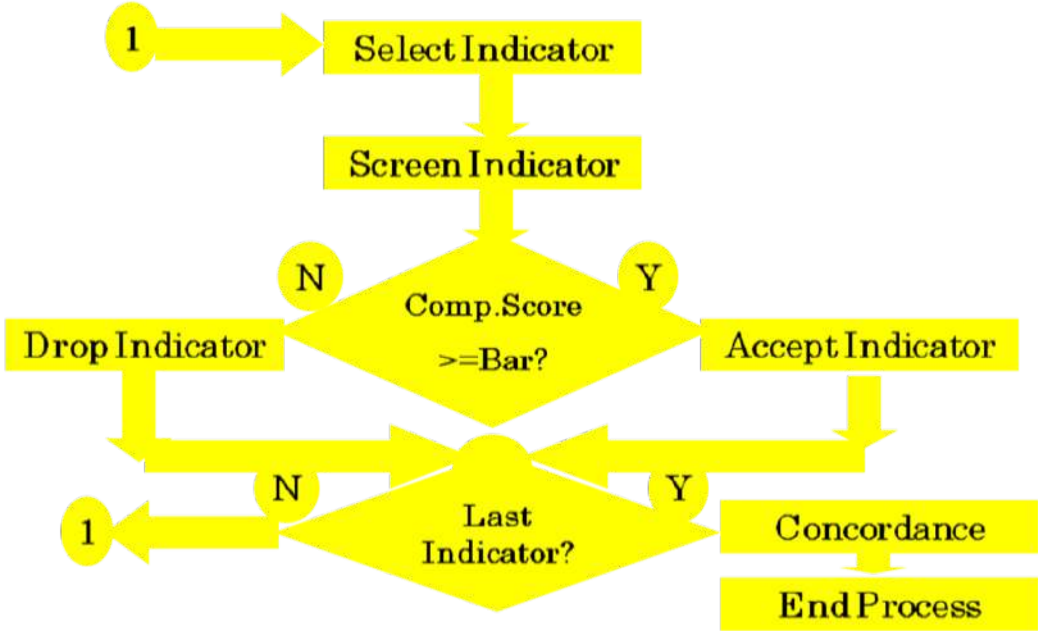


Fig. 2: Graphic Algorithm of the Implementation Process (Lainjo, 2013)

Descriptive Procedure of PRISM Algorithm

10 For Any Theme;
15 Are there any more themes?, NO →→ Step 70
    20 Select thematic Indicator;
    25 Has the last thematic Indicator been Screened? YES→→ Step 70
    30 Screen thematic Indicator against Criterion; {Process continues through every Criterion};
    35 Has Indicator been Screened against ALL criteria? YES>→→ Step 45
    40 →→ Step 30;
    45 Compute Indicator Composite Score {(Sum of "1"/(Sum of ("1" + "0"))};
    50 Compare Composite Score with pre-defined BAR;
    55 IF Composite Score >= BAR, ACCEPT Indicator >>>>>>Step 20;
    60 IF Not, DROP Indicator →→ Step 20;
70 Calculate Group Concordance;
80 END PROCESS

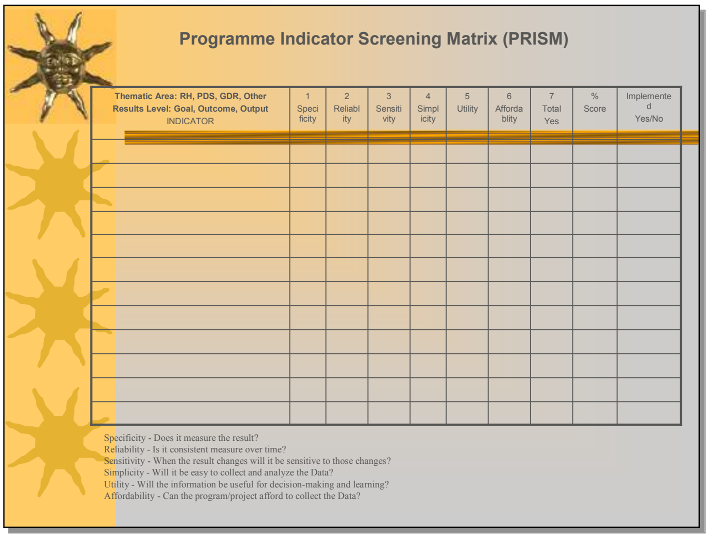
Fig. 3: Procedure Narrative of the Implementation Process (Lainjo, 2013)

Results and Discussions

The definition of a team is this aspect is made up of groups and sub-groups with the latter serving as a sub-set of the former. As a rule, the two groups are composed of odd numbers. For instance, the team cannot work if only a single expert is available. On the other hand, the presence of two or more experts means that it is possible to establish one group and a coin can be tossed in case of a disagreement in establishing an indicator.

Furthermore, if there are experts available, a sub-group will represent a group. That is, all the three members will work as a group, and the recommendations will be considered a group decision based on the degree of concordance. The process, in this case, is simple and obvious. Therefore, the majority decision (in this case, two out of three) prevails. This is how the rule of odd numbers applies, and the preceding description addresses outlier scenarios.

To the extent possible, this model works better if we can establish as many subgroups and groups as possible without losing sight of the distribution (odd number of sub-group and group members). For example, if we have ten experts, we can easily create two sub-groups of five members each. In this case, the group will be ten while the sub-groups will be two. In general, the total number of sub-group members should be limited to eight. Experience has confirmed that when we have more than eight members in a sub-group, some members become overwhelmed and tend not to participate fully. Finally, before each sub-group work starts, the members are required to select a moderator and a rapporteur. The former then presents the sub-group findings during the final group meeting.
The table that is used in establishing the number of acceptable indicators is made up of as many ROWS as there are indicators and TEN COLUMNS. The first row represents descriptions of each column. For example, in row one, column one, we fill in the relevant thematic area, result-level, and indicator. In the next eight columns (still on row one), we fill in the respective criteria that will be used in screening the indicators. In the row below and subsequently, we have a table of binary elements, i.e. zeros and ones (0, 1). The former represents a corresponding indicator, which does not satisfy the criterion and the latter, a corresponding indicator that fulfills the criteria. The same process applies to \all the criteria and corresponding indicators. Column 7 summarizes the scores in terms of the number of yeses (or 1s). The seventh column is the final score attained by each indicator. This is represented as a percentage of yeses in the row. The last column is the final outcome. It tells us if, based on the scores (1s), we should go ahead and recommend the indicator or not. The 'gold standard' for this exercise is 100%. That is an indicator that "yes' scores in the entire criterion qualify for implementation automatically. Criterion and description are described in table 1. Self-descriptive tables 1b, 1c, 1d.

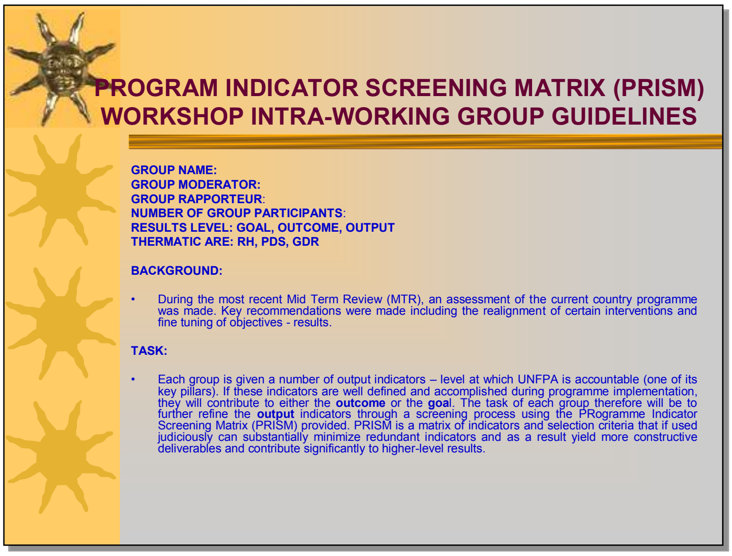


Programme Indicator Screening Matrix (PRISM)

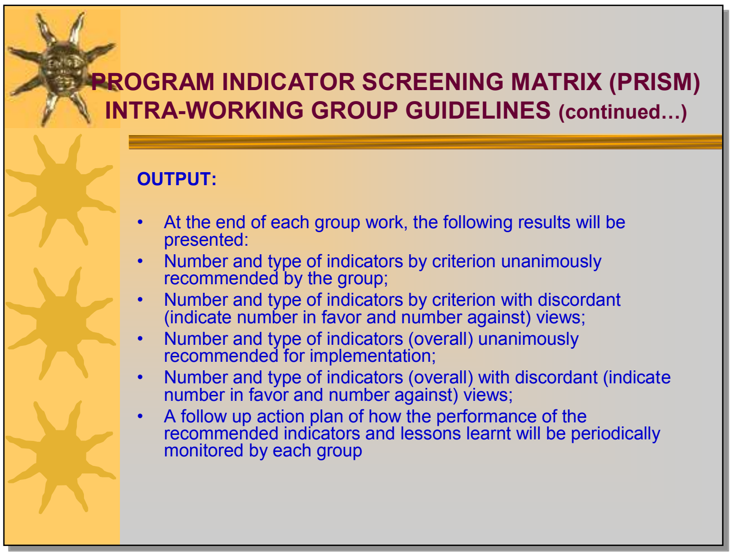
Thematic Area: RH, PDS, GDR, Other Results Level: Goal, Outcome, Output INDICATOR	1 Speci ficity	2 Reliabl ity	3 Sensiti vity	4 Simpl icity	5 Utility	6 Afforda blity	7 Total Yes	% Score	Implemente d Yes/No

Specificity - Does it measure the result?
Reliability - Is it consistent measure over time?
Sensitivity - When the result changes will it be sensitive to those changes?
Simplicity - Will it be easy to collect and analyze the Data?
Utility - Will the information be useful for decision-making and learning?
Affordability - Can the program/project afford to collect the Data?

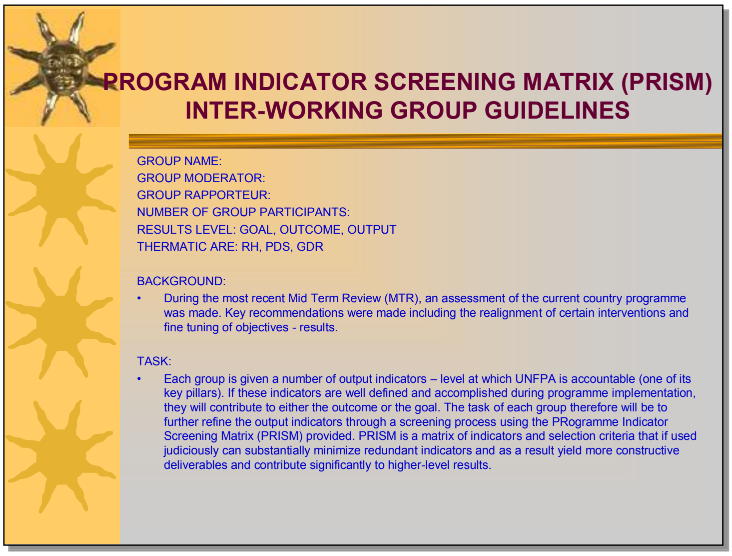
Tab.1: Program Indicator Screening Matrix (PRISM) (Lainjo, 2013)



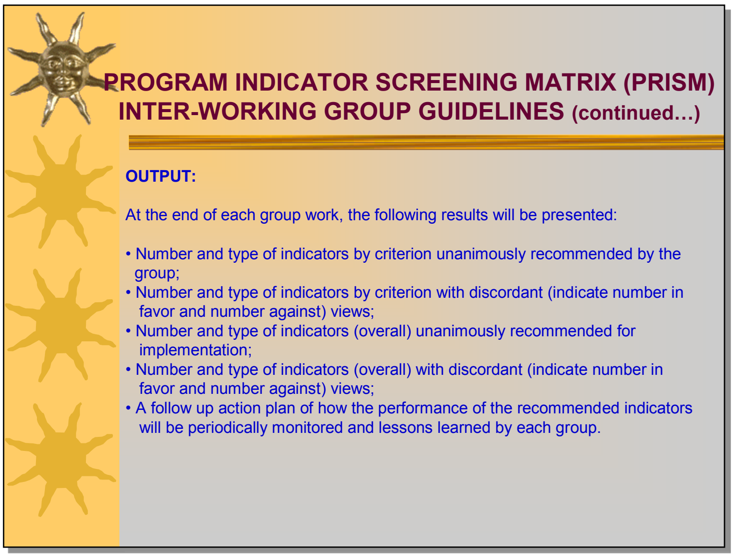
Tab. 1b: PRISM Case Study – Intra-group Screening



Tab. 1c: PRISM Case Study – Intra-group screening (Cont'd)



Tab. 1d: PRISM Case Study – Inter-group Screening



Tab. 1e: PRISM Case Study – Inter-group screening (cont'd)

Because this is a composite analysis, we need to remember that a final outcome is only valid when all these criteria are considered simultaneously. That is, the outcome identified in the last column. What happens if no indicator satisfies all these conditions? The answer is simple. Before all the sub-groups begin their assignment, the team establishes an acceptable level a priori. For example, the team could agree before the exercise starts that any indicator that scores 70% (total yeses divided by sum of yeses and nays) or decision level, will be considered acceptable. Sometimes, this bar can vary. For example, if the team recognizes that a certain threshold tends to admit too many redundant indicators, the bar can be raised higher in order to further refine and streamline our choices.
The following paragraphs attempt to define the meaning of each criterion as it applies to the matrix as well as explaining research-based strategies that can be used to improve the quality indicators.

Sensitivity
It's a test that tries to assess the stability of an indicator. For example, does the indicator continue to deliver the same result with a small variation of either the numerator or denominator? How does the result change when assumptions are modified? Does the indicator actually contribute to the next higher level? For example, an indicator at the output level accounting for one at the outcome level will yield a misleading result. If the same indicator accounts for two or more result levels

simultaneously, it is not stable. As indicated earlier, any indicator that satisfies a criterion is given a one in the corresponding cell and a zero otherwise.
Sensitivity assesses the stability of an indicator as it highlights the indicator`s ability to correctly come up with similar or closely similar results with a slight change of the primary variables. Therefore, improving the sensitivity of an indicator involves ensuring that as a fixed characteristic of the test, it provides a true positive rate. It can be calculated in a two-by-two table as:

$$\text{Sensitivity} = \frac{\text{True Positives}}{\text{True positives + False Negatives}}$$

Indicator		Criterion		Total
		Yes	No	
Y=1		30	6	36
N=0		5	4	9
		35	10	45

Table 2: Sensitivity and Specificity Analysis

In the hypothetical example presented in table 2, initial program designers classified an indicator as associated (contributes to) with a criterion (specific/sensitive). This classification could have either been true (yes) or false (no). Such classifications are either based on experience or "guts". The judges in response and using pre-defined definitions of the criterion re-assess the designers' judgment and come up with the following outcomes:
Thirty out of forty-five judges agreed that the indicator was indeed associated or directly contribute to one at the higher level of the results framework. This outcome is based on the definition of the criterion.

This conclusion among the judges resulted in the indicator sensitivity outcome of about 86% and should be accepted as a sensitive indicator.
The corresponding specificity is only 60%. Assessing "specificity" at this stage is inappropriate. It also needs to be highlighted here that the assessment was on the sensitivity – criterion of interest - of the indicator and not on the specificity. A similar exercise needs to be conducted using "specificity" as the criterion of interest. And there is a strong likelihood that the score would be significantly higher.

An indicator with 86% of sensitivity detects 86% with 14 % considered false negatives (Fishman, Penuel, Allen, Cheng, & Sabelli, 2013). To improve the sensitivity of the indicator, it should be evaluated against various changes in the numerator and the denominators so that it can be observed whether it successfully delivers similar results with a small variation. A more valuable and practical indicator will be the one that produces similar or close to similar results with a slight change in the primary variables.

Specificity
This refers to the likelihood of the indicator measuring the relevant result. In other words, is there a possibility that the result the indicator represents does not represent exactly what we are looking for?
The specific characteristics of a test represent the ability of the test to appropriately correspond with the program`s objective. Thus, to successfully improve the specificity of an indicator, specificity needs to display a fixed characteristic of the test as well as represent a true negative rate. Specificity can be calculated as:

$$\text{Specificity} = \frac{\text{True negatives}}{\text{True Negatives + False positives}}$$

The above formula is used to calculate specificity.
Based on this example, there is an observed difference in terms of fewer observations as compared to the more observations. As a result, the specificity needs more work than the sensitivity since the latter is already performing better when both are compared.
I indicate a large percentage of positive cases. Besides, a high sensitivity test that produces negative results suggests the absence of a condition being measured. In contrast, specificity indicates negative test results. Improving specificity will involve a highly specific test that is efficient for the detection of a particular factor or element under study if an individual test positive; similarly, it should not falsely indicate the presence of a factor that is absent.
The specificity and sensitivity of a program depicted in a quantitative test depend on a cut-off value, which determines the limit between test results that are either positive or negative (Lip, 2015).

Reliability
This criterion is synonymous to replication. That is does the indicator consistently produce the same result when measured over a certain period of time? For example, if two or more people calculated this indicator independently, would they come up with the same result? If the answer is yes, then the indicator has satisfied that condition and hence a 'one' is entered in that cell, and zero entered otherwise. To improve the reliability of the indicator, it is significant to consider the different types of reliability.

Test-retest reliability
This form of reliability measures the reliability attained in the process of administering a single test twice to a group over a specified period. Then, the available scores from the different periods can be correlated to evaluate the stability of the test over the period (Neely, Adams, & Crowe, 2001). Thus, to improve reliability, the test-retest reliability offers the option of presenting a test twice to a group of individuals to identify a correlation coefficient (needs further explanation) that would signify the score`s stability.

Parallel forms reliability
It measures reliability attained in the process of administering different adaptations of an assessment tool to the same group of persons; however, both versions should contain items that explore the same knowledge base, skill, construct, etc. To improve the reliability of the indicator, the two version`s scores are correlated to evaluate the result`s consistency across the versions (Velligan. et., 2014). For instance, to assess the reliability of the indicator, a large set of items that pertain to the indicator can be created and then various variables are randomly split into two sets that would represent the parallel forms.

5.3 Inter-group concordance
It examines the reliability that assesses the degree to which different the evaluators or judges agree in their assessment. This reliability is useful since it may not be possible for various persons to interpret results the same way. Probably, evaluators could disagree on how individual responses demonstrate knowledge of the skill or construct being assessed. In improving the reliability of the Inter-group concordance, reliability might be used when there are different evaluations of the degree to which the indicator meets certain standards, and it is most useful when judgments are considered relatively subjective (Vărzaru, 2015).

Internal consistency reliability
It is the reliability that evaluates the scale to which different indicators probing the same construct have identical results. Internal consistency reliability is further divided into Average inter-item correlation and Split-half reliability (Venable, Pries-Heje, & Baskerville, 2012).

Average inter-item correlation
It is obtained by taking all variables on an indicator that explore the same factor, and it determines the correlation coefficient for each variable as it finally takes the average of the correlation coefficients to yield the average correlation.

Split-half reliability
It involves the process of attaining a split-half reliability by first dividing all indicators intended to explore the same factor in half to form two different sets of indicators. In this process, the reliability is improved by administering the entire test to a group of persons and computing the total score for every set and then obtaining the split-half reliability by determining the correlation between the two set scores (Danks & Allen, 2014).

Validity
Validity refers to how well the indicator measures what it is meant to or how well it can reflect the reality. Improving the validity of the indicator increases the reliability of the test. Similarly, in this case, it is important to look at the various types of validity to determine the means of improving the overall outcome (Fornari. et al., 2014).

Face Validity
It establishes that the indicator assesses the PRISM`s construct. Thus, stakeholders can easily evaluate this kind of validity. Face validity is not entirely a precise form of validity; however, it is an essential component in enlisting stakeholders` motivation. If it cannot be proved that the indicator is an accurate assessment tool, the task may face numerous disengagements. In improving the validity of the indicator, every single item needs to be related to the different types and components of the study if the measure of the indicator appreciation is created. Besides, there needs to be a reference to the indicator`s movement for it to gain recognition and reflect the real assessment of the result or outcome (Ahmadi et al., 2014).

Construct Validity
It ensures that the indicator measures what the construct or the PRISM intends for it to measure, and not any other variable. In this case, to improve the validity, there will be a need to use a panel of professionals or experts that are more familiar with the construct to assess the validity of the indicator. The professionals will be required to examine the applicability of the indicators and decide what they are intended to depict. By employing the skills and knowledge of the experts, the PRISM

will be able to incorporate an indicator or indicators that adequately evaluate the proposed construct, rather than any other irrelevant element (Froyd, Borrego, Cutler, Henderson, & Prince, 2013).

Criterion-Related Validity
It predicts current or future performance by correlating test results with another interest criterion. To improve the validity of an indicator, it is important to associate the indicator with standardized measure ability in the same scope. If the correlation between the new measure and the traditional measure is high enough, the indicator will gain great approval in regards to its assessment potential (Subramanian, Ramkumar, Narendran, & Ganesh, 2013).

Formative Validity
It assesses how efficiently a measure can provide information to improve the program being studied when it is applied to the assessment of outcomes assessment. Thus, if the indicator can measure how well a particular factor is being processed, then the tool provides meaningful information that can be effectively used to improve the requirements of the program.

Sampling Validity
This form of validity is quite similar to content validity as it ensures that the indicator covers an extensive range of areas within the concept or idea being studied. Since not every item is included, the validity is improved by making sure that the different elements are sampled from all the relevant domains. Experts could effectively implement this process. That would help in ensuring that there is an effective exhaustion of all possibilities and the content area is sufficiently sampled. Besides, a good mix of experts assists in limiting bias as the assessment will adequately reflect the entire content area in its entirety (Woodbridge et al. 2014).

As Woodbridge et. al (2014) emphasize, another way that validity can be improved in general is by making sure that the goals and objectives of the program are operationalized and clearly defined. Moreover, the expectations of the program and indicators should be well outlined. Also, the assessment measures should be matched to the program`s objectives and goals, and the entire process should be reviewed by experts or professionals.

Simplicity
A convoluted indicator represents challenges at many levels. Hence here, we are looking for an indicator that is easy to collect, analyze and disseminate. Any indicator that satisfies these conditions automatically qualifies for inclusion. The zero/one process is then followed as indicated above.
The quality, reliability, validity, and acceptability of the indicators used to develop the results must not be enforced in a way that it leads to complexity (Bonnefon, 2012). To improve simplicity, the indicators should ensure that the ethical aspects of research, while they may occur in several circumstances, must observe traditional norms. Some may not regard this form of mundane science or inquiry to qualify as valid research. Nonetheless, these aspects are very much significant to ensure simplicity and relevance of the research. Simplicity and other participatory research forms serve to bring appropriate stakeholders together in a flexible and reflective process that will maximize research possibilities and other success factors (Baskerville & Wood-Harper, 2016).

Utility
This refers to the degree to which information generated by this indicator will be used. The objective of this criterion is to assist in streamlining an indicator in an attempt to help the decision-making team in making an informed decision. This can either be during the planning process or the re-alignment process. The latter representing occasions when organizations are evaluating the status of its mandate.

Utility and the relevance of research have been a major topic requiring serious consideration for many years. The issue of utility appears to be more sensitive for programs and projects that are faced with wider competing demands and more severe limitations (Gidron, 2013). Besides, there are divergent and multiple beneficiaries and users of the knowledge and results generated from research, for instance, service providers, action implementers, policymakers, and the wider communities. Besides, the competitiveness of a nation is also linked with innovation and research. Hence, it is highly important to develop research-based strategies that can improve the element of utility and the relevance of the research. The benefits associated with research may emerge from the research process rather than the results or the final products. Thus, assessment of the utility and relevance of research becomes complex. In an attempt to improve the utility of the indicator, it is important to incorporate critical appraisal, intelligent choice, and appropriate adaptation of various items in the application of the knowledge.
The problem`s manifestation may be different in diverse programs, and a diversity of responses and information is required. Thus, it would also be important to incorporate a detailed analysis of problems that include their extent and nature in specific areas of the program, and concerning the program`s goals and objectives and other underlying factors (Lerch, & Hermann, 2015). Besides, in regards to Information Technology, the necessary infrastructures, such as management, personnel, facilities, infrastructure, and the societal wealth affect the practicability of making use of the acquired knowledge, while cultural beliefs and attitudes can influence the societal acceptability of the program. Consequently, the indicator applied in the program should address the above issues as one form of necessary research is the one that supports the formulation, implementation, and evaluation of policies.

Additionally, the indicator needs to link with the sustainable and efficient systems by presenting an inclusive and comprehensive information, which forms the basis of the program`s planning. Moreover, the indicator and the program must strike a balance between timely output within practical limits and the scientific severity. It is also important for the statistically and quantitatively proven results to be complemented by descriptive and qualitative case studies.

Affordability
This is simply a cost-effective perspective of the indicator in question. Can the program/project afford to collect and report on the indicator? In general, it takes at least two comparable indicators to establish a more efficient and cost-effective one. The one that qualifies is included at that criterion level. And the same process as outlined above is followed.

Kwiatkowska, Norman, & Parker (2002) emphasize that since affordability is a cost-effective perspective of the indicator being measured, it evaluates the capacity or potential of the program in reporting and analyzing the indicator. To assess the affordability of an indicator, there is a need for a detailed analysis of the efficiency of the indicators. In most cases, there is an evaluation of two or more indicators to identify the most preferable and profitable one, and that can efficiently produce the intended goals and objectives of the program (Chan & Chung, 2015). Similar to the above factors, affordability of an indicator is highly instrumental as it illustrates the most efficient and practical indicator. Indicators that do not meet this criterion and respond to the above factors will not be considered in the program as they are not cost effective.

Inclusion
The penultimate column (8) simply represents the composite score. The total number of yeses is divided by the total number of criterion (in this case, seven) and multiplied by 100 to produce the relevant score for each indicator. During this process, each indicator is then classified as either accepted (if it scores 70% or more) or rejected otherwise.
In both quantitative and qualitative designs, there must be considerable thought into the determination of various recruitment procedures that can be employed to obtain the proposed sample (Kwiatkowska, Norman, & Parker, 2002). Consequently, to improve on the inclusion criterion of the research and the indicator, there should be a deployment of various cultural and multiple relevant recruitment strategies, particularly in meeting the objectives of the program and the relevance of the project. Also, there needs to be a reporting on the number of eligible subjects approached, the data on various recruitment methods, the enrolled number, and the number that completed each phase of the program. This type of information has important implications for the interpretation of data is required in the reporting of results as a primary research-based strategy. The Consolidated Standards of Reporting Trials Statement commonly known as CONSORT gives relevant recommendations for the reporting of study participants from the entry of the study to completion. Also, there should be a precise elaboration of the scores of each indicator that will include a classification of the indicators and the basis for inclusion (Hinton, Kwiatkowska, Norman, & Parker, 2006).

5. Conclusions

This framework has been successfully implemented in countries in Africa and Asia. The challenges notwithstanding, the model confirmed that when implanting partners are collectively involved in program development, there is a significant degree of synergism that facilitates partnership establishment and promotes a common understanding of potential major challenges in some development program areas.

Some of the lessons learned included:

- Prior limited understanding of development frameworks and their hierarchies;
- Relationships between lower and higher level indicators;
- Inability to conceptualize the framework from a program perspective;
- The longer the training period, the more the likelihood of high attrition rate;
- The tendency to set lower gold standards;
- Expertise was limited to thematic groups;
- Identifying team leaders and rapporteurs was challenging;
- Duplication with relevant oversight was quite successful;
- Initial program evaluation was a wake-up call to many program managers.

12. Recommendations:
For any degree of success to be accomplished in implementing this framework, there will be a need to:

- To get all stakeholders practically involved;
- Include as many development partners as possible;
- Include as many implementing agencies or partner (IP) as possible;
- Recruit facilitators with adult-learning backgrounds complemented by adequate field experience;
- Avoid contradicting the on-going modus operandi as much as possible;
- Seek authorization from National governments with adequate time between training and authorization;
- Promote active participation by all trainees;
- Divide the teams by thematic area;
- Limit the sub-groups to between three and five members;
- Toss a coin in case of a tie;
- Spend at least half a day reviewing results-based management concepts;

- Conduct a rapid evaluation at the end of the training session;
- Share training evaluation findings with participants;
- Conduct post-training follow up in order to re-enforce self-confidence;

Review individual IP work plan in order in line with the selected or recommended indicators. The draft is ultimately reviewed by each development agency.
Constantly remind the stakeholders that the ownership of the program is theirs
Design and distribute a diploma at the end of the workshop. This is very important for most of the participants.

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Environmental policies performance evaluation in Portugal

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Abstract

Environment is a central aspect in any sustainable future scenario. Environmental policy, despite being relatively recent, is now one of the most regulated aspects of modern societies. Countries develop at different paces, just as their approach to environmental problems does. Portugal, as a member state of the European Union, has made most of its progress with help from European policies. Portuguese legal and regulatory framework is now wide and embraces almost every environmental subject. However, visible outcomes often do not meet expectations. The main goal of this study is to evaluate the performance of Portuguese environmental policies. Ten themes were selected, a combination of environmental domains and economic sectors: water; waste; agriculture and forestry; energy and climate; mobility and transport; industry; biodiversity; cities and territory; oceans; and tourism. A systematic review of environmental goals and targets in national and European policy instruments was conducted. Quantitative indicators were used to verify the evolution of the main environmental aspects, supporting a comparison with the objectives and goals stated in the policy instruments. The causes and consequences of the noted successes and failures were discussed. Results point to divergent evolutions over different environmental themes. Water and waste have had mainly positive performances, although many indicators are below targets. Energy and climate policy have presented mixed outcomes, with mainly negative trends until 2005, when a paradigm shift has begun, with more attention being given to energy efficiency and renewables. Agriculture, industry, tourism, and ocean management also have shown mixed outcomes: often efficiency of resources use improved, but common practice is far from sustainable. Biodiversity and land management have degraded rapidly for decades; they are now more stable, but most negative trends have not inverted. Mobility shows heavily negative trends: increasing overuse of road transport and private cars. Overall, a notable priority has been given to infrastructure construction, often not accompanied by adequate planning and management. This partially justifies the successes achieved in water and waste policies, but also the failure of territorial planning, biodiversity and transportation policies. Results of the study are being presented to social stakeholders and policy-makers, to enable well-informed and better quality decision-making, leading to successful policy implementation.

Keywords: Environmental policy; Performance evaluation; Green growth; Portugal; Indicators and Monitoring

1. Introduction

Throughout the years, resource depletion and the increasing pressure on ecosystems have threatened sustainable future scenarios. Over the last decades, most policy papers point growth as the major objective for the development of modern societies. In many cases, growth has been more of a problem than the solution (Martínez-Alier, Pascual, Vivien, & Zaccai, 2010; Soromenho-Marques, 2011). The European Union (EU) 7th Environment Action Programme (EU, 2013) has a vision for 2050 in which we "'live well within the planet's ecological limits".

Nowadays, the Environment is already one of the most regulated aspects in modern societies. The EU's body of environmental law is now the most comprehensive modern set of standards in the world, amounting to more than 500 directives, regulations and decisions (EEA, 2015).

Portugal has made most of its progress in this area based on EU law and regulation (Schmidt, 2008). We now perceive that economic, social and environmental systems are closely intertwined. Basic principles and goals of the policies are usually adequate; lack of effectiveness seems to result more from faulty implementation strategies and means (Maas, Kruitwagen, & Van Gerwen, 2012; Schmidt, 2008).

This paper aims to understand if the stated goals and targets presented in the various domains of the Portuguese Environmental policy briefs were achieved, and then discuss the causes and consequences of the noted successes and failures.

2. Methods

The scope of the study comprehends major national policies on environment and sustainability of the past 25 years, when most of the Portuguese environmental policy instruments were published and the monitoring data, essential to build performance indicators, starts to become available.

The thematic structure of the study followed the "Commitment to Green Growth" (MAOTE, 2015), the most recent strategic document for national environmental policy in Portugal.

The study adopted a three-staged approach: first, identify the relevant themes and policy instruments (legislation, plans and strategies); second, consolidate available monitoring data; third, datasets were crossed, comparing performances with targets and discussing the progress.

Table 1 shows the selected policy instruments. The dates indicated refer to the first publication of the policy document, although all revisions of the referred documents were analyzed and included in this study.

The goals and targets were compared with the statistical data available in official reports and databases, such as published by Eurostat, the Portuguese Environmental Agency (APA), the National Statistics Institute (INE) and the PORDATA database. There was a relevant component of data treatment, which involved filling information gaps, crosschecking information from several sources, unit converting, among others. The key indicators selection was based on the quantitative targets proposed in policy documents, to ensure the comparability of the analysis.

On the last step, the stated goals and performance indicators were compared and then discussed, supported by the assessment of findings of a large set of policy studies, scientific papers and reports, developed by national and international public agencies, Universities, technical experts and environmental NGO.

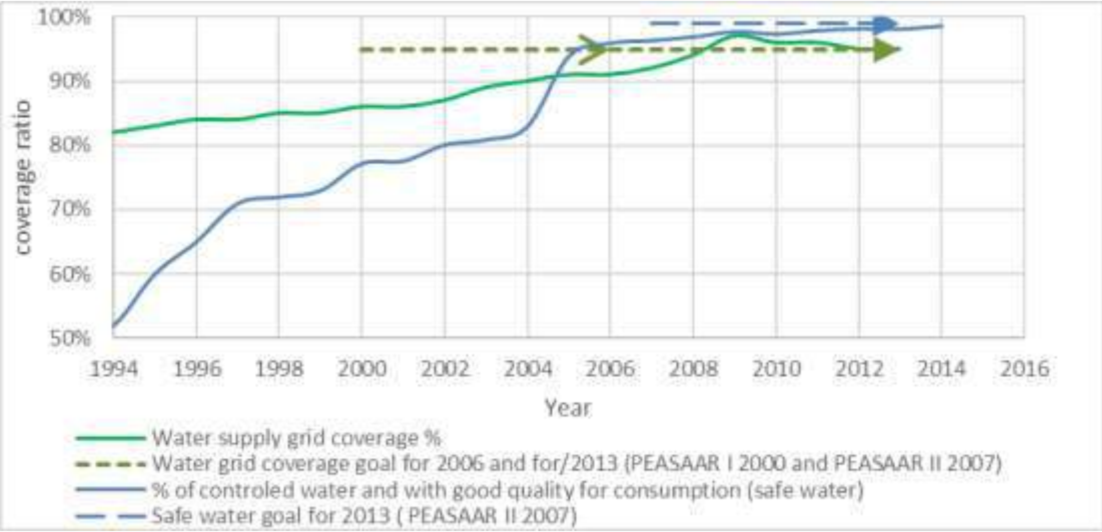
Table 1. *Relevant policy instruments on environment and sustainability*

	European framework	Strategic instruments	Action/sector instruments
Environment and sustainable development	Europe 2020 (2010) EU Environmental Action Programs (1973)	National Strategy for Sustainable Development - ENDS (2005), Commitment to Green Growth CCV (2015)	
1. Water	Water Framework Directive (2000)	National Water Plan - PNA (2002) Strategic Plans for Water Supply and Sanitation - PEAASAR (2000) and PENSAAR (2014)	National Program for the Efficient Use of Water - PNUEA (2012) Management Plans for Hydrographic Basins - PGBH (2009)
2. Waste	Waste Framework Directive (2008) Directive Landfills (1999) Packaging Directive (1994)	National Plan for Waste Management - PNGR (2011) Strategic Plan for Urban Solid Waste - PERSU (1997)	Urban Waste Prevention Program - PPRU (2009)
3. Agriculture and Forestry	Common agricultural policy (1962)	National Strategy for Forests - ENF (2006) National Plans for Rural Development: PEN DR (2007), PDR (2014)	National Forest Fire Protection Plan - PNDFCI (2006)
4. Energy and Climate	EU Strategy on Adaptation to Climate Change (2013), Renewable Energy (2009), Energy Efficiency (2006). Energy and Climate Package 2020 (2008)	National Adaptation Strategy for Climate Change - ENAAC (2010), National Climate Change Program - PNAC (2004), National Energy Strategy - ENE (2005)	National Action Plan for Renewable Energy - PNAER (2010) Plan of Action for Energy Efficiency - PNAEE (2008) E4 (Energy Efficiency and Endogenous Energies) (2001)
5. Mobility and Transport	Roadmap to a single European transport area (2011)	Transport Strategic Plan - PET (2008); Strategic Plan for Transport and Infrastructures - PETI (2011)	Operational Plan for Access and Transport - POAT (2000-2006)
6. Manufacture and Mining Industry	Ecodesign (2009), Energy Label (2010), Regulation Concerning the Ecological Label (2000), Roadmap to resource efficiency (2011)	National Strategy for Geological Resources - ENRG (2013)	
7. Biodiversity and Ecosystem services	Birds Directive (1979), Habitats Directive (1992), Biodiversity Strategy 2020 (2014)	National Strategy for the Conservation of Nature and Biodiversity - ENCNB (2001)	Protected Area Management Plans – POAP (last of 1st generation published in 2008), Sector Plan Natura 2000 Network (2008)
8. Cities and Territory	Framework Management of Air Quality (1996), National Emission Ceilings (2001)	National Air Strategy 2020 - ENAr (2015), National Program of Territorial Planning Policy - PNPOT (2007), Sustainable Cities 2020 (2015)	Municipal Master Plans - PDM (the last of 1st generation published in1995), Regional Planning Plans - PROT (2010 the last of the 1st generation), Coastal planning plans - POOC (2005 the last of 1st generation)
9. Ocean Management	9. Marine Strategy Framework Directive (2008)	National Strategic Plan for Fisheries - PEN-Fisheries (2007), National Strategy for the Sea - ENM (2006)	Strategic Plan for Portuguese Aquaculture - PEAP (2014) Plan of Maritime Spatial Planning - POEM (2014)
10. Tourism		National Strategic Tourism Plan - PENT (2007)	

3. Results and discussion

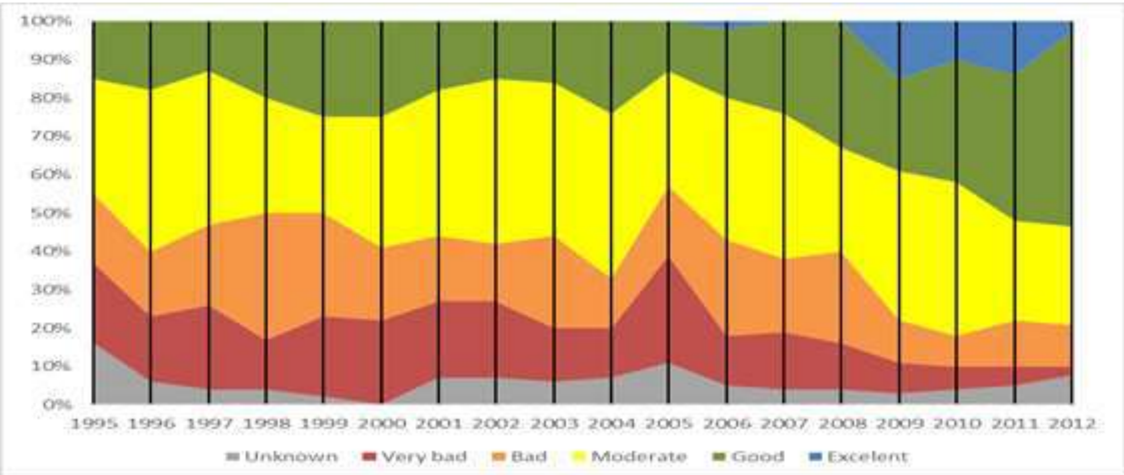
3.1. Water

Water supply has some of the best performing indicators of the evaluation. As we see in figure 1 the evolution of safe water supply is remarkable. In the early 90's, only half of the supplied water was controlled and presented good quality for consumption. This ratio surpasses 98% nowadays, fulfilling the proposed targets. Public sanitation and drainage systems also presented positive 82% coverage, below the target (ERSAR, 2015). Despite this positive development, only 50% of Portuguese surface water quality has presented good quality or above (figure 2). EU's Water Framework Directive states that all EU surface water should present good environmental and chemical status in 2015. Major public health problems were solved with the development of essential infrastructures, backed up by solid Community funding over time.



Adapted from: (APA, 2015a; ERSAR, 2015; MAOTDR, 2007a)

Figure 1 – Water supply grid coverage

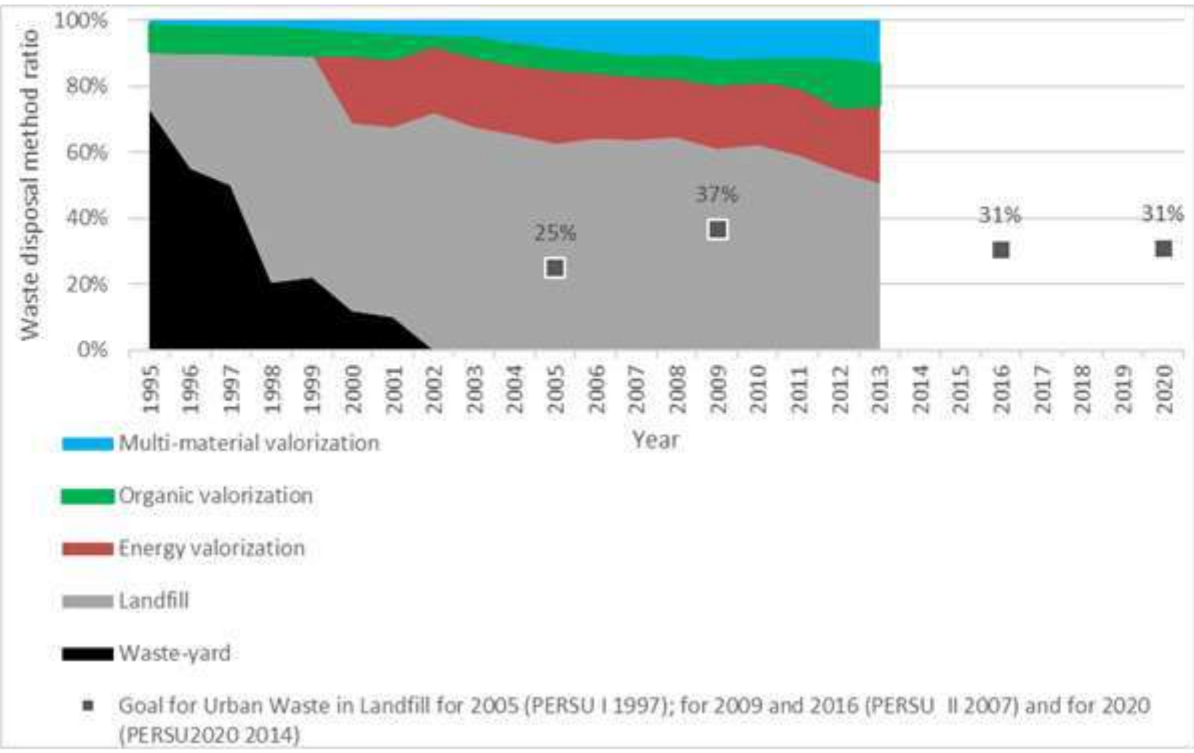


Adapted from: (APA, 2012, 2015a)

Figure 2 – Surface water quality over time

3.2 Waste

Waste had a positive evolution, due to the public pressure to solve the waste-yards problem, a major political issue at the time. People demanded local action and waste was taken off the streets. The solution was only partial however: the waste problem was just hidden, as the major final disposal method only shifted from waste-yard to landfill, with slow progress on recycling and organic valorization, a paradigm that still stands to this day, as we see in Figure 3. Also, there are no clear signs of reduction in waste production, and the individual targets for recycling and reusing are rarely achieved. This clearly demonstrates the gap between the current state of urban waste disposal and the circular economy vision.



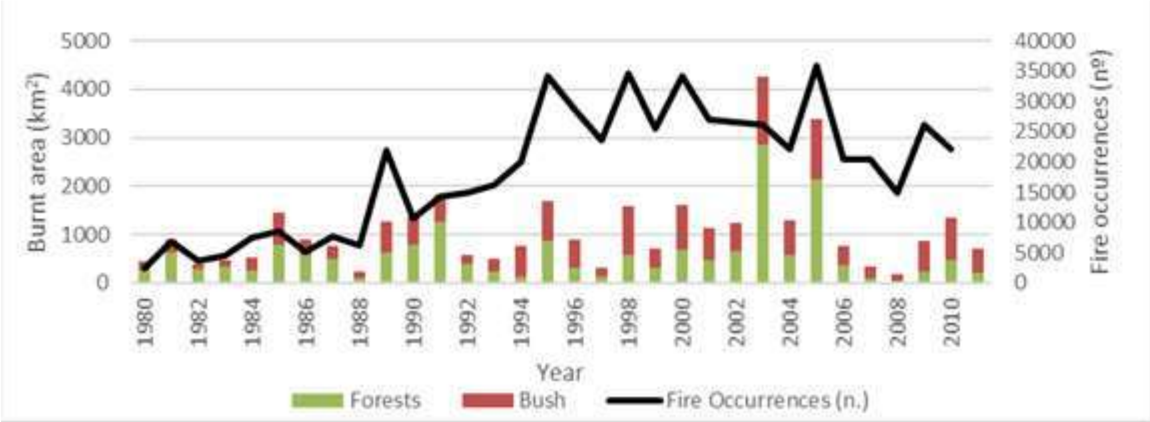
Adapted from: (APA, 2014, 2015c; INE, 2014; MAOTDR, 2007b)

Figure 3 – Urban Waste disposal and destination

3.3. Agriculture and Forestry

In Agriculture and Forestry we can find mixes outcomes. In Figure 4 we see the increasing forest fire occurrences. Forest fires are a major issue in the environmental agenda. Poor forestry management, the dominance of pine and eucalyptus monoculture in vast continuous areas, allied with climate change and rural depopulation trends, were the main drivers for the poor progress in this subject.

On a positive note, there is a clear trend of increase in adoption of organic farming methods, and better fertilizer and pesticide control in conventional agriculture.

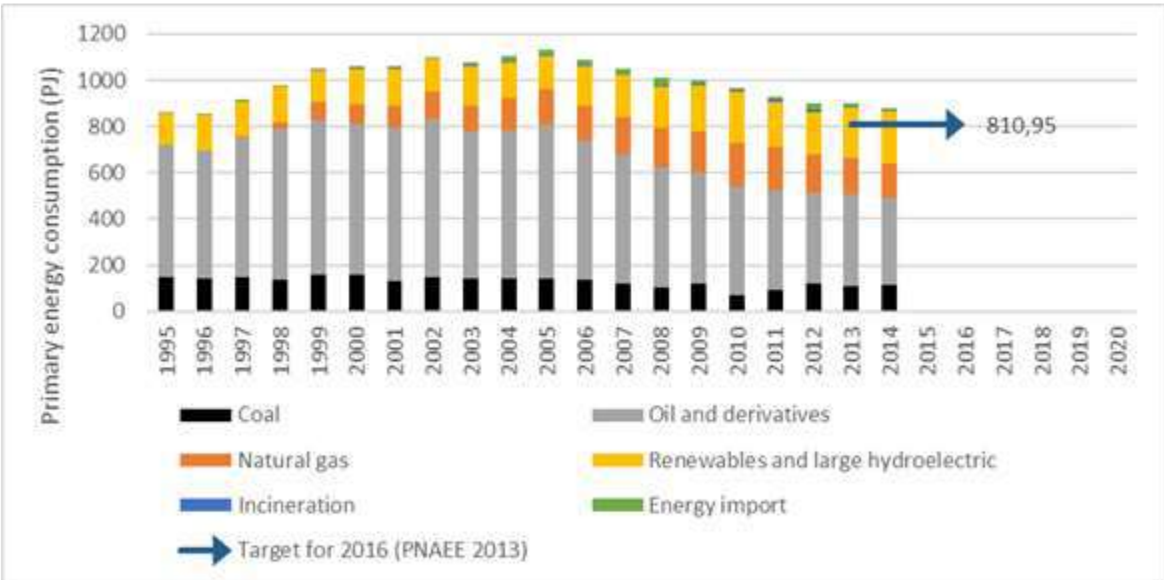


Adapted from: (ICNF, 2013)

Figure 4 – Burnt forest areas and fire occurrences in Portugal

3.4 Energy and climate

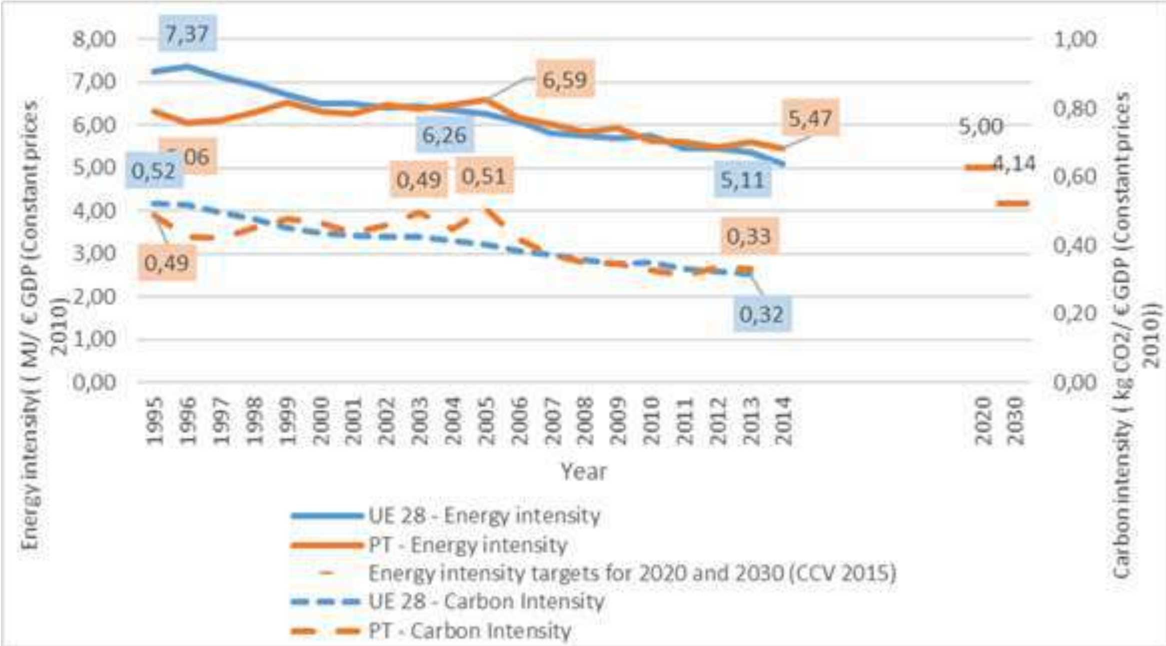
Portugal, as a country with no significant internal sources of fossil fuel has always presented high energy dependence. In 2005, 90% of the total amount of energy used was imported. Nowadays, Portugal has lowered those numbers to around 70% (DGEG, 2015). As we see in figure 5, in 2005 there was a paradigm shift that lowered consumption and diversified the energy mix, mainly due to technological improvement, renewable energies initiatives, but also due to the economic crisis. (GEOTA, 2013) This process was not sufficiently accompanied by the development of effective energy planning policies.



Adapted from: (DGEG, 2015; PCM, 2013)

Figure 5 – Energy consumption by source and target PNAEE 2013-2016

The performance regarding GHG emissions has been continuously positive, which opens the opportunity to present more ambitious targets. In 2013 the national target for GHG emissions of 2020 was achieved, although part of this result can be attributed to the economic crisis. Currently Portugal is very close to ensuring the achievement of the 2030 target. (APA, 2015b). The targets need to be revised, as the current energy efficiency plan and all scientific studies state that there is a very significant cost-effective reduction potential that could be implemented. The targets were set this way based on inflated consumption increase previsions, which year after year have been proven incorrect. The energy and carbon intensity of the economy are presented in Figure 6. It is visible that the EU average started the paradigm shift in 1995, but Portugal only in 2005.



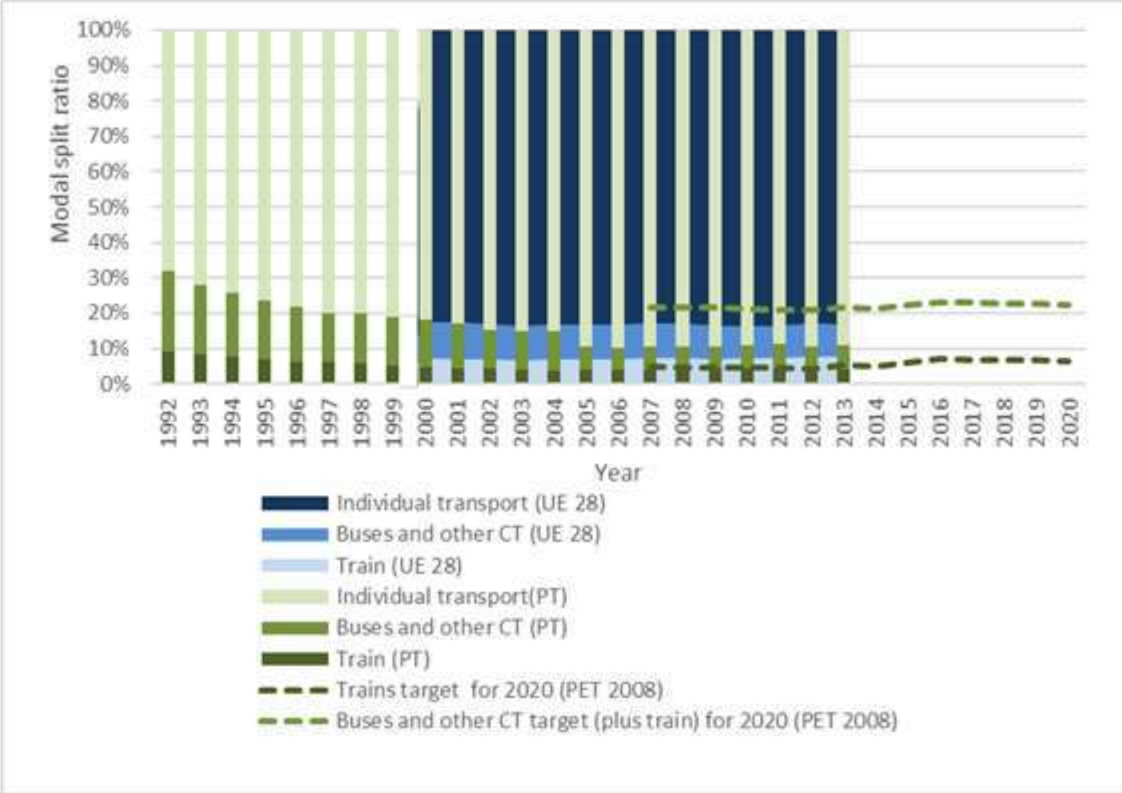
Adapted from:(Eurostat, 2016a, 2016b, 2016c; MAOTE, 2015)

Figure 6- Energy Intensity and Carbon Intensity of the economy in Portugal and in EU-28

We can state that Portugal still has an immature and inconsistent energy policy, despite some positive outcomes. Renewable energy is progressing: the wind power program was a success, and solar energy is now rising rapidly. Nonetheless, there are still some serious problems in the Portuguese energy policy, as fossil fuels and unsustainable energy solutions (such as the useless large hydropower dam program) still receive large benefits from the central government (GEOTA, 2013; SGMAOTE, 2015).

3.5. Mobility and Transport

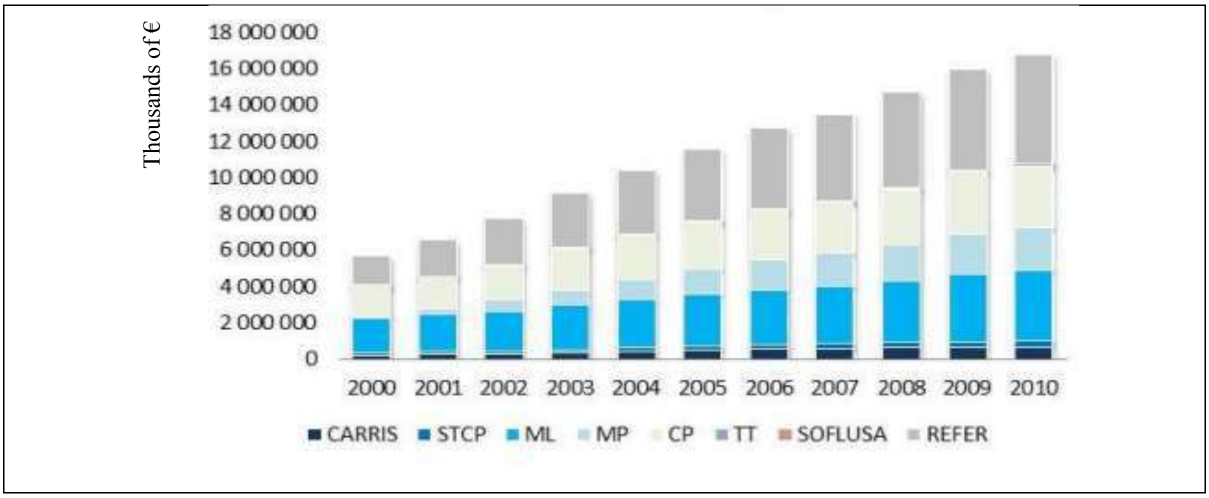
The transport network depends upon available infrastructures, but the success of the transport policies relies as much on choosing the right strategies as it does on having the right infrastructures. Portuguese policy in this matter has proven to be completely inept. In 1992, the collective modes of transportation accounted for 30% of the passenger modal split. In 2012, 20 years latter, Portugal was the European country with higher dependence on individual motorized transport (Alvarenga, 2014), as shown in figure 7.



Adapted from:(Eurostat, 2015; MOPTC, 2009) : CT – Collective transport

Figure 7 – Modal split of passenger transport in Portugal and EU-28 and PET 2008-2020 targets

This situation led the sector to an unsustainable financial situation, as shown in figure 8. The main causes of this negative performance are linked to organizational flaws and unjustified decision making, where, in a recurrent manner, scientific evidence was ignored and large, useless, infrastructure development did not protect the public interest. Some textbook examples are the excessive motorway grid construction (Mendes, 2012), adopting private-public partnerships and the Vasco da Gama bridge process (Melo, 2000).



Source: (ME, 2014)

Figure 8 –Public transport sector debt evolution: 2000-2010

3.6. Manufactory and mining industry

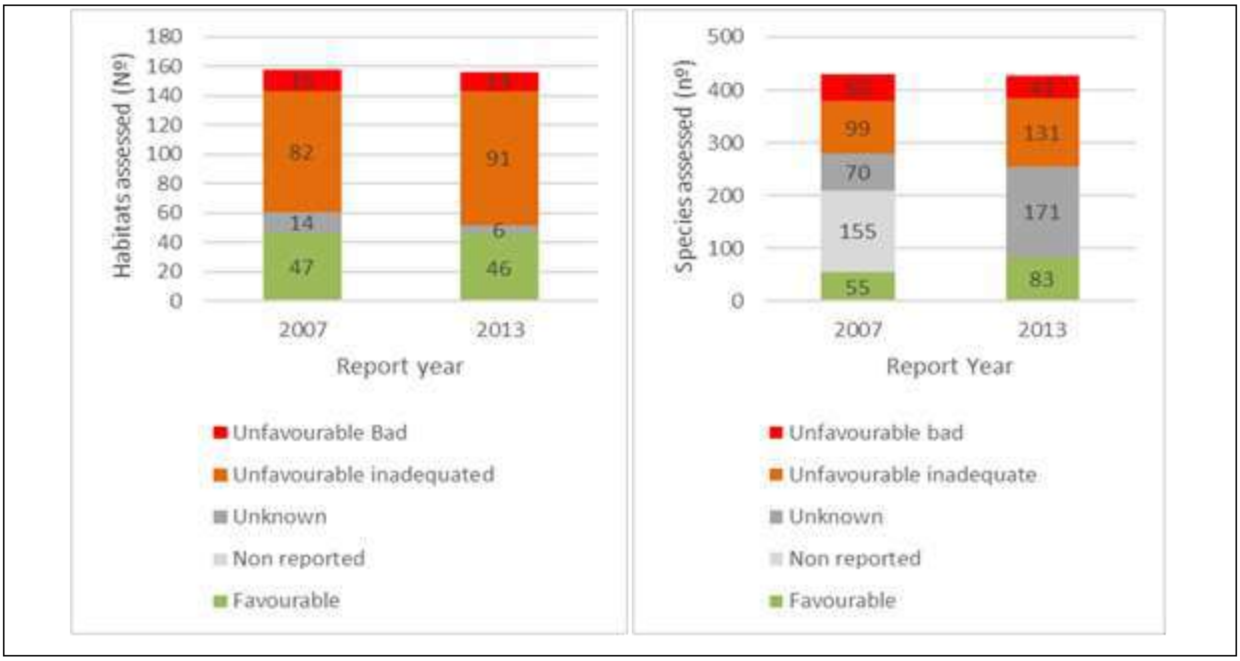
In the manufactory and mining industry, the opportunities for environmental labeling and certification are plenty, and the successful implementation of environmental management systems seems to be on the rise, as companies intend to create value and gain competitive market advantage. In figure 9 we can see that for each kg of materials consumed, Portugal generates 1,14€ of GDP, as EU generates almost double (1,98€). This shows the difficulty in adding value to products, one of the causes for Portugal's low economic performances among the EU countries.

Adapted from: (Eurostat, 2016b, 2016d)

Figure 9 – Material productivity in Portugal and EU-28

3.7. Biodiversity and Ecosystem Services

In Biodiversity and Ecosystem Services the performance was remarkably poor. Even though Portugal has 21% of classified territory (Protected Areas and Natura Network 2000) (ICNF, 2015), the Habitats directive reports show no significant progress over the years, as we can see in Figure 10. Conservation of habitats and species is stagnant at best, in truly low levels. A huge difficulty in applying reliable monitoring methods is evident; not only because monitoring biodiversity is intrinsically challenging, but also because Portuguese nature conservation authorities seem not to have enough means, budget and organizational structure to ensure quality habitat conservation.

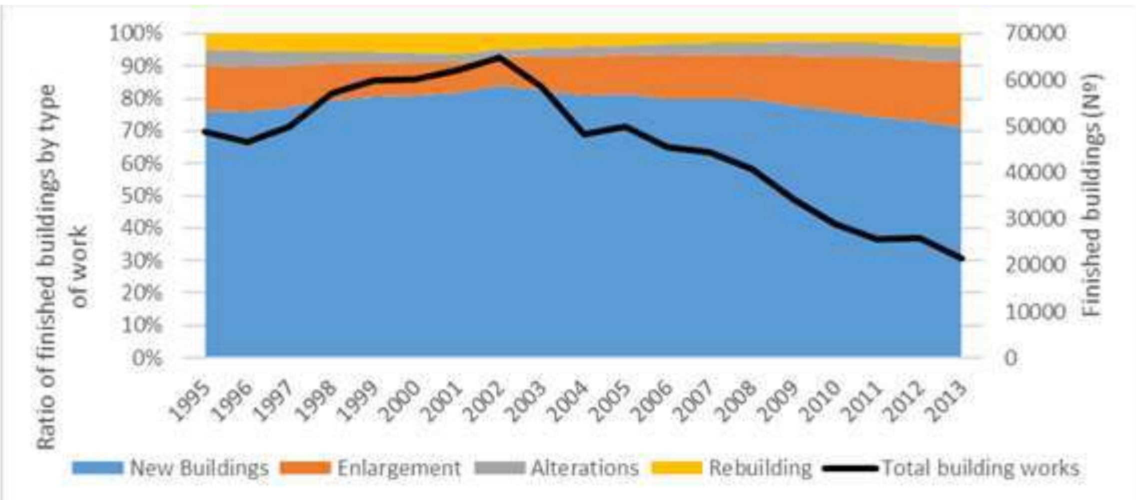


Adapted from: (CE, 2013)

Figure 10- Habitats and species conservation status

3.8. Cities and Territory

In Cities and Territory there have long been strong negative trends. Some aspects have performed clearly against the stated objectives. The rural exodus to the cities suburbs and to the coastline, since the 60's, generated heavy stress on the land management process. The urban area has increased by 35% from 1995 to 2010. Portugal has cities with a great lack of functionality (particularly regarding transportation), and with a large amount of empty buildings. Predictably, the crisis hit the construction sector hard, proving that the policies that promoted growth based on increasing housing and construction were clearly wrong (INE, 2012). Currently, urban rehabilitation is the stated priority, but rehabilitation (alterations, rebuilding and enlargements) only accounts for 30% of finished constructions (Figure 11).

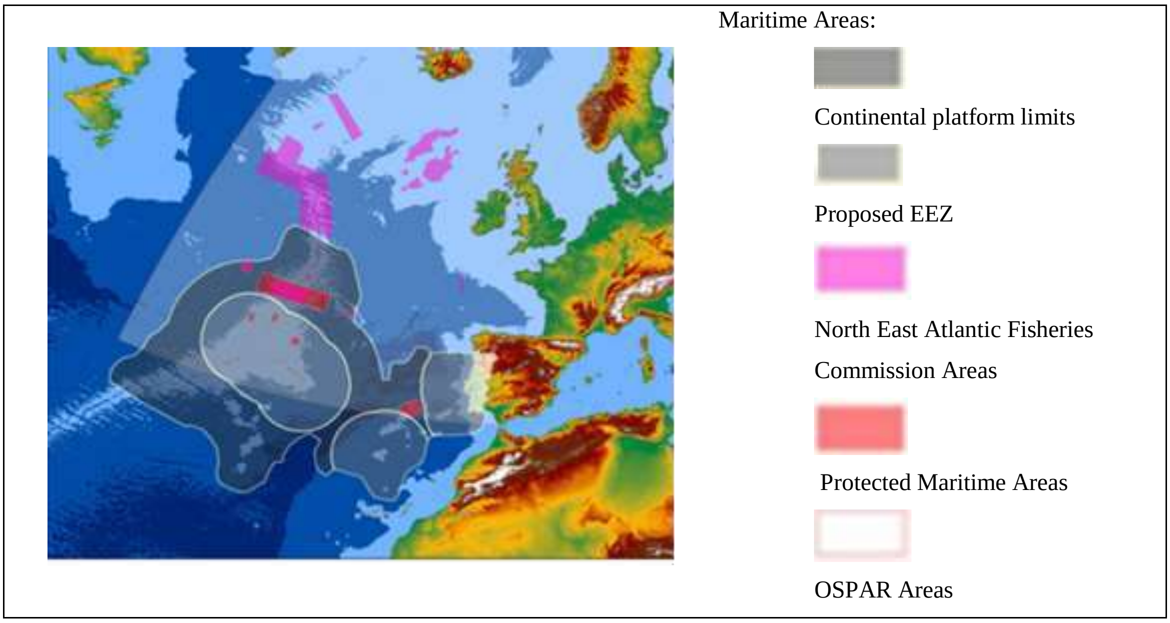


Adapted from: (INE, 2015)

Figure 11 - Finished buildings yearly amount and type of work

3.9. Ocean management

In Ocean management, Portugal is currently on the verge of a great opportunity as the process for increasing its Exclusive Economic Zone (EEZ) to one of the largest in the World is unfolding (figure 12).

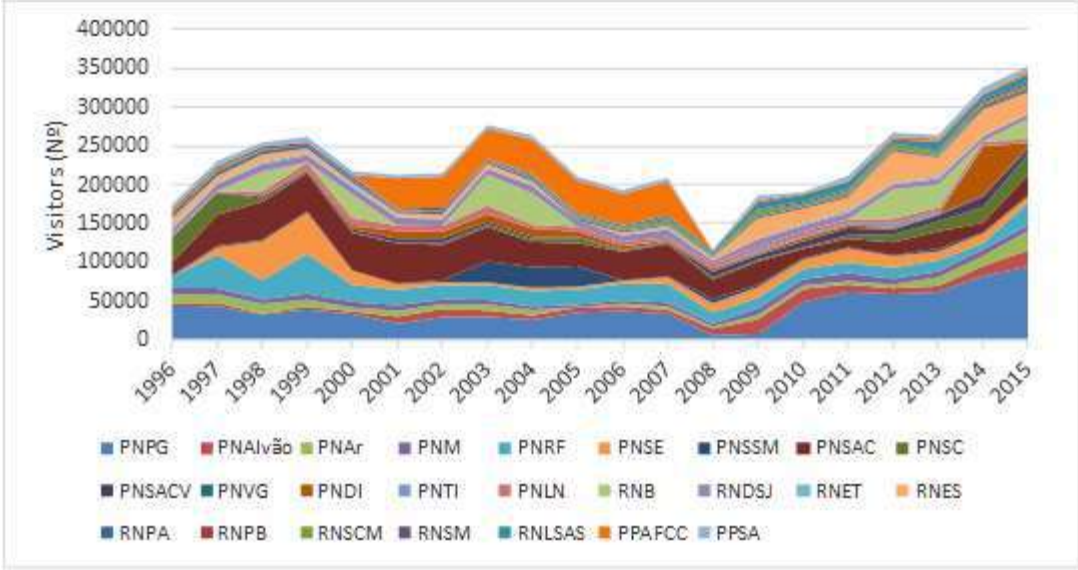


Source: (DGPM, 2013)

Figure 12 – Maritime areas in Portugal's EEZ extension proposal

3.10. Tourism

Tourism in Portugal has been improving in quality and is among the sectors which have increasingly adopted better practice such as environmental management systems. Ecotourism is on the rise in Portugal, being sought by national and foreign tourists alike. In particular, visitation of protected areas is increasing. Figure 13, based on official data of visitors in protected areas, shows two opposite trends. On one hand, the number of visitors is unequivocally increasing. On the other hand, some areas indicate several years with "zero" visitors accounted for, a value that is not real: it simply signifies that in those years there were no statistics from those areas, an indicator of insufficient management effort (or lack of means) by the nature conservation authorities.



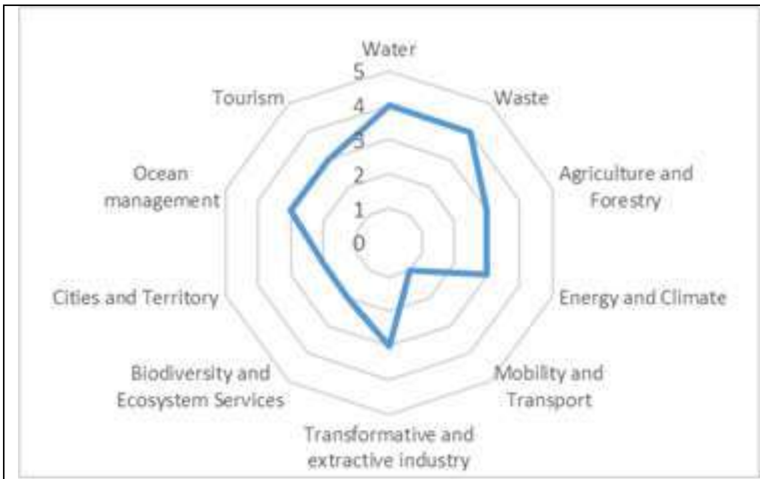
Peneda Geres National Park – PNPG; Montesinho Natural Park- PNM; Litoral Norte Natural Park – PNLN; Alvão Natural Park – PNALV; Douro Internacional Natural Park – PNDI; Serra Estrela Natural Park – PNSE; Tejo Internacional Natural Park – PNTI; Serra Aire E Candeeiros Natural Park – PNSAC; Serra S Mamede Natural Park – PNSSM; Sintra Cascais Natural Park – PNSC; Arrábida Natural Park – PNA; Litoral Alentejano C Vicentina Natural Park – PNSACV; Vale Guadiana Natural Park – PNVG; Ria Formosa Natural Park – PNRF; Dunas S Jacinto Natural Reserve – RNDSJ; Serra Malcata Natural Reserve – RNSM; Paul de Arzila Natural Reserve – RNPA; Berlengas Natural Reserve – RNB; Paul Boquilobo Natural Reserve – RNPB; Estuário Tejo Natural Reserve – RNET; Estuário Sado Natural Reserve – RNES; Lagoa Sto. André E Sancha Natural Reserve – RNLSAS; Sapal Castro Marim VRSA Natural Reserve – RNSCMVRSA; Serra Açor Protected Landscape – PPSA; Arriba Fóssil Costa Caparica Protected Landscape - PPAFCC

Source: (ICNF, 2016)

Figure 13 – Portuguese Protected Areas Network visitors

4. Synthesis and conclusion

Figure 14 shows a graphic synthesis of the performance by environmental domain and sector.



Levels of performance:

1. Negative performance (against stated objectives);
2. Slow or non-significant progress;
3. Mixed progress
4. Positive Progress
5. Performance above expectations

Figure 14 –Graphic synthesis of performance of environmental policies

As we have seen, the compliance with stated goals varies widely across the subjects. The causes for success and failure are various, but we can point several policy aspects that contributed horizontally for the performances. In the past, top priority was attributed to the creation of infrastructure, which helped develop the water supply, sewage and waste disposal systems, along with motorways. Examining the implementation tools (or lack thereof) we find that the construction dimension was seldom based on or complemented with a solid long-term strategy. So, subjects that require careful planning and vision have been performing negatively, as we can see in the Transport and Biodiversity subjects. Also, these subjects are more vulnerable to conflicts of interest, which recurrently lead to biased decisions that do not take the public interest into account, by any objective indicator (let alone environmental concerns).

In a general manner, we can state that the problem of policy success is more associated with the faulty implementation processes and tools, than with the policy principles (which most often are in line with good international practice). Law making and policy is only the first step. Often there is no monitoring of performance, no reevaluation of policies; the quality control of decision-making and reevaluation cycle is alien to Portuguese government culture. Technical and scientific knowledge showed not to be enough to solve the problem. There is a great need for more transparency in the policy making processes and this can only be achieved if society demands it.

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Environmental Management Systems in the Wine Industry: Identification of Best Practices toward a Circular Economy

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Abstract

Over the last decades, great attention has been paid to sustainability issues in the wine industry. Thus, many sustainability practices are spreading and at the same time many efforts have been carried out to spread them. In pursuing sustainability, a great number of wine firms have also implemented Environmental Management Systems (EMSs), in compliance with international standards for EMS as ISO 14001 and EMAS (Eco-Management and Audit Scheme). Furthermore, in recent years also the concept of circular economy (CE) has become widely diffused. The transition from the dominant "take-make-dispose" economic model towards a circular economy is engaging governments, institutions and researchers around the world, with the goal of achieving a more sustainable society. Limited natural resources and environmental issues related to production are the main drivers of this revolution. Indeed, several national policies, businesses and consumers are gradually adapting to this new approach. Different tools have been proposed to enhance the process circularity in different sectors, including the EMAS Regulation. The aim of the present paper is to examine the potential contribution of the Environmental Management System, defined by the European Regulation EMAS, toward a circular economy and society. In particular, it explores the potential application of EMAS environmental indicators as a baseline for the implementation of specific CE indicators. It also evaluates the role of EMAS for the dissemination of good practices and the identification of indicators for CE in wine industry. Starting from the analysis of indicators defined by the EMAS European Regulation, we have identified how these indicators can capture the 3R principles of CE. Even though they can describe companies' efforts in terms of input material and output waste streams reductions, they lack in measuring reuse and recycling practices that are core activities in a CE approach. Nevertheless, these indicators are a starting point to evaluate circular processes that fully embrace the logic of the "closed loop" production. As the paper has shown, the micro-level CE indicators that have been developed till now might be integrated together with EMAS indicators developed in the wine industry to create common metrics to measure CE progress in the wine sector.

Keywords: Wine; EMS; Circular Economy; Environmental Indicator; Eco-Management and Audit Scheme.

1. Introduction

Ecological impact of wine production drew the attention of firms and researchers towards the importance of wine industry sustainability. Sustainable vitiviniculture is defined by the OIV as a: "*Global strategy on the scale of the grape production and processing systems, incorporating at the same time the economic sustainability of structures and territories, producing quality products, considering requirements of precision in sustainable viticulture, risks to the environment, products safety and consumer health and valuing of heritage, historical, cultural, ecological and landscape aspects*" (International Organization of Vine and Wine, 2011). In this context, sustainability is a strategic choice for companies. This choice is influenced by both internal and external drivers. The internal ones are the ethical motivations that inspire the top management and the perception of being able to obtain from sustainability strategies a competitive advantage. The external drivers, however, concerns the pressures exerted towards the company by customers, environmentalists, institutions, community and more generally by all those actors that can be considered, in one way or another, company's stakeholders (Santini et al., 2013). The problem of sustainability in the wine industry has led in the recent years to a proliferation of projects, protocols and tools to develop sensitivity, for both enterprises and consumers (Giacomarra et al., 2015; Gilinsky et al., 2016; Hughey et al., 2005; Pullman et al., 2010). A systematic way through which companies can manage their environmental pressure and embrace a voluntary path for sustainability are the Environmental Management Systems (EMSs) (Steurer et al., 2005). Together with the ISO 14001:2015 standard, the Eco-Management and Audit Scheme (EMAS) is the most widely third-party certified EMS. The EMAS has more stringent requirement respect to the ISO 14001, especially considering external communication, as registered organizations have to produce a public document (Environmental Statement) that includes specific environmental indicators (Testa et al., 2014). The EMAS has been employed also by wine producers as an effective way to analyze and improve wine production processes, and with the use of specific indicators to monitor the progressive reduction of their environmental impact (Gemmrich and Arnold, 2007). As the path toward sustainability has been traced, still considerable steps forward must be made to identify ways for a production that is inspired by the concept of Circular Economy (CE). By adopting a circularity approach, the sector could identify paths that put together the improvement of environmental performance with that of reuse of secondary raw materials, which might come as an input of the production process, also generating economic benefits (Bocken et al., 2016; Ghisellini et al., 2016). A first step in this direction would be the identification of potential areas of CE implementation in the wine production, together with the development of specific indicators that could measure the circular potential of the industry. Today, both the implementation of circular principles and of an indicators system for circularity in the wine industry is lacking. This work aims at boosting the debate and starting to collect ideas to understand how to implement circularity and how to measure it in the industry. For this purpose, beginning from the identification of the main environmental impacts of wine production and from the indicators system developed by EMAS registered organizations in the wine sector, this paper explores which circularity practices may be implemented in the wine production. Moreover, it tries to identify which indicators may be suitable to measure circular practices in this field.

The paper is structured as follows. After this Introduction (Section 1), material and methods (Section 2) are presented. Next, Section 3 presents the main environmental impacts of wine production, mainly measured with an LCA approach, while Section 4 explores the potential contribution of EMS in the wine industry sustainability. Then, the paper illustrates the environmental best practices available and the indicators system proposed by the Italian winery companies awarded with the EMAS registration (Section 5). Section 6 provides a discussion to conceptualize the meaning of CE in the wine industry. Section 7 provides an overview of circularity indicators for micro level specifically drawn up to embrace CE concepts. Discussion (Section 8) and Conclusion (Section 9) summarize the main results of the study with functional suggestions for future research.

2. Material and methods

The analysis has employed different typologies of materials for data collection, such as scholars' literature, reports and protocols. Initially, to identify the current state of academic insight with regards to wine sustainability, a review of existing literature has been carried out. Sections 3, 4, and 5 aim at framing the phenomenon through previous academic studies. Published articles have been extracted from the Web of Science, as well as from Scopus and Google Scholar databases. Section 3, regarding the environmental impacts of wine production, has been developed starting from a specific review of LCA studies in this sector. Implementing an EMS in the wine industry to improve firm's environmental performance has been discussed in Section 4, through a literature review specifically dealing with this subject. Furthermore, analyzing EMAS' indicators provided by SRD in Section 5, we have tried to frame a set of Wine sustainability indicators. Section 6 provide a hypothesis of CE conceptualization in wine industry. A review of CE indicators, instead, is provided in Section 7.

3. The environmental impact of wine production

Despite the fact that the wine industry is often promoted with an eco-friendly image (Delmas and Grant, 2010), the cultivation of wine grapes and wine production are far from being environmentally friendly activities (Gabzdylova et al., 2009). To identify a performing set of indicators for the wine sector it is first necessary to identify the environmental impacts of wine production. To estimate these impacts, many methodological tools are helpful, one of this is certainly the Life Cycle Assessment (LCA). LCA has been defined in ISO standards 14040 and 14044, as "an internationally recognized environmental accounting apparatus, which offers a standardized framework for quantifying the environmental impacts of a product or a production system throughout its life cycle” (European Commission - Joint Research Centre - Institute for Environment and Sustainability, 2010; ISO, 2006). In recent years, a great number of LCA studies in the wine sector has been carried out (Pattara et al., 2012; Rugani et al., 2013). The use of LCA has been proved as useful to analyze the different life cycle stages of wine (Neto et al., 2013; Petti et al., 2010; Rugani et al., 2013; Vázquez-Rowe et al., 2013; Villanueva-Rey et al., 2014). This methodology can be used in the wine industry to quantify, evaluate and interpret the environmental impact of wine considering all its life cycle, thereby developing continuous improvement projects, that can increase the environmental sustainability of the entire wine industry. This approach also reduces the risk of transferring pollution from one life stage to another, trying to improve the overall effects of the product on the environment. The environmental impacts of wine production are generally categorized in four areas: those associated with the growth of the vine, winemaking, distribution and bottle disposal (Saxe, 2010). The impact of the four stages is not univocally considered by LCA researchers. For instance, some scholars (Gonzalez et al., 2006) divide the first three stages relative impact in 27 % (viticulture), 32 % (bottles) and 41 % (transport). For others (Gazulla et al., 2010) instead, the relative impact of the four stages are 46 % (viticulture), 4 % (wine making), 36 % (bottles and barrels), and 14 % (transport from Spain to UK). In this study, we concentrate our analysis only on the winery phase. Table 1 summarize the main environmental aspects and pressures in winery phase. According to the performed literature review, the main environmental issues related to wine production are:

- Water consumption (Marshall et al., 2005).
- The use of fossil fuels running equipment which contributes to greenhouse gases emission (Greenhouse Gas Working Group, 2010).
- Energy consumption (Smyth and Nesbitt, 2014).
- The packaging phase, in particular the use of glass bottles (Glass Packaging Institute, 2010). Impacts from packaging are due to the energy requirements for producing the required materials, such as the glass bottle and corrugated box (California Sustainable Winegrowing Alliance, 2011). Other environmental impacts can be caused by the use of high environmental impact materials in the production of packaging, like glues and inks. In addition, the presence of material waste in the production phase should be considered. Furthermore, too bulky packaging increase the space required during transport and distribution (Amienyo et al., 2014; Cleary, 2013).
- The Greenhouse gases emissions in winery are methane (CH_4) emissions linked to anaerobic degradation of organic matter and coalmines. Hydro-fluorocarbons (HFC), sulphur hexafluoride (SF_6) and fugitive perfluorocarbons (PFC_s), caused by use of refrigerant fluids (Organisation Internationale de la Vigne et du Vin, 2015).
- The distribution of the finished product often associated with carbon-intensive mode of transportation (Cholette and Venkat, 2009; Neto et al., 2013).

Table 1. *Main environmental aspect and pressures in winery phase.*

Main direct environmental aspects	Main environmental pressures	
	INPUTS	OUTPUTS
Stemming/Stalking	Water use Energy use	Wastewater generation Organic matter, mainly stems and stalks from the grapes
Crushing		Waste water generation
Pressing		Waste water generation Pomace: residue from pressing (skins, seeds and stems of the grapes, as well as yeast)
Fermentation		Waste water generation

Settle Decanting/Racking		Waste water generation Lees: sediments resulting from the fermentation of wine (yeast remnants, colloidal matter, and other remains).
Malolactic fermentation		Waste water generation
Fining/Filtration		Organic matter Used filter plates and diatomaceous earth
Stabilization		Tartrates Waste water generation
Bottling		Waste water generation Waste from bottling/packaging

Source: adapted from (JRC, 2015).

4. Environmental management system in the wine industry

Environmental issues and increasing concerns in sustainability, from both consumers and governments, has led wine industry associations to develop and promote various EMSs or sustainability systems in recent years (Forbes and Silva, 2012). Implementing an EMS gives companies the opportunity of analyzing specific processes in the winery and think how to improve in terms of environmental impact (Gemmrich and Arnold, 2007). In addition, EMS implementation can assist firms in environmental management and with the formalization of their environmental activities (Delmas and Grant, 2010). The wine industry is investigating whether there is a relationship between EMS and performance, able to bring a real competitive advantage for businesses (Melnyk et al., 2003). In recent years several studies have been conducted in wine businesses sustainability focused on the factors leading to adoption of EMS (Atkin et al., 2012; Gabzdylova et al., 2009; Hughey et al., 2005). Atkin et al., (2012) found that incorporating an EMS into business models positively influence a differentiation strategy for wineries. Some authors examined the drivers for wineries implementing an EMS, found out that personal beliefs, corporate culture, regulatory and industry pressures and differentiation can led firms to join the regulation scheme (Marshall et al., 2005). Gabzdylova et al., (2009), instead, identifies these drivers in environmental values, personal satisfaction, product quality and customers. However, implementing EMS is not free of barriers and limiting factors (Tee et al., 2007). In fact, implementing an EMS can be very costly for companies both in terms of money, time and bureaucracy with the possibility that the effort made by the company to protect the environment is not recognized by consumers and therefore not paid back (Hughey et al., 2005; Tee et al., 2007). However, literature shows that little attention has been paid to the benefits that implementing EMS might have for wineries (Forbes and Silva, 2012). Encouraging and assisting wineries to develop an EMS may be more likely to generate beyond-compliance initiatives than ratcheting up enforcement or developing new regulations (Silverman et al., 2005).

5. Wine sustainability indicators in the EMAS

The first essential aspect for the development of a sustainability model, linked to concepts to be measured, is the identification of indicators that express in a clear and effective way the path towards continuous improvement and achieved results. To promote information and communication on firm's objectives and strategies, a set of indicators should be developed. Indicators are, in fact, a decision support tool and a benchmark for analyzing the effectiveness of policies implemented. The Eco-Management and Audit Scheme (EMAS), with ISO 14001, is the most widely third-party certified EMSs. The next step of our analysis has been to identify the environmental indicators used by wine companies that have implemented EMAS Regulation. To obtain this certification, companies must develop an Environmental Statement, validated by an accredited Environmental Verifier that aims to inform external stakeholders on company environmental performance. The creation of a system for measuring and monitoring the performance of the EMS, and check compliance with mandatory regulations and with the objectives and environmental goals established by the company, has resulted in the development of the Key Environmental Indicators, which become part of the Environmental Statement. Annex IV of EMAS Regulation, entitled "Environmental

Communication", introduces environmental indicators in section C as "Key indicators and other relevant existing environmental performance indicators". Key indicators, as specified in that Annex, are made up of a value indicating the total annual input/impact in the given field; a value indicating the overall annual output of the organization; and a value which represents the ratio (a)/(b) (Annex IV, EC Reg. No.1221/2016). The total annual input/impact in the given field (figure a), is constructed as indicated in Table 2.

***Table 2**. EMAS key indicators construction.*

Indicators		Unit of measurement
Energy efficiency	Total direct energy use, the total annual energy consumption	expressed in MWh or GJ
	Total renewable energy use	the percentage of total annual consumption of energy (electricity and heat) produced by the organization from renewable energy sources
Material efficiency	The annual mass-flow of different materials used (excluding energy carriers and water)	expressed in tons
Water	Total annual water consumption	expressed in m^3
Waste	Total annual generation of waste, broken down by type	expressed in tons
	Total annual generation of hazardous waste	expressed in kilograms or tons
Biodiversity	The 'use of land'	expressed in m^2 of built-up area
Emissions	Total annual emission of greenhouse gases, including at least emissions of CO_2, CH_4, N_2O, HFC_s, PFC_s and SF_6	expressed in tons of CO_2 equivalent
	Total annual air emission, including at least emissions of SO_2, NO_x and PM	expressed in kilograms or tons

The EMAS Regulation (Article 46) also encourages the development of specific Sector Reference Documents (SRD) to assist registered organizations. These documents are aimed to the identification of the best environmental management practices and environmental performance indicators for each specific sectors, in order to define a comparison between organizations according to their environmental performance levels (JRC, 2015). The aim of SRD is to provide to all organizations an overall picture of the best management practices in their own environmental field. The SRD also want to serve as a guide not only for organizations already registered under EMAS, but also for those seeking to achieve the registration in the future, those who already have an EMS or those who are simply interested in improving their environmental performance. The SRD final draft for food and beverage also provide a specific section for wine production best environmental management practices and indicators. Table 3 summarizes the results of this study.

***Table 3**. Best environmental management practices and indicators on SRD for wine production.*

Most relevant direct environmental aspects	Related main environmental pressures	BEMPs	Indicators

Wine making processes	Energy use; Water use; Waste generation; Wastewater generation.	Reducing water use, energy use and waste generation in the winery organic (Section 12.4.1)	• Total water used (L or m^3) per L of wine produced. Water used can also be measured at process level. • Organic waste generation either mass or volume per liter of wine produced per month/year • Energy use o Thermal energy used – kWh/L of wine produced: can be calculated annually or during the harvesting season o Electricity used – kWh/L of wine produced: can be calculated annually or during the harvesting season
		Deploying energy management and energy efficiency throughout all operations ((Section 3.8)	• Overall energy use per unit, weight or volume of output product (e.g. annual kWh / ton output product) • Overall energy use per facility space (kWh / m^2 of productive facility) • Net energy use per unit, weight or volume of output product (e.g. annual kWh / ton output product) i.e. total minus recovered and renewable energy • Energy use for specific processes (kWh per process) • Deployment of heat exchangers to recover hot / cold streams (Y/N) • Insulation of all steam pipes (Y/N)
		Avoiding food waste in food and beverage manufacturing (Section 3.10)	• Overall Equipment Effectiveness (OEE) • Tons of food waste generated ((sent for recycling, recovery and disposal, including food waste used as a source of energy or fertilizing material) per ton of finished products
Cleaning of equipment and installations	Energy use; Water use; Use of chemicals; Wastewater generation; Waste generation	Environmentally friendly cleaning operations (Section 3.5)	• Cleaning-related energy (kJ) per unit of production • Cleaning-related water use (m^3) per unit of production • Waste water generation (m^3) per unit of production • Waste water generation (m^3) per clean • Water consumption volume (m^3) per day • Mass (kg) or volume (m^3) of cleaning product (e.g. caustic soda) used per unit of production • Share (%) of chemical-free cleaning-agents • Share of cleaning-agents (%) with recognized environmental certification (e.g. EU ecolabel)
Bottling (Packaging)	Energy use Water use Use of material (packaging) Wastewater generation Packaging waste	Improving or selecting packaging to minimize environmental impact (Section 3.4)	• Packaging related CO_2 eq per unit weight of product manufactured • Volume/weight packaging per unit weight of product manufactured. • % of packaging which is recyclable • % recycled material content in packaging • Weight of packaging per unit product • Average density of product category in kg (net) product per liter of (gross/packaged) product.

Energy supply	Air emissions GHG emissions Fossil fuel consumption	Integrating renewable energy in the manufacturing processes (Section 3.9)	• % of production energy demand (heat and electricity) met by renewable energy sources • % of production energy demand (heat and electricity) met by on-site or nearby renewable energy sources
Supply chain management	GHG emissions, energy use, water consumption, air emissions etc.	Sustainable supply chain management (Section 3.3)	• % of suppliers engaged in sustainability programs • % of ingredients or products (e.g. packaging) sourced via green procurement • % of ingredients or products (e.g. packaging) meeting company's specific sustainability criteria or complying with existing sustainability standards •% of suppliers with EMSs in place
Transport and logistics	Energy use, GHG emissions, air emissions (CO_2, CO, SO_2, NOx, particulate matter, etc.)	Improving transport and distribution operations (Section 3.6)	• kg CO_2 eq emitted during transport per: t, m^3, pallet, or case (according to relevance) or kg CO_2 eq per net amount of product delivered • Total energy consumption of warehouse (kWh/m2/yr.) normalized by relevant unit of throughput (e.g. kg net product). L/100 km (vehicle fuel consumption) or mpg; or: kg CO_2 eq /t·km. • % of truck empty runs • % of deliveries carried out through back-hauling

Source: adapted from (JRC, 2015).

6. Towards CE in the wine industry

Significant efforts have been made to introduce sustainability practices and indicators in the wine industry. Nevertheless, the industry has not implemented yet strategies to promote a more circular approach to its operations. Especially in Europe, the CE has been recently introduced as a pillar for guiding all production and consumption activities and to concurrently promote economic gains and reduce environmental impact. While many industries are re-defining their operational principles in the light of this approach, in the wine industry the CE potential is still largely unexplored. The European Union defines the CE "*an economy where the value of products, materials and resources is maintained in the economy as long as possible, and the generation of waste minimized*" (Rizos et al., 2016). Considering the wine industry, there is still a lack of a comprehensive approach to CE. Nevertheless, the potential contribution of the wine production to the 3R (Reduce, Reuse, Recycle) strategy has been explored especially with regard to waste management, as waste represents one of the major environmental concerns of wine production (Arvanitoyannis et al., 2006; Oliveira and Duarte, 2016; Ruggieri et al., 2009). Considering the wine making phase, Figure 1 hypothesizes how waste outputs may return as production inputs and become a valuable resource for the company with a circular approach. According to the input-output flow of winery phase (Iannone et al., 2016), output like residues, sub products and waste water could return into the production phase through a circular process. The wine industry has already experienced some of these practices, using solid and organic wastes as raw materials in other industrial sectors. However, other materials, like stalk and wastewater sludge, often are not valorized by reason of their low economical value and are carried out via external companies. This management choice, however, is correlated with high transport cost, disposal costs and high environmental and social impacts (Ruggieri et al., 2009). Some alternatives can be taken into consideration: composting (Ruggieri et al., 2009); fractionation of grape; hydrolysis and fermentation distillation; extraction; fermentation of grape seed; solubilization and precipitation; lyophilization and co-composting extraction; anaerobic digestion (Oliveira and Duarte, 2016); aerobic digestion, thermophilic anaerobic digestion, sequencing batch reactor (SBR), electro dialysis (ED), wet oxidation (WO), pyrolysis, incineration, solid- state fermentation (SSF) and ozonyzation (Arvanitoyannis et al., 2006).

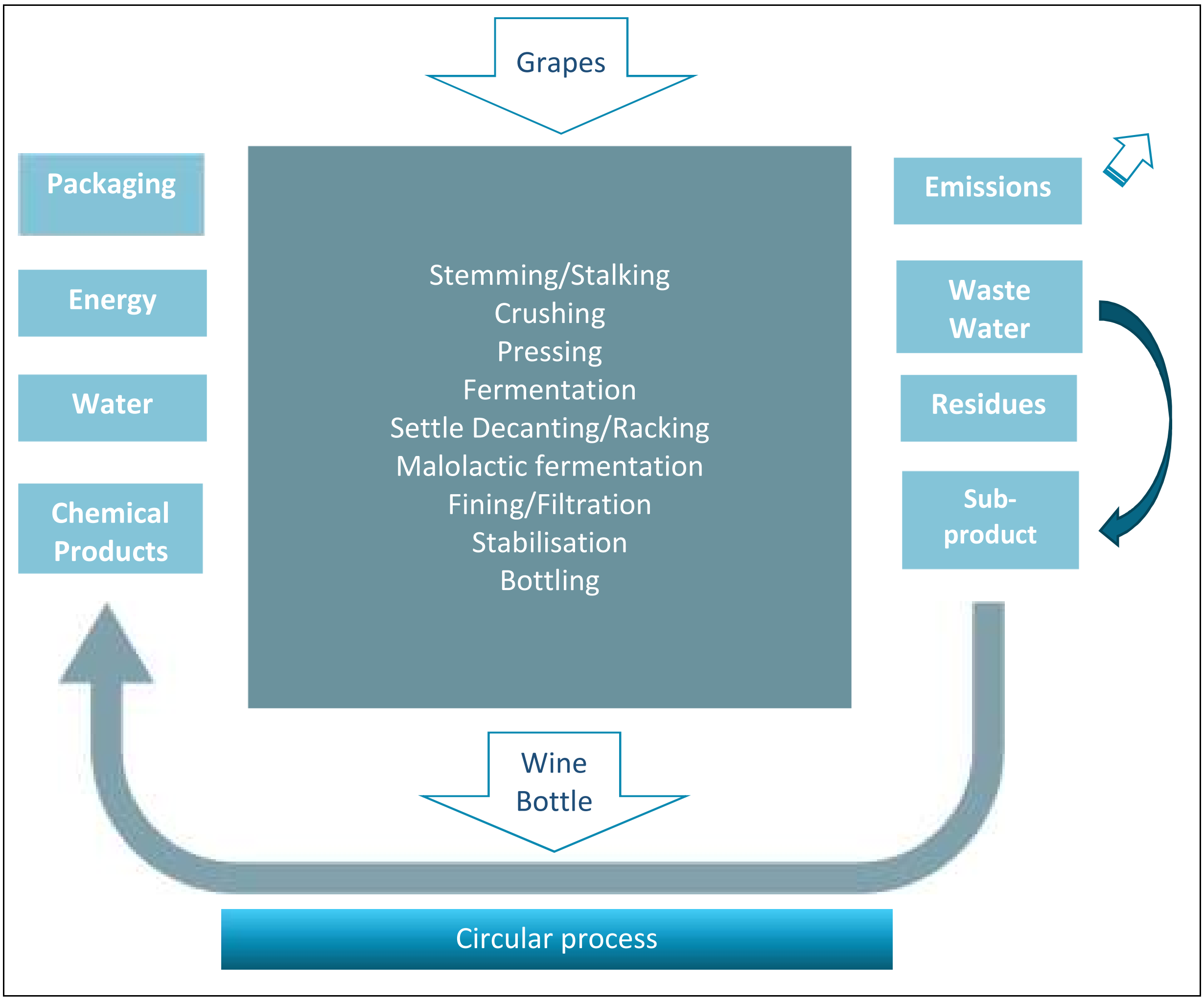

***Figure 1**. Implementation of circular processes in wine-making phase.*

7. Development of CE indicators

As for a sustainability strategy, a starting point to elaborate a CE strategy for wine is the identification of indicators to measure performances. In fact, to promote CE, it is necessary to measure the effectiveness of strategies deployed at national, regional, or local level. Therefore, it is becoming essential to introduce monitoring and evaluation tools such as indicators to measure and quantify this progress (Geng et al., 2012; Su et al., 2013). Despite the growing interest of scholars and practitioners, research about indicators and methodologies for measuring the application level of CE strategies is still in its earliest phase, particularly on the micro level (Elia et al., 2016). CE models and implementations, indeed, are usually performed at three systemic levels (Ghisellini et al., 2016; Saidani et al., 2017). Firstly, the macro level of CE implementation, which includes activities developed at a city, province, region or nation level (Franklin-johnson et al., 2016; Geng et al., 2012; Geng and Doberstein, 2008; Ghisellini and Thurston, 2005; Su et al., 2013; Yuan, Zengwei; Bi, Jun; Moriguichi, 2006) and activities that promote a recycling oriented society (Geng et al., 2012; Shao-ping and Yun-jie, 2010). Secondly, the meso level that is an inter firm level characterized by geographic proximity. It includes industrial Symbiosis as Eco-industrial parks (Chertow, 2000; Geng et al., 2012; Geng and Doberstein, 2008; Ghisellini et al., 2016; Park et al., 2010; Su et al., 2013; Yuan, Zengwei; Bi, Jun; Moriguichi, 2006). Finally, the micro level that corresponds to single companies (Franklin-johnson et al., 2016; Geng et al., 2012; Geng and Doberstein, 2008; Ghisellini et al., 2016; Park et al., 2010; Shao-ping and Yun-jie, 2010; Su et al., 2013) or consumers (Ghisellini et al., 2016; Su et al., 2013). However, the state of the art shows that a deep research on CE assessment and indicators is still lacking, in particular on the micro level (Elia et al., 2016; Ghisellini et al., 2016; Saidani et al., 2017), so more efforts are required to establish a set of reliable indicators. For what concern this study, we only focused on the evaluation of micro level indicators. Table 4 shows the existing indicators for the company level assessment.

***Table 4**. CE Indicators for micro level assessment.*

Indicators/Metrics	Authors
Material Circularity Indicator (MCI)	(Ellen Macarthur Foundation, 2015)
The CE Index (CEI)	(Maio and Rem, 2015)
Reuse potential indicator	(Park and Chertow, 2014)
The CE Toolkit	(Evans and Bocken, 2017)
The CE Indicator Prototype (CEIP)	(Griffiths and Cayzer, 2016)
Waste Input-Output Analysis	(Li, 2012)
Factor analysis based on ESCC and CE-targeted performance indicators	(Zhu et al., 2010)
Performance indicators for a CE, plastic waste treatment	(Huysman et al., 2017)
Recyclability benefit rate (RBR) indicator	(Ardente and Mathieux, 2012)
Indicators for iron and steel enterprise	(Zhou et al., 2013)

Some authors point out that using only one single set of indicators at the micro-level, may fail to capture the full development of the CE in different enterprises (Banait, 2016; Su et al., 2013). To avoid this, each enterprise should set firm-specific indicators according to its characteristics, conditions and existing problems (Su et al., 2013). However, according to Elia et al. (2016), existing index-based methodologies can be successfully used to measure the environmental effectiveness of CE strategies in relation with the system to be measured (Elia et al., 2016). These methodologies should fill the current gap in the environmental evaluation of CE strategies on the micro level. Also the EASAC (2016) underlines that many available indicators may be appropriate for monitoring progress towards a CE. These indicators have been grouped into sustainable development, environment, material flow analysis, societal behavior, organizational behavior and economic performance. However, product circularity performance was not directly considered in these indicators. Another study divided frameworks for measuring CE arise in literature in three categories: Material flow accounts (MFA); Eco efficiency indicator frameworks; Hybrid indicator frameworks (Wisse, 2016).

8. Discussion

In this study, we have tried to decline the concept of CE in the wine sector. More specifically, we have analyzed the environmental impact of the wine-making phase to track best practices and indicators that can help companies in the path to circularity. In this context, the EMSs represent a significant support tool through which monitor the environmental variables and develop sustainable practices. In the European context, the EMAS has been chosen as a baseline, providing an indicator system that partly develops the key themes of the CE. The literature analysis in the wine sector shows how EMSs are a strategic element, both in terms of environmental performance and sustainability practices communication. Many studies confirmed the positive perception of consumers towards eco-labels and EMSs with a third-party certification in the wine industry. In addition, the introduction of an EMS can also help companies in the path towards a CE, introducing a framework to recognize the main direct and indirect environmental aspects. The EMAS, with its environmental performance indicators, provides a concrete starting point for companies. To identify a framework for the construction of circularity indicators for the wine sector we have initially analyzed the indicators of CE at the micro level from the literature, identifying a lack of multi-sectoral indicators. Many indicators are also still in the pilot phase. Others, however, are designed on business or sector-specific reality. These indicators could be partially considered as a starting point for the definition of a set of specific indicators to measure the circularity of practices in the wine sector. Taking into consideration the three "R", we have investigated the indicators prepared by the EMAS Regulation to evaluate whether these may be performing to measure the circularity of wine production (Table 5).

Table 5. *Circular indicators in EMAS scheme and the 3R of CE.*

Circularity indicators in EMAS			
n.	Indicators	Source	3R
1	Material efficiency: The annual mass-flow of different materials used (excluding energy carriers and water) expressed in tons	Key indicators	Reduce
2	Waste: 1) Total annual generation of waste, broken down by type expressed in tons; 2) Total annual generation of hazardous waste expressed in kilograms or tons	Key indicators	Reduce
3	Total water used (L or m^3) per L of wine produced. Water used can also be measured at process level.	SRD	Reduce
4	Cleaning-related water use (m^3) per unit of production	SRD	Reduce
5	Water consumption volume (m^3) per day	SRD	Reduce
6	Waste water generation (m^3) per unit of production	SRD	Reduce
7	Waste water generation (m^3) per clean	SRD	Reduce
8	Organic waste generation either mass or volume per liter of wine produced per month/year	SRD	Reduce Recycle
9	Tons of food waste generated (sent for recycling, recovery and disposal, including food waste used as a source of energy or fertilizing material) per ton of finished products	SRD	Reduce Reuse Recycle
10	Volume/weight packaging per unit weight of product manufactured	SRD	Reduce
11	Weight of packaging per unit product	SRD	Reduce
12	% of packaging which is recyclable	SRD	Recycle
13	% of recycled material content in packaging	SRD	Recycle

We have limited our analysis to the stage of the wine production, bottling, packaging and transport, omitting the vineyard phase. First, we have analyzed the Key indicators of EMAS. In this set of indicators, not specific to the wine sector, we have identified that "material efficiency" indicator embraces one of the key concepts of the CE. This indicator, present in Annex 4 of EMAS, it is a starting point for accounting the business processes circularity. Even the “Waste indicator”, in the Key indicators of EMAS, supports companies towards more circular processes, helping them to account the total waste annually produced. Furthermore, we have analyzed the indicators provided by the SRD. Indicators from 3 to 7 aims to account the water use and the wastewater issues, as they are critical for organizations in the wine industry (Christ, 2014). This industry requires a large amount of fresh water for winery-based activities, determining also a significant impact in terms of wastewater quality (Gabzdylova et al., 2009). Issues related with wastewater generation, treatment and disposal, disclose recycling and reuse opportunities (Mosse et al., 2011). Food and organic waste are accounted through indicators 8 and 9. These indicators measure the quantity of residues and sub products coming from the wine production. Measuring them is the first step towards the reduction of waste and the implementation of circular practices. Indicators from 10 to 13, instead, try to consider the impact of the packaging phase. Reducing the impact of this phase is fundamental for the wine industry. Packaging materials, in fact, impact on natural resource stocks and pose landfill issues (Silverman et al., 2005). From the analysis it emerges that EMAS indicators are useful to account companies’ efforts to reduce both inputs and outputs of their operations. However, these indicators fail to fully describe the circularity of the processes for wine production, as they do not address reuse and recycle practices. Therefore, to internalize CE principles in EMAS indicators, all the action taken toward inputs and outputs reduction, reuse and recycle should be considered. Considering the micro level circular economy indicators developed until now, they are unable to capture the potential of circularity in wine-making processes. These indicators are mostly designed for manufacturing companies or, in any case, for sectors with a high degree of generalizability. Furthermore, most of these indicators are still in the pilot phase. Until now, the CE indicators that can be more effective and applicable in the wine industry are:

Material Circularity Indicator (MCI) (Ellen Macarthur Foundation, 2015);
Circular Economy Index (CEI) (Maio and Rem, 2015)
Reuse Potential Indicator (RPI) (Park and Chertow, 2014).
The MCI indicators were conceived by the Ellen MacArthur Foundation to measure how restorative flows are maximized and linear flows minimized, considering also the length and intensity of the product use. The CEI indicator, instead, has been defined by authors like "the ratio between the material value obtained from recycled products and the one entering the recycling facility". Finally, RPI indicators define how much a material is "resource-like" rather than "waste-like", according to the current available technologies.

9. Conclusion

The wine industry has made great improvements toward sustainability in recent years, and the EMSs have been proven to be an effective way to analyze and improve production processes in this industry. Particularly, the use of specific indicators to monitor environmental performance, assist firms in the continuous performances improvement . In this context, the EMAS is also a driver for boosting and guiding a transition to a circular economy. In this study, we have tried to approach CE in the wine sector. The concept of CE was recently conceptualized at the European level, and more efforts should be made to define what CE means for the wine production. Starting from the analysis of the indicators used in the EMS defined by the EMAS European Regulation, we have identified how these indicators can capture the 3R principles of CE. Even though they are able to describe companies' efforts in terms of input material and output waste streams reductions, they lack in measuring reuse and recycling practices that are core activities in a CE approach. Nevertheless, these indicators are a starting point to experience circular process that fully embrace the logic of the "closed loop" production. As the paper has shown, the micro-level CE indicators that have been developed till now might be integrated together with EMAS indicators developed in the wine industry, to create common metrics to measure CE progress in the wine production.

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HIP — a Happier Index for the Planet?

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Abstract

Measuring complex and rather intuitive qualities such as sustainability requires combining variety of measures together. The resulting composite indicator depends not only on the component sub-indices but also on the way they are combined together. We are considering the Happy Planet Index (HPI) as an example of a composite sustainability indicator that aggregates information on positive qualities like life-expectancy and human wellbeing with negative ones like ecological footprint to rank countries according to their sustainability state. However, since component indices are often mutually correlated and feature quite different distributions of entities ranked, elaborate rules are used in the process of combination. As a result, the resulting composite index may look somewhat contrived and its rankings may depend heavily on subjective parameters in the combination process. We propose a geometrically motivated parameter-free method for combining indices with contrasting effects together. The method is independent of the number of sub-indices to be combined and eliminates mutual correlation between component indices by using Singular Value Decomposition (SVD) analysis. By applying our methodology, we reconstruct the latest Happy Planet Index results (2016) and prove the feasibility of the proposed approach. As a result we conclude that altering the measures of life expectancy and wellbeing with the inequality adjustments improves the objectivity of the sustainable wellbeing assessment.

Keywords: Sustainability indicators, Composite index, Singular value decomposition, Happy Planet Index

1. Introduction

Sustainability science as an academic discipline has emerged at the turn of 21st century, taking its roots from the environmental science. However, the concept of sustainability is becoming more complicated and embraces a wider range of mankind activities, besides just the environmental impact on the natural ecosystems: like those associated with economic stability and social integrity. Currently there is no unified method to measure such complex human-nature interactions, so far the best attempts to assess sustainability come in a form of various indicators and indices (Kates, Parris and Leiserowitz, 2005; Todorov and Marinova, 2011; Singh *et al.*, 2012). Whereas having the capacity to carry out a scientifically substantiated message, sustainability indicators are also very effective in communicating the results of research to stakeholders and political decision-makers.

Probably the most prominent example of sustainability indicators at the moment is the Sustainable Development Goals initiative by the United Nations and associated with them targets (UNDP, 2016). It also represents a rising trend of shifting the governmental focus from maintaining just the monetary value (GDP) towards peoples' wellbeing and life satisfaction.

Happiness is increasingly considered to be the proper measure of social progress and the goal of public policy (Helliwell, Layard and Sachs, 2017).

Indicator schemes share a common goal of measuring the key sustainability dimensions, yet they differ in conceptual definitions, methodological approaches and modes of operation. For example, in Krajnc and Glavič (2005) or Zhou *et al.* (2012) a model is considered to assess companies' sustainability performance based on their composite sustainable development index. Measuring complex and rather intuitive qualities such as sustainability or wellbeing implies combining a variety of measures together. The idea behind composite indicators is to aggregate multidimensional issues into a single index, as a result the composite index depends not only on the component indices used but also on the way these sub-indices are combined together. However, there is a lot of criticism toward such an approach due to the subjective nature of the composite indicators, since they are heavily dependent on the way they are handled: the normalization, weighting and aggregation methods used.

We are basing our work on the Happy Planet Index (HPI) as an example of the global measures to assess such a subjective matter as sustainable wellbeing (NEF, 2016a). HPI uses global data on experienced wellbeing, life expectancy, and ecological footprint to generate an index revealing which countries are most efficient at producing long, happy lives for their inhabitants, whilst maintaining the conditions for future generations to do the same (NEF, 2016b). Inherently, HPI is a measure of efficiency: it is defined as a product of national wellbeing and life expectancy achieved per unit of resource use (ecological footprint).

We are considering the HPI as an example of a composite sustainability indicator that aggregates information on positive qualities (life expectancy and human wellbeing) with negative ones (ecological footprint) to rank countries according to their sustainability state (NEF, 2016b). However, since component indices are often mutually correlated and feature quite different distributions of entities ranked, elaborate rules are used in the process of combination. As a result, the resulting composite index may look somewhat contrived and its rankings may depend heavily on subjective parameters in the combination process.

In our previous paper (Bondarchik *et al.*, 2016) we proposed a different way of building a composite indicator, which was based on the HPI 2012 methodology and data. This is a universal algorithm, dubbed a *Happier Index for the Planet* (HIP) which aims to build an aggregate indicator from a set of sub-indices that can feature both positive and negative impact. Our main argument is that the HIP methodology is more robust than the one for the HPI and, therefore, it is not depending on the number of variables used in the calculations plus there are no free parameters to readjust for the new set of data. To prove this argument we are going to test our algorithm on the recently issued HPI 2016 results (NEF, 2016a).

2. Methods

In comparison to the HPI 2012 report (Abdallah *et al.*, 2012) some minor changes have occurred in the HPI 2016 methodological approach. In the latest calculations inequality adjustments were applied, instead of wellbeing and life expectancy indicators their inequality adjusted versions are introduced (NEF, 2016b). Indeed, people across the world are experiencing the impact of growing inequalities which cannot be omitted when talking about measuring happiness. The HPI 2016 methodology includes a component «inequality of outcomes» to account for this, adjusting the average wellbeing and life expectancy in each country downwards to account for inequalities in each of these outcomes.

According to the HPI 2016 methods paper HPI is calculated as the following:

$$HPI = \varphi \times \frac{(WB - \alpha \times LE) + \pi}{EF + \beta} \qquad (1)$$

Where WB is wellbeing (inequality adjusted), LE — life expectancy (inequality adjusted), EF — ecological footprint, and $\alpha, \beta, \pi, \varphi$ are constants. Despite the fact that these constants are derived based on the statistically justified measures, these manipulations cause for criticism and loss of credibility, even though the adjustments of the sub-indices are based on «educated guesses».

As an alternative to such an arbitrary approach we propose a geometrically motivated parameter-free method for combining indices with contrasting effects together. This method is independent of the number of indices to be combined and eliminates mutual correlation between component indices by using Singular Value Decomposition (SVD) analysis. By applying our methodology, we reconstruct the HPI and demonstrate the impact of adding new component indices to HPI on ranking nations by their sustainability state.

As it was mentioned before in this work we test the algorithm which was described in our previous paper (Bondarchik *et al.*, 2016) by using the most recent HPI 2016 data published by New Economics Foundation (NEF, 2016a). Our calculation of the HIP will use similar indicators as are used in HPI, since we acknowledge that the indicators (ecological footprint, wellbeing and life expectancy) well represent the state of sustainability in all three considered dimensions. Even though since the 2012 report the new adjustments were introduced, we are using the exact same algorithm as before to prove its robust nature. It includes five steps, which are described in the following subsections.

2.1. Data normalization

Many of the chosen indicators have very different statistical distributions. Therefore, the first act aims to normalize the data, which means that the values of the variables are rescaled to have the same mean value and standard deviation. Normalization procedure includes the following steps:

a) Shift each value of a variable by one and calculate its logarithm as demonstrated in Equation (2):

$$Y_i = \ln(X_i + 1), i = 1, \dots, k \qquad (2)$$

We know that all of our original sub-indices do not contain negative values. However, the shift by one ensures that we avoid taking the logarithm of zero or any values close to zero. On the other hand, the logarithm operation scales down any possible outliers (outperforming/underperforming countries) to make the values of all countries more comparable.

b) Rescale all the variables to have mean value 0 and standard deviation 1/3. This is done using formula (3):

$$Z_i = \frac{Y_i - \overline{Y_i}}{\sigma_{Y_i}}, i = 1, \dots, k \qquad (3)$$

Where $\overline{Y_i}$ represents the mean value and σ_{Y_i} — the standard deviation of variable Y_i.

c) Shift all the variables by one. This is necessary due to the fact that the calculation of the HIP will require division of one variables by the others. Therefore, to ensure the feasibility of these simple mathematical operations, we need to have the values of the variables to be centred around 1 rather than 0.

2.2. Singular value decomposition

The next step is to apply the SVD analysis in order to find the principal components for each of the distributions to avoid a high level of correlation between the indices. Those components will become the new variables in our calculation of the HIP.

According to the definition (Barnett, 1990), for any matrix $\boldsymbol{X}_{m\times n}$ with the rank r, there exist matrices $\boldsymbol{U}_{m\times m}$ and $\boldsymbol{V}_{n\times n}$, such that $\boldsymbol{X} = \boldsymbol{USV}$, where $\boldsymbol{S}$ is an $m \times n$ diagonal matrix with the singular values of $\boldsymbol{X}$ located on its diagonal (all the rest elements equal 0). At the same time, $\boldsymbol{U}$ is the matrix of singular vectors and $\boldsymbol{V}$ demonstrates the scores of how much each of the principal components represents (explains) the original variables.

2.3. Renormalization of the principal components

After the principal components have been identified, they are all renormalized to have mean value 1 and standard deviation 1/3 to assure the values are not the exact original values, but rather the relative distribution shapes that carry out the key information for the index calculation.

2.4. Identification of the positive/negative impact of the principal components

The obtained principal components are assigned to positive and negative ones. Instead of the product, the geometric average of both sets is taken separately and the quotient of these two geometric averages defines the HIP value for each target country. Moreover, since SVD is applied to all variables, positive and negative simultaneously, it is ascertained that principal components in the denominator and nominator do not correlate.

2.5 HIP calculation

In this approach, the SVD is performed on a matrix containing the normalized indicator column vectors. After the principal components are identified from our data set, HIP is calculated as presented in Equation (4):

$$HIP = \frac{\sqrt[k]{\prod_{i=1}^{k} P_i^+}}{\sqrt[l]{\prod_{j=1}^{l} P_j^-}} \qquad (4)$$

Where the principal components P_i^+ represent the indicators with positive effects and the principal components P_j^- represent the indicators with negative effects. The choice of components of the P^+ and P^- sets is based on the analysis of score matrix $\boldsymbol{V}$.

3. Results and Discussion

As it was mentioned in the previous section the same set of the sub-indices (*LE*, *WB* and *EF*) is used for the HIP calculations. In the Figure 1 the histograms of these sub-indices are presented for the list of the 140 countries under consideration. As can be seen from this figure the chosen indicators have very different statistical distributions and, therefore have to be normalized in order to make them comparable to each other. At this point the inequality adjusted life expectancy and wellbeing represent the indicators with the positive impact, whilst the ecological footprint carries the negative impact on the sustainability ranking.

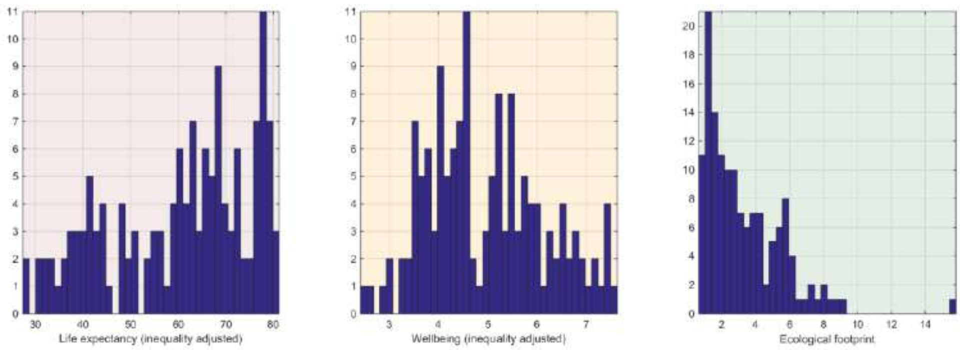

Figure 1. *Histograms of the sub-indices used in the calculation of the Happier Index for the Planet (data source* NEF (2016a)*).*

The first step of our methodology is data normalization for all the variables to be of the same scale and range of values. Figure 2 shows the base indicators normalized with respect to the steps (a)–(c) given in the subsection 2.1. As can be seen from these histograms, the values of all the indicators now range between 0 and 2 with a rather similar spread. Moreover, even though the histograms remain quite different, they all could be interpolated by a Weibull distribution approximation, but with different parameters. In this case, the Weibull representation is more appropriate than normal distribution for the two following reasons:

- Weibull can fit a whole range of shapes from exponential-like to Gaussian bell-shaped histograms; and
- it has the non-negativity feature which cannot be guaranteed in data coming from a normal distribution.

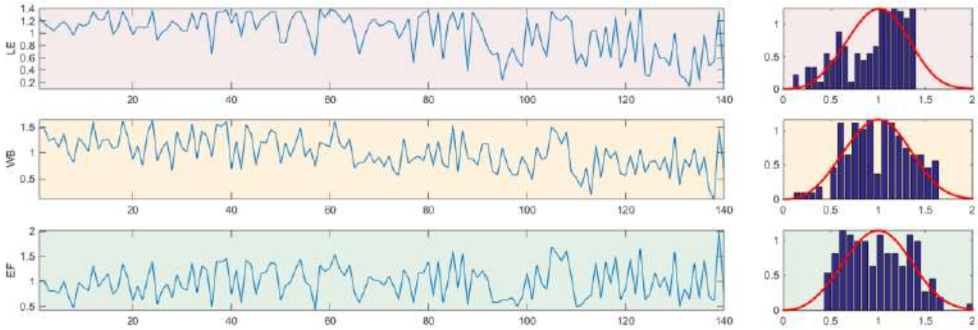

Figure 2. *Normalized sub-indices used in the calculations of the Happier Index for the Planet (LE — life expectancy, WB — wellbeing, EF — ecological footprint).*

Once the sub-indices are normalized, they can now be subjected to SVD to reduce their mutual correlation and identify the real information each of them carries in the entire data set. Let us consider the set of the orthonormal eigenvectors obtained after performing the SVD analysis on the combination of *LE*, *WB* and *EF* sub-indices. The columns of the matrix $\boldsymbol{V}$ determine the principal components, and the rows — the original variables in the stated order. To calculate HIP, in is necessary to know which variable represents the negative indicators and which the positive indicators.

$$\boldsymbol{V} = \begin{bmatrix} 0{,}569556619 & 0{,}732600469 & -0{,}372695331 \\ 0{,}572472188 & -0{,}678930923 & -0{,}459704683 \\ 0{,}589814251 & -0{,}048470133 & 0{,}806082995 \end{bmatrix}$$

The values in matrix $\boldsymbol{V}$ are color-coded for easier interpretation, where green colour indicates a positive effect and red colour indicates a negative effect. In the first column, which represents the first principal component, the first two scores which represent *LE* and *WB* respectively, remain positive. Regardless the fact that the score for the negative effect variable *EF* has negative value, the first principal component is positive. Analogously the second principal component can be seen to have a positive effect as well, but the third one is clearly negative. So in this particular case the principal components do not change the direction of their impact compared to the original variables. If we denote the principal components as $P_i,\ i = 1, 2, 3$, then $\{P_1, P_2\} \in P^+$ and $\{P_3\} \in P^-$. Thereby, after the principal components are re-normalized, the HIP is calculated for this case as presented in the following Equation (5):

$$HIP = \frac{\sqrt{P_1 \cdot P_2}}{P_3} \qquad (5)$$

Table 1 presents the final result, the top–10 and bottom–5 ranked countries calculated using HIP when compared with the original Happy Planet Index 2016 results.

Table 1. *The top–10 and bottom–5 ranked countries calculated using the Happier Index for the Planet in comparison with the original Happy Planet Index 2016 results, where **r** is the original HPI rank.*

r	HPI	HIP	
1	Costa Rica	Bangladesh	(8)
2	Mexico	Costa Rica	(1)
3	Colombia	Vietnam	(5)
4	Vanuatu	Nicaragua	(7)
5	Vietnam	Colombia	(3)
6	Panama	Vanuatu	(4)

7	Nicaragua	Jamaica	(11)
8	Bangladesh	Sri Lanka	(28)
9	Thailand	Palestine	(22)
10	Ecuador	Albania	(13)
136	Mongolia	Cote d'Ivoire	(135)
137	Benin	Nigeria	(95)
138	Togo	Swaziland	(132)
139	Luxembourg	Sierra Leone	(133)
140	Chad	Chad	(140)

As can be seen from the Table 1, it is rather challenging to compare our results to the HPI ranking just by looking at them. Because the scales of HPI and HIP are different, an additional mathematically justified tool should be used to determine the degree of the correlation. We will use the Spearman's correlation coefficient (Spearman, 1904), which measures the strength and direction of association between two ranked variables and calculated as in Equation (6):

$$\rho = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2-1)} \qquad (6)$$

Here d represents the difference between the ranks of the respective sample observations and n is the size of the sample. Basing on our rank results and the sample size $n = 140$ (amount of countries), the correlation coefficient between HPI and HIP equals **0.96**. This basically means that the rank correlation reaches 96% with the original HPI ranking by using our methodology, where there are no subjective free parameters to be readjusted.

In our previous work (Bondarchik *et al.*, 2016) to obtain such a high level of correlation we had to add a Global Peace Index (GPI) to the set of the sub-indices as an auxiliary measure of the political stability and militarization (IEP, 2016). However, in this work we were basing on the inequality adjusted data (for life expectancy and wellbeing), which already accounts for the dimension of sustainability that GPI is intended for. In Table 2 below we present the correlation coefficients as a result of using other sets of sub-indices for HIP calculations — by adding GDP (economical welfare) and GPI (political stability).

Table 2. *The correlation coefficients obtained respectively to the sets of the sub-indices used to the calculation of the Happier Index for the Planet.*

Set of the sub-indices used in the HIP calculations	**Correlation coefficient ρ (with the original HPI ranking)**
LE, WB, EF	**0.96**
LE, WB, EF, GDP	0.65
LE, WB, EF, GPI	0.64
LE, WB, EF, GPI, GDP	0.71

Even though adding complementary variables decreases the correlation with the original HPI ranking, the similarity still remains above 60%. Moreover, the inequality adjustments diminish the correlation between life expectancy, wellbeing and GDP as well as GPI. As a result this enhances the range of the sustainability issues taken into the account and, therefore, changes in the ranking naturally occur.

4. Conclusions

In this work we have tested our approach, which was developed to calculate the composite indicators in which sub-indices with contrasting effects are incorporated. As a case study, the Happy Planet Index was chosen, which represents a subjective measure of countries' sustainable wellbeing. Initially the methodology was built on the Happy Planet Index 2012 ranking, but in this work we proved its feasibility with the newly released Happy Planet Index 2016 data. Despite the fact that HPI calculations were modified since, we still obtained a strong correlation with our sustainability ranking using the same mathematical algorithm.

However, in this case including a Global Peace Index as a measure of the political stability to the data set, decreased the correlation with the original HPI ranking. We suppose that is due to the fact, that the inequality adjusted measure of life expectancy and wellbeing are used instead of the ordinary ones. Those inequality adjustments allude to the resembling issues as GPI. GDP in its turn is no longer correlated with the wellbeing and life expectancy and, therefore, introduces an additional sustainability dimension.

Based on the results, we argue that the proposed Happier Index for the Planet calculations are more robust than the ones for Happy Planet Index. First of all, it allows the freedom to include any set of explanatory sub-indices with respect to which aspects of sustainability are most relevant in a particular context. Moreover, the mathematical approach is universal for any set of variables. Thus, it was proved that there is no need to re-tune any constants through hand-picked educated guesses, no matter how many sub-indices are required to be considered. On the other hand, we can claim that by altering the life expectancy and wellbeing measures with the inequality adjustments in the HPI calculations the New Economics Foundation (NEF) have strengthen their methodological approach from a mathematical point of view.

It is important to emphasize that the new index combination methodology proposed here is not an absolute measure of sustainability. The rankings it produces still depend completely on the validity and relevance of the component indices chosen. But because the process of index combination is no longer subjective, we hope that the relative rankings calculated with this method are consistent over time, and time series of such rankings can be used for establishing reliable trends in sustainability.

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Pollution indicators for use in Life Cycle Assessment: review and simplification

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Abstract

Life Cycle Assessment (LCA) is a well-known tool in the scientific community, useful to compare products and industrial processes. However, LCA is not commonly used in the industry, as it requires a large effort and investment. There is a large variety of Life Cycle Impact assessment (LCIA) methods, some quite complex, each with different methodologies that lead to different results and eventually different decisions. In particular, the integration of pollutants into aggregate indicators has been treated in many different ways, both due to different approaches and because the impact of certain pollutants is not yet fully understood by the scientific community (dioxins and furans are a case in point that merited particular attention). Additionally, the range of local impacts is wide and not easy to adapt to LCA (which of necessity must be standardized over multiple products and processes). The aim of this work is to provide a solid comparison of indicators of pollution to air, water and soil, provided by a variety of LCIA methods: CML2001, Eco-indicator99, EDIP2003, Impact2002+, ReCiPe, TRACI and EcoBlok. The pollutants considered are those in the Pollutant Release and Transfer Register (PRTR), established by the Kiev Protocol under the Aarhus Convention, which covers nearly all pollutants invoked by the LCIA methods and is supported by international databases. The first step was to compare the relative importance attributed by each method to the range of pollutants. The second step was to compute equivalent pollution, as defined by each method, for nine major industrial sectors (energy, metallurgy, mining, chemicals, waste treatment, wood and paper, livestock, agri-food, and others), using available information of the PRTR-Europe database. The third step was to compare results provided by the different methods and examine similarities and differences between them. Results indicate that most methods converge in impact categories such as global warming and acidification potential. The most significant differences emerge in the human health and ecotoxicity impact categories, where the same pollutant may vary in relative importance by five orders of magnitude, from one method to the other; similar differences appear when comparing economic sectors in those impact categories. Although these are preliminary findings, it can be argued that the additional work required by some complex methods does not seem to be rewarded by more robust or useful results. Simpler methods may be as meaningful, more transparent and easier to use in practice by the industry.

Keywords: environmental indicators, life cycle assessment, pollution

1. Introduction

LCA is a tool used in the evaluation of impacts resulting from the different phases of the life cycle of a product or service. It is an important tool concerning decision making, both in terms of public policy development and in the industrial context. It is, however slightly used due to its high cost and lack of standardization.

In the specific field of LCIA, several methodologies are available, which should be considered when analysing the results of an LCIA study. The existence of various methodologies can mean a difference of several orders of magnitude in the result of evaluating the impact of a product or service.

Different LCIA methods have been developed over time. Existing methods have been updated and renewed. There are numerous examples of LCIA methods available in the literature.

The most common impact categories in these methods are climate change, acidification, eutrophication, stratospheric ozone depletion, tropospheric ozone formation, ionizing radiation, ecotoxicity, human toxicity, resource depletion and land use.

2. Methods

The scope of the work was the following:

a) The chosen LCIA methods for comparison are: CML 2001(Guinée, J.B. *et al* 2004), Eco-Indicator 99 (Goedkoop, M. and Spriensma, R., 2000.), EDIP 2003 (Hauschild, M.Z. and Potting, J. 2005), IMPACT 2002+ (Humbert, S. *et al* 2012), ReCiPe (Huijbregts, M. A. J. *et al* 2015) TRACI (Bare, J. C. *et al*, 2003), EcoBlok (Melo, J.J. and Pegado, C.,2002) (Melo, J.J. *et al* 2003). Several indicators were considered, as relevant for each method. The seven methods were also compared with relative hazardousness implicit in the PRTR thresholds

b) The pollutants considered are those in the Pollutant Release and Transfer Register (PRTR), established by the Kiev Protocol under the Aarhus Convention, which covers nearly all pollutants invoked by the LCIA methods and is supported by international databases.

c) The chosen impact categories are climate change, acidification, eutrophication, photochemical ozone formation, ozone depletion, ecotoxicity and human toxicity. Some pollutants figure in various impact categories but with different equivalence factors.

d) The Comparison/normalization method is stated in normalized equivalence factors as shown in the equation 1:

Equation 1

$$EF_{Ni,j} = \frac{EF_{Ai}}{\sum EF_{Aj}}$$

Where: $EF_{Ni,j}$ is the normalized equivalence factor for pollutant i and impact category j; EF_{Ai} is the absolute equivalence factor for pollutant I; and EF_{Aj} is the sum of the absolute equivalence factors for impact category j.

3. Results and discussion

Figure 1 shows the normalized equivalence factors for ecotoxicity, relatively to air emissions. It is verified that PCDD and PCDF have the highest equivalence factors, followed by heavy metals. Relatively to PCDD and PCDF these methods are meeting the precautionary principle since there is a high uncertainty about the real effects these pollutants have in the environment. About the heavy metals those effects are well known by now, so there is a high consensus between LCIA methods. The remaining pollutants show no agreement, specifically to benzene and trichlorobenzene where the is a difference of five and eight orders of magnitude, respectively.

For other impact categories like climate change, acidification, eutrophication, stratospheric ozone depletion and photochemical ozone formation, the results are quite similar between methods. The main difference relies on the chosen inventory, as there are pollutants not considered in the impact categories calculation.

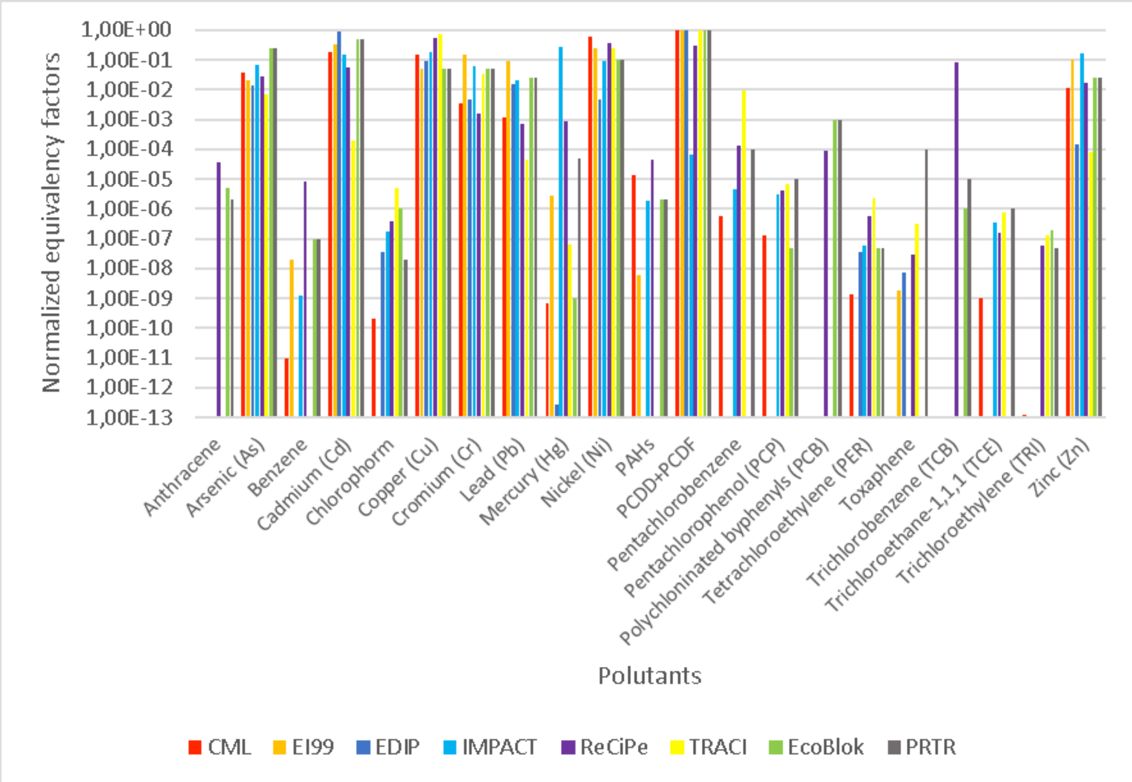

Figure 1-Normalized equivalence factors for ecotoxicity (emissions to air)

Figure 2 shows the normalized equivalence factors for human toxicity, relatively to air emissions. We can see PCDD and PCDF have the highest equivalence factors, followed by heavy metals.

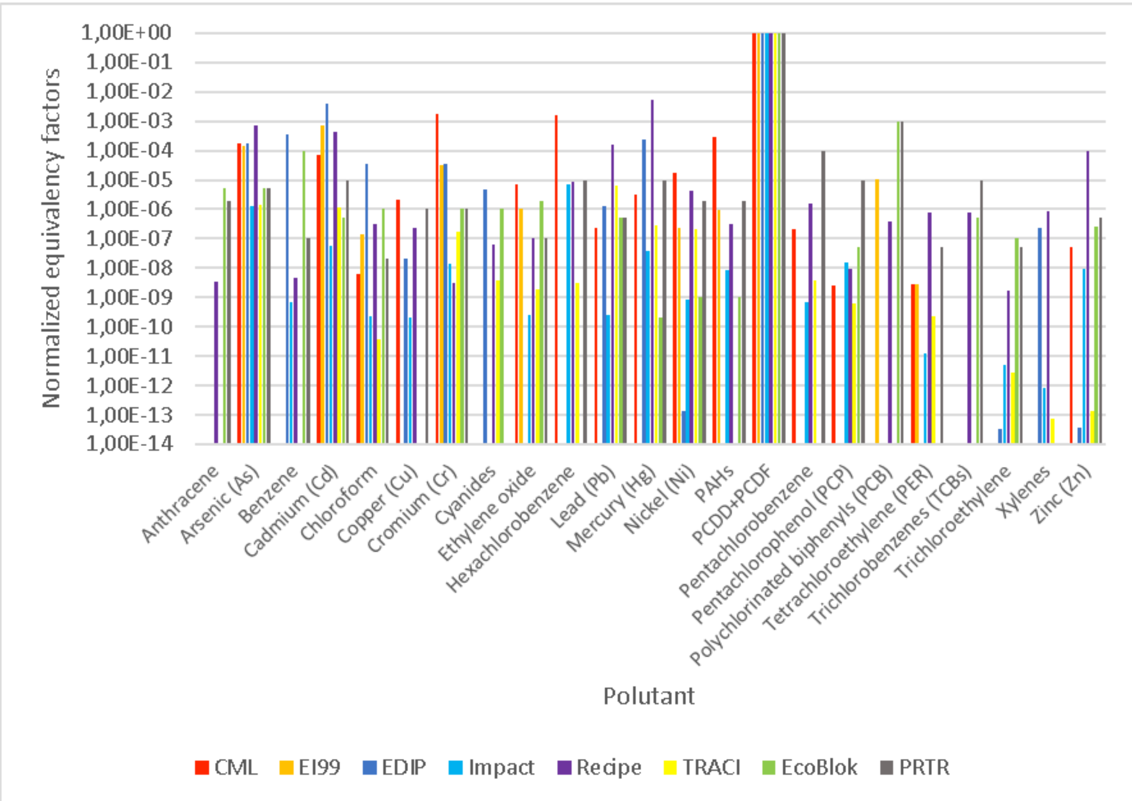

Figure 2 - Normalized equivalence factors of each method for human toxicity (emissions to air)

Relatively to PCDD and PCDF these factors are even higher than those related to ecotoxicity, because the precautionary principle related to human health must be treated more carefully, since there is a high uncertainty about the real effects these pollutants have in the human health. About the heavy metals those effects are well known by now, so there is a high consensus in the normalized equivalence factors between LCIA methods. The remaining pollutants present no agreement, specifically to benzene and trichloroethylene where the is a difference of six orders of magnitude, between Impact and EDIP and between EDIP and EcoBlok respectively.

Figure 3 shows the equivalent pollution (resulting from the product of emitted quantities and equivalence factors) in the industry sectors for ecotoxicity. In general, there is no uniformity between methods, for instance, Recipe shows an impact five times bigger for the chemical industry, when comparing with the other methods. For the metal industry methods, can vary in 50%, for EI99 and Recipe. For the waste sector the differences are smaller but it can achieve differences of 40% between EI99 and EDIP.

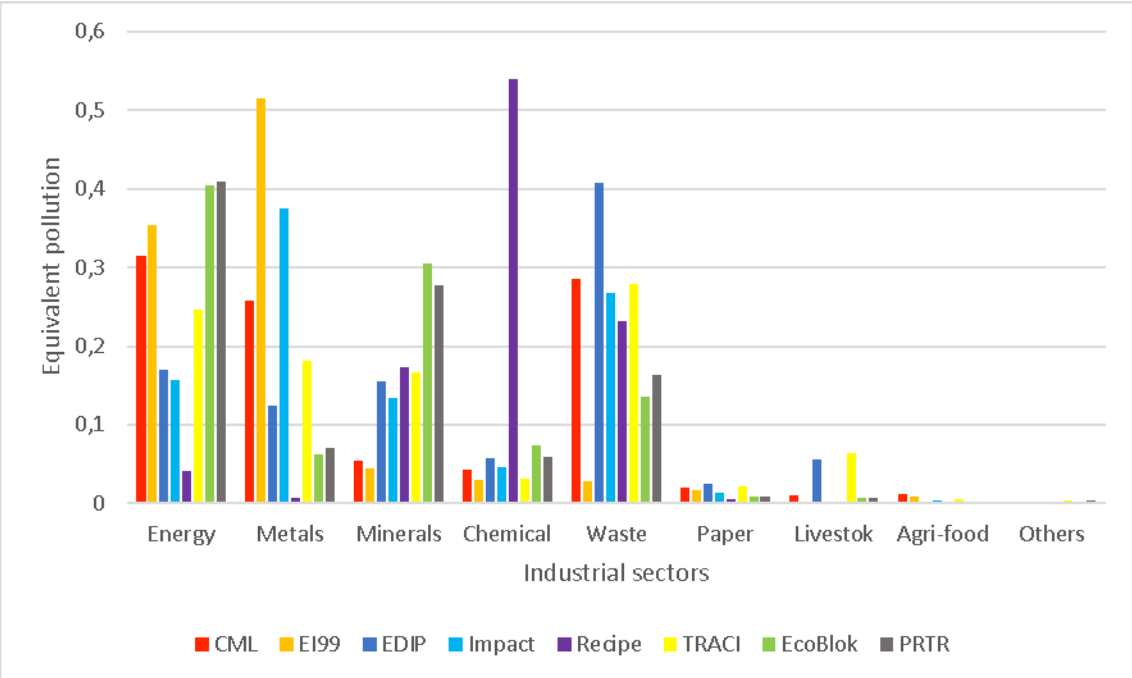

Figure 3 - Normalized emissions for industrial sectors for ecotoxicity

For other impact categories like climate change, acidification, eutrophication, stratospheric ozone depletion and photochemical ozone formation, the results are quite similar between methods.

Figure 4 shows the equivalent pollution (resulting from the product of emitted quantities and equivalence factors) in the industry sectors for human toxicity. In general, there is no consistency between methods. For instance, Recipe and EDIP show an impact five times bigger for the chemical industry, when comparing with the other methods. For the metal industry methods, can vary in 40%, for CML comparing with EDIP and Recipe. For the waste sector the differences are smaller but it can achieve differences of 40% between CML and EI99. For the energy sector CML, EcoBlok and PRTR show similar results, as well as between EI99 and Impact. For EDIP and Recipe, the values are shown to be similar, however when comparing with the average the results are quite below, resulting in a difference in the range of 20-40%.

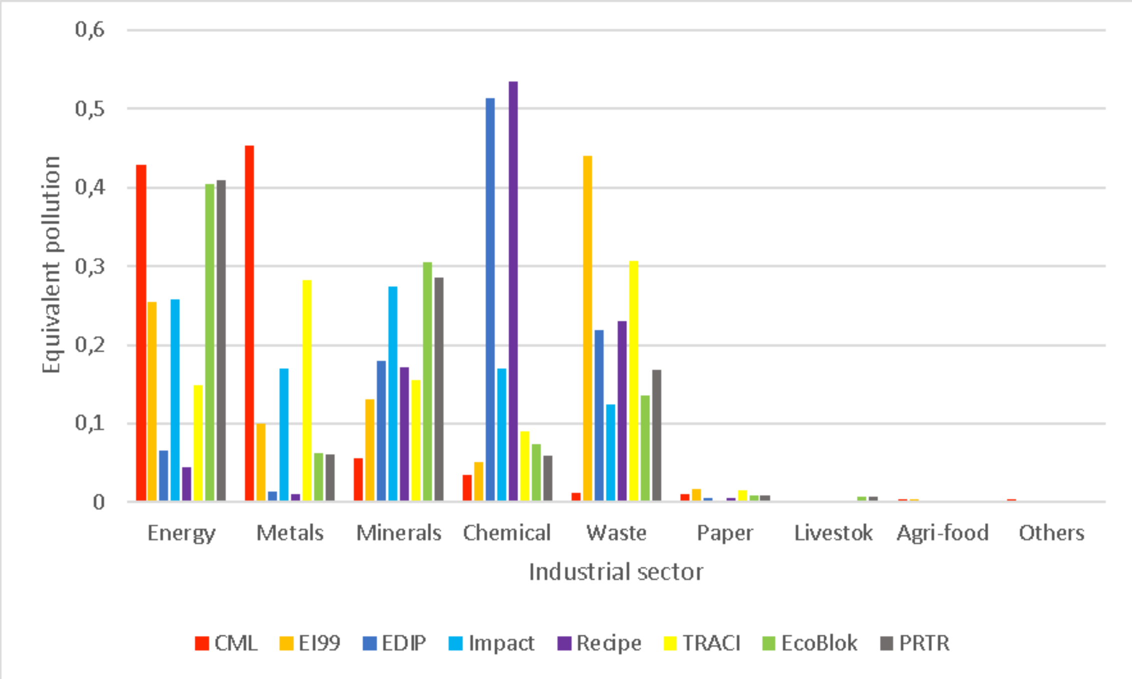

Figure 4 - Normalized emissions for industrial sectors for human toxicity

Figure 5 shows the equivalent pollution (resulting from the product of emitted quantities and equivalence factors) given to the selected pollutants for ecotoxicity. The pollutants selection was made by the highest contribution/value to the impact category. It is shown that heavy metals have the largest contribution. Results suggest that even for methods which have thousands of pollutants in the inventory (like Recipe and TRACI) the relative contributions appear not to be that different from other methods.

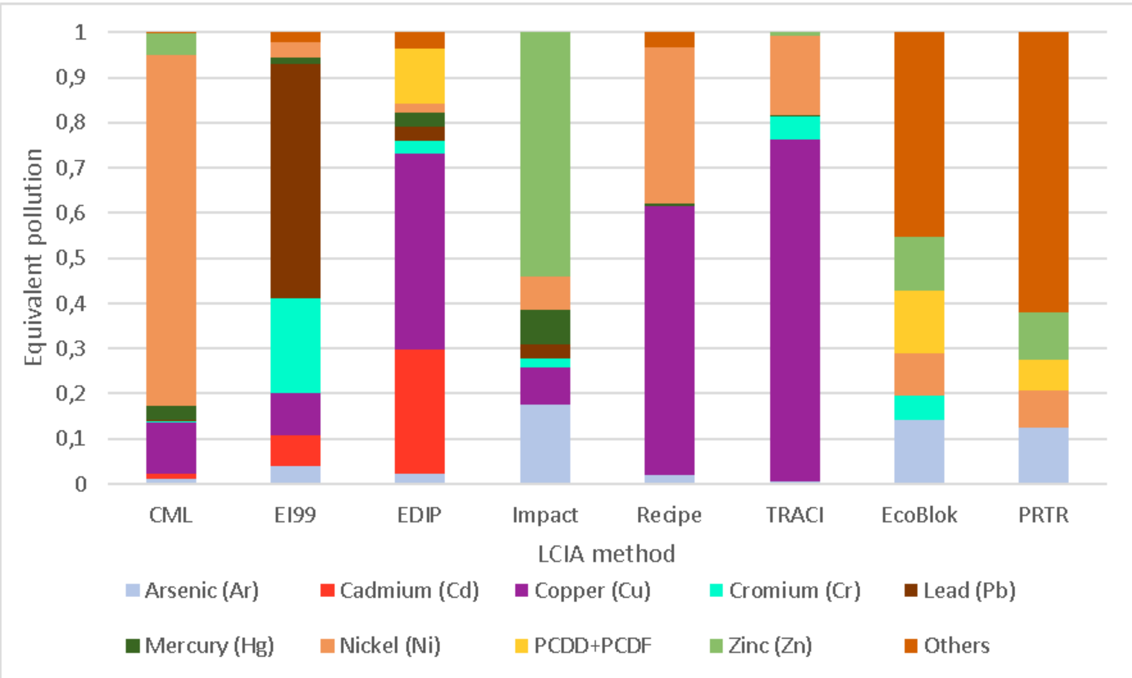

Figure 5 -Normalized emissions for selected pollutants for ecotoxicity

Figure 6 shows the equivalent pollution (resulting from the product of emitted quantities and equivalence factors) given to the selected pollutants for human toxicity. The pollutants selection was made by the highest contribution/value to the impact category. It is shown that heavy metals have a big contribution. However, for this impact category polychlorinated biphenyls have clearly the biggest weight, appearing in EI99 with an 85% contribution for the total reckoning of the impact category. For EDIP the main contribution is due to benzene, appearing with 90% of the total reckoning if the impact category.

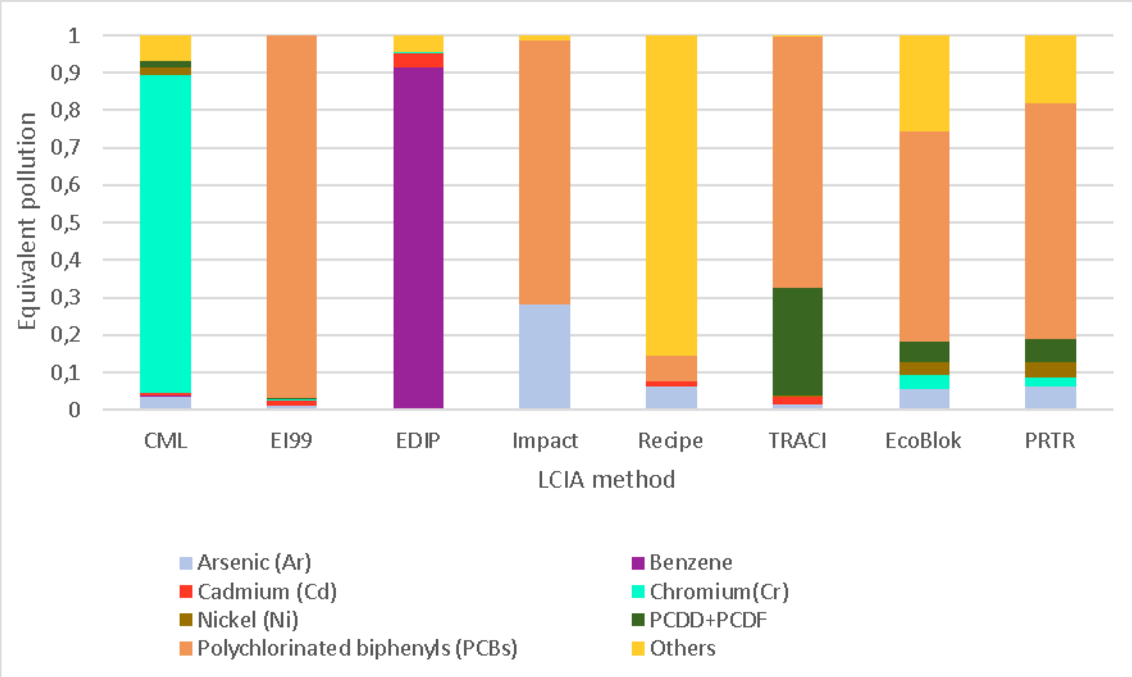

Figure 6 Normalized emissions for selected pollutants for human toxicity

4. Conclusion

The most significant differences emerge in the human health and ecotoxicity impact categories, where the same pollutant may vary in relative importance by five orders of magnitude, from one method to the other; similar differences appear when comparing economic sectors in those impact categories. Although these are preliminary findings, it can be argued that the additional work required by some complex methods does not seem to be rewarded by more robust or useful results. Simpler methods may be as meaningful, more transparent and easier to use in practice by the industry.

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PRTR-E. European Pollutant Release and Transfer Register. Obtained from prtr.ec.europa.eu

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[2,3,n] *Authors two, three and n affiliation(s), e-mail addresses*

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1. Introduction

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2. Methods

Please insert your Methods text here. Text alignment is formatted as justified. Figures, like Figure 1, should have a self-explanatory caption placed under the figure and should be referenced in the main text like in this sentence.

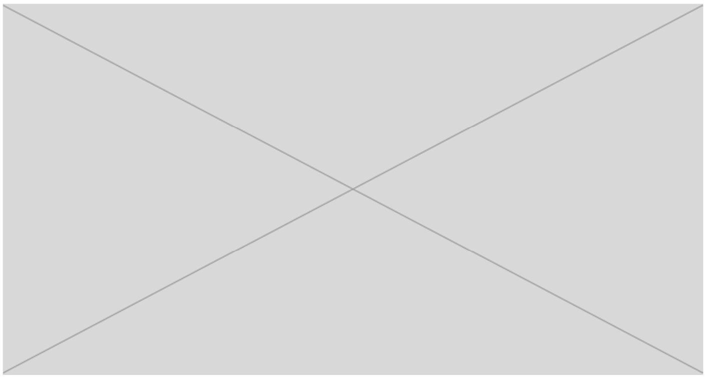

Figure 1. *Example of figure. Figures and captions should be centred and captions should be self-explanatory.*

3. Results

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Table 1. *Example of table. Tables and captions should be centred and captions should be self-explanatory.*

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4. Discussion

Please insert your Discussion text here. Text alignment is formatted as justified. The Results section can be combined with the Discussion section. In that case, name the section **Results and Discussion**

5. Conclusions

Please insert your Conclusions text here.Provide the main conclusions and implications of the study. Please avoid the use of references in this section.

References

Please make sure that every reference cited in the text is also present in the reference list (and vice versa). All citations in the text should refer to:

1. Single author: the author's name (without initials, unless there is ambiguity) and the year of publication;

2. Two authors: both authors' names and the year of publication;

3. Three or more authors: first author's name followed by 'et al.' and the year of publication.

Citations may be made directly (or parenthetically). Groups of references should be listed first alphabetically, then chronologically. Examples: 'as demonstrated (Allan, 2000a, 2000b, 1999; Allan and Jones, 1999). Kramer et al. (2010) have recently shown ....'

List: References should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', 'c', etc., placed after the year of publication.

Examples for the most common types of references:

Berners-Lee, T., 2009. Title of a web page. http://www.pageaddress.com (accessed 01.02.2015).

Darwin, C., 2000. Title of an article published in a journal. Journal Name, Volume number, pages.

Darwin, C., Einstein, A., Descartes, R., 1970. Title of a book section, in: Hooke, R., Newton, I. (Eds.), Title of a book. Publisher, Place, pp. 102 – 200.

Darwin, C., Einstein, A., 1930. Title of a book, edition number. Publisher, Place.

Newton, I., 1700a. Title of a report. Publisher or Institution, Place.

Newton, I., 1700b. Title of an article published in a journal. Journal Name, Volume number, pages.

Appendices

If there is more than one appendix they should be identified as A, B, ...

Stakeholder engagement-based evaluation of social sustainability with respect to the mining sector

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Abstract

The mining sector exploits the non-renewable natural resources and supplies them to the industry and energy sector. Hence, it has considerable share in the national and local economies of the large number of countries. Besides the economical impacts, the sector has impacts on environment, and society. Therefore, effective integration of the environmental, social and economic dimensions of sustainability into the decision-making in the mining sector promises contribution for the achievement of the sustainable consumption and production patterns. However, quantitative evaluation of the social impacts, exposed by the local communities, is not performed as effectively as the environmental, technical, managerial and economic issues. In this regard, the paper discusses if and how much the mining sector contributes to enhance the social sustainability in the mining communities in terms of social impacts of the operations based on the quantified parameters. For this purpose, a local stakeholder engagement-based methodology is proposed for quantification and integration of the social parameters into the assessment and decision-making related to the planning in the mining sector. The methodology is applied with a case study in Afşin-Elbistan Coal Basin (AECB) in Turkey. The case study shows that quantitative integration of the social parameters is significantly important to evaluate the negative and positive impacts of the mining sector on the social sustainability at the local-level. Moreover, it is observed that participation of the local communities into the assessment process make the social sustainability concept tangible and it prevents to use de facto social sustainability criteria for different cases.

Keywords: Mining sector, social sustainability, sustainability indicators, stakeholder engagement

1. Introduction

The mining sector exploits the non-renewable natural resources and supplies them to the industry and energy sector. Hence, it has considerable share in the national and local economies of the large number of countries. Besides the economic impacts, the sector also has impacts on environment, and society. Therefore, effective integration of the environmental, social and economic dimensions of sustainability into the decision-making in the mining sector promises contribution for the achievement of the sustainable consumption and production patterns. In fact, such integration of the environmental and economic dimensions is usually succeeded with the quantitative methods, like life cycle assessment and cost benefit analysis (Moran and Brereton, 2013). Furthermore, the analyses are generally conducted based on the parameters under the environmental and economic dimensions (e.g. water and air quality, ecosystem components, paid taxes and royalties) due to the quantitative nature of these parameters.

Nevertheless, integration of the parameters under the social dimension, which are relatively difficult to quantify, into the analysis is also important for the mining sector in order to minimize the negative impacts on the local communities and to obtain the social license to operate. The primary negative impacts of the mining sector on the local communities are discussed by Gibson (2006). Gibson indicates that the limited timeframe of operations based on the ore body characteristics and the market fluctuations cause a fast improvement in the local economic and social factors, which is often followed by a bust that causes severe environmental, social and economic negative effects at the local-level. These negative impacts on the local communities do not only harm the community and individuals, who expose to these but also affect the business significantly as it creates business risks associated with the social impacts in the future projects. This is clearly highlighted in a mining sector related report, published by ERM (2016), which states that the share of social opposition and environmental concerns in the delays of large mining projects were 42% and 35%, respectively. ERM (2016) also indicates that the technical challenges as the source of delay were only 3% between 2008 and 2012, which mean approximately 20 million US$ per week of delayed production in Net Present Value (NPV).

Therefore, it is important to evaluate the potential social impacts of the mining operations quantitatively at the planning stage, and analyze and monitor during the operational period in order to prevent and minimize the negative impacts timely. Additionally, obtaining quantified information on if and how much the mining sector contributes to sustainable development at the local-level is significantly important to avoid using sustainability term as ‘green-washing’ and also to prevent potential business risks, due to the social unrest during the operational stage. Hence, providing effective engagement procedures of the local stakeholders and consideration of the social parameters, which are raised by the locals, are as important as the technical parameters to be considered during mine planning and design. In this regard, this paper discusses how the parameters under the social dimension can be quantified and integrated into the analysis of the mining sector in order to evaluate how much the mining sector contributes to social dimension of sustainable development in the mining communities.

2.1. Case study area: Afşin-Elbistan Coal Basin (AECB)

The stakeholder engagement-based framework is applied with a case study in Afşin-Elbistan Coal Basin (AECB) in Turkey. The AECB is located in the South-east of Turkey, as shown in Figure 1. The main reason for selecting the AECB as the case study is that it is an important basin for two conflicting sectors that are the mining and agricultural sectors. On the one hand, the basin is focused due to the energy policy of the county, which is built on the security of energy supply. Thus, diversifying the energy sources and using the domestic resources are two important parameters. Moreover, the AECB has 38% of the proven lignite reserve of Turkey. It also involves two open cast mining operations, and two thermal power plants with the total of 2500 MW installed capacity (EÜAŞ, 2015a; EÜAŞ, 2015b). On the other hand, the basin is the fourth important agricultural basin in Turkey (EMDA, 2015). Hence, the local economy is highly dependent on the agricultural activities. Consequently, these two sectors are conflicting and creating socio-economic problems among the different social groups in the basin.

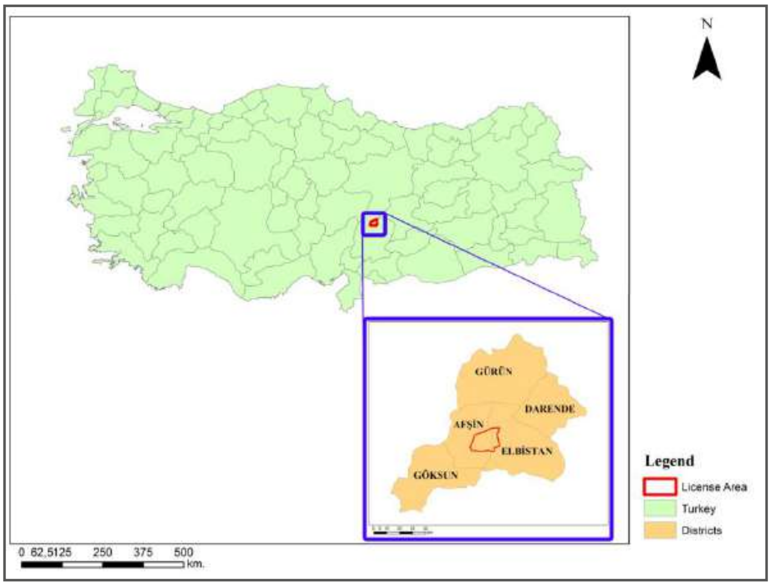

Figure 1. *Location of Afşin-Elbistan Coal Basin in Turkey (Yaylacı and Düzgün, 2016)*

The lignite basin is between Afşin and Elbistan districts of Kahramanmaraş Province (Figure 1). Elbistan has 142,168 inhabitants and Afşin has 82,122 inhabitants in 2014 (TURKSTAT 2015). The total mining license area covers 34,310 ha and 29,700 ha of which is owned by EÜAŞ, the energy company owned by the state. As it is shown in Figure 2, the state owned license area is divided into five sub-sectors. Open cast mining, a surface mining method, is applied in the basin. Stripping the overburden material and exploitation of lignite are continuously conducted with bucket-wheel-excavator and belt conveyors in the Sector A (Figure 2). The lignite layer is almost horizontal in the Sector A. The Sector B is the second active operation in the basin since 2007 (Tutluoğlu et al., 2011). Similar to the Sector A, continues mining operation was planned with bucket-wheel-excavator and belt conveyors in the Sector B. However, after opening the box-cut in the sector with hydraulic excavator and truck system method, two slope failures occurred in the Sector B in 2011. After these incidents, the operations have not restarted yet.

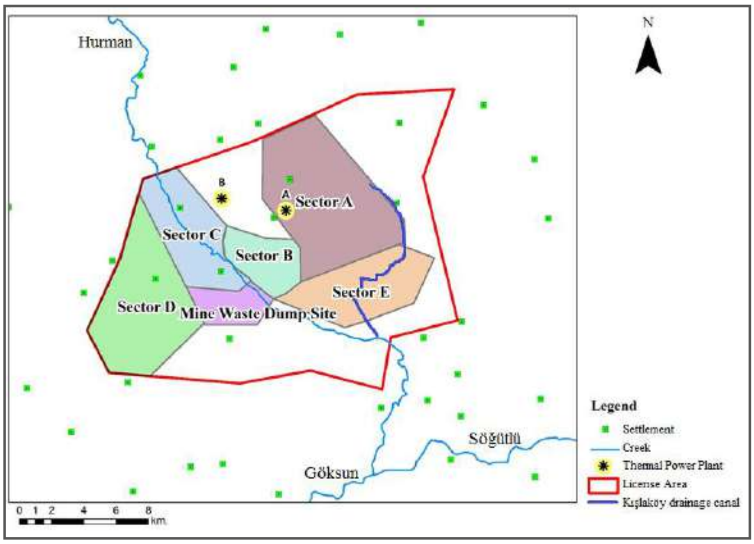

Figure2.*Mining license area in the AECB and mining sectors determined by EÜAŞ (Yaylacı and Düzgün, 2016)*

2. Methods

The methodology, which is used for evaluating if and how much the mining sector contributes to the social sustainability at the local level in order to provide quantified information to the decision-makers, is structured under four interacting phases (Figure 3). The methods, used in these phases, are literature review, stakeholder engagement, expert judgment and index-based assessment for Phase 1, 2, 3, and 4, respectively.

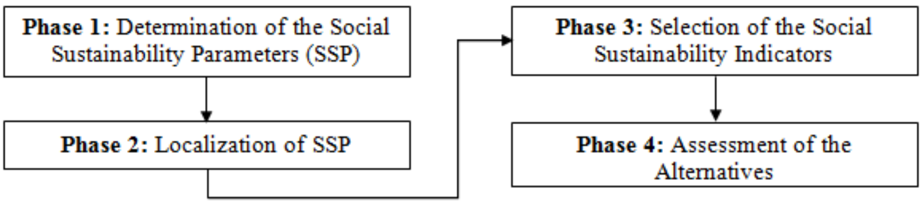

Figure 3.*The methodology for evaluating the social sustainability at the local-level*

2.2. Determination of the social sustainability parameters with respect to the mining sector

The discussion if the mining sector advances the sustainable development or the characteristics of the sector are conflicting with the sustainable development concept has not been agreed yet. Among others, Laurence (2011), Franks et al. (2010), Giurco and Cooper (2012), Worrall et al. (2009), Gibson (2006) highlight that even there are counterintuitive conditions, the mining sector is under pressure to reduce the local negative impacts and risks in order to gain social license to operate. The sector is also trying to guarantee the local benefits for long terms re-build its reputation in regulatory and investment cycles globally. Consequently, the leading actors of the global mining sector as well as regional and international organizations have been working on this issue since the late 1990s (Hilson and Basu, 2003; Azapagic, 2004; Gibson, 2006; Laurence, 2011).

Even there are efforts, the sustainability concept and the mining sector is mostly seen as conflicting due to the degradable and non-renewable nature of the mining sector as well as the significant impact on the natural environment (Giurco and Cooper, 2012; Kirsch, 2009; Bridge, 2004). However, as sustainability, based on the Brundtland Commission Report (WCED, 1987), is defined as to meet the needs of present generation without degrading the ability of the future generations to meet their needs, it may be also argued that the mining sector could contribute to sustainability if the wealth, generated from the exploitation of the minerals and metals, will continue in the future for allowing the future generations to meet their needs. In this regard, the sustainability in the mining sector context is mainly about the continuity of the generated wealth from the exploitation of the natural reserves (NRC, 2003).

The generated mineral wealth includes monetary parameters as well as the environmental and social parameters. Indeed, the social dimension cannot be considered isolated from the environmental and economic dimensions of the sustainability. Hence, when the social dimension is considered in the context of mining sector and sustainability, the main theme becomes people (NRC, 2003). Therefore, the generated wealth should be also discussed within the focus of people, specifically the local people, as the major negative impacts of the sector are seen at the local-level.

The mineral wealth is discussed under the following components in the Social Dimension of the Sustainable Development and the Mining Sector Report of Natural Resource Canada (NRC, 2003);

- Healthy People, Healthy Environment: Health and safety; health care; aboriginal peoples; women; religious and cultural values.
- Innovation and Learning: Education; employment; economic diversification.
- Vigorous and Proud Communities: Community involvement; outsiders, access; foundations; displacement of populations; mine closure.

In addition to these, 10 principles of International Council of Minerals and Metals (ICMM, 2015) are also considered in order to extend the concept of the mineral wealth in the context of the mining sector. Thus, these principles are studied in terms of the main focus and priority subjects, given for each principle by ICMM (2015). Then each of these is classified under sustainability themes according to the objectives and focuses. Consequently, based on the 10 principles of ICMM, the mineral wealth in the context of social sustainability and the mining sector is determined as;

- respecting human rights, the local culture, customs and traditions;
- minimizing the involuntary resettlement and compensating fairly if resettlement is unavoidable;
- practicing stakeholder engagement for understanding and mitigating the negative impacts;
- early and continual stakeholder communication with the affected parties, including also the minority and marginalized groups;
- fighting against poverty;
- improving the local capacities, including health, education infrastructure, local businesses.

The themes of the mineral wealth as the sign of realization of the social sustainability in the mining sector are grouped as given in Table 1. These themes are used as the parameters for quantification of the social dimension of the sustainability in terms of the mineral wealth in the mining sector. Moreover, these themes are used for determination and selection of the social sustainability indicators for the evaluation of the mining plan alternatives quantitatively.

Table 1. *The social dimension of sustainability in the context of the mining sector*

Theme	Sub-theme
Safety	1.Avoiding to create any safety risk at the local level
	2.Contributing to build a safe society for women, children, the minority and marginalized groups
Health	3.Preventing any treats on health of local individuals
	4.Avoiding to degrade the health of the local environment that sustains the quality of human life (including flora, fauna, and water-, soil- and air-quality)
Human rights	5.Respecting religious and cultural values, customs, traditions
	6.Avoiding involuntary resettlement
	7.Compensating involuntary resettlement fairly
Information accessibility	8.Performing continual communication
	9.Establishing timely and deliberative stakeholder engagement
Infrastructure accessibility	10.Improving health care, education, physical accessibility
	11.Providing electricity, internet etc.
Enhancing the local employment	12.Creating direct employment to locals
	13.Helping locals to gain new skills
	14.Contributing to strengthen local businesses
	15.Helping locals to diversify economic activities
	16.Preventing corruption in any means and levels

2.3. Localization of the social sustainability parameters

The localization process involves two main actions, which are establishment and conduct of the local stakeholder engagement (Figure 4). The establishment of the stakeholder engagement includes four steps. The first step is studying the literature for collecting the data about social, environmental and economic structure, population characteristics, local economic activities, local culture, customs, conflicting local issues and other relevant information about the mining sector and the local society. The identification of the local key stakeholders is the second step in the framework. The information, obtained from the literature review, is used to list the key local stakeholders. This list is expanded and modified after the preliminary stakeholder analysis (Step 3), based on the field investigation.

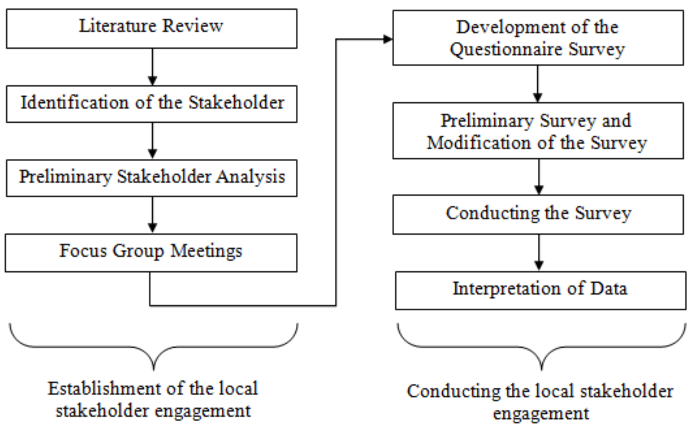

Figure 4. *Localization of the social sustainability*

The preliminary stakeholder analysis (Step 3) is conducted as the first field-based analysis in the framework. The obtained preliminary information is verified and updated if necessary. The local communities, including individuals and representatives of the political, social, businesses and other interest groups in the study area are visited. The main objective of this step is getting familiar with the local key stakeholders and issues, including culture, customs, infrastructure, environmental and economic situation, potential social risks and conflicts among the local interest groups, as well as observing the political atmosphere, and legislative background. Step 3 aims to obtain a strong understanding and familiarity with the focused community as well as the key local stakeholders. Therefore, it might necessary to repeat the field visits. Step 3 was implemented in three different time periods; December 2014, January and March 2015; for three days of site visits during the case study.

As a result of the preliminary stakeholder analysis, the locals also become familiar with the terms and concepts, which will be discussed with them in the future. Moreover, this gives them an opportunity to describe the potential risks, current problems and outline their priorities. The methods, used in the case study for this step, are semi-structured face-to-face interview, spontaneous village visits and group meetings at the villages, group meetings with the governmental authorities and non-governmental organizations (NGOs). After the field based preliminary analysis, the key local stakeholder list is updated and the main social sustainability issues and concerns of the local stakeholders are determined.

The fourth step of the framework is organization of focus group meetings in the case study area. Unlike semi-structured group meetings conducted in Step 3, the focus group meetings in Step 4 should be organized with a structured content and targeted to the specific local stakeholder groups. In the case study, the focus group meetings were targeted to the governmental local authorities and NGOs, representing the local business and interest groups, such as labor, youth and disadvantaged groups.

After conducting the local stakeholder engagement, the questionnaire survey is developed (Step 5). The questionnaire survey needs to cover the social issues determined during the establishment of local stakeholder engagement phase. It should also provide the necessary information to analyze the parameters, determined in Phase 1. Step 6 of the framework is the implementation of preliminary survey. After the development of the questionnaire survey, a preliminary application of the survey should be performed in order to observe if the survey is applicable as it is originally planned in Step 5. According to this evaluation, the necessary modification is completed on the questionnaire survey. As a result of this modification, the final version of the questionnaire is obtained. This step was conducted with a small group of researcher by visiting several households in and around the mining license area in the case study. 60 preliminary questionnaires were applied in eight different villages and in two town centers during the case study between March and May 2015.

The final version of the survey is carried out in Step 7 for collecting the necessary data for the assessment. In the case study, 1008 questionnaires were performed in the case study region in 14 days with a team of 10 women and 10 men in June 2015 (Düzgün et al., 2015). The conductors were grouped in two as a woman and a man. Also, before the field work, legal permissions were taken from the local governmental authority and this permission was shared with the village representatives in all the villages in the AECB and also in Elbistan and Afşin town centers.

Interpretation of the Data, Step 8, involves analysis of the performed surveys. This step helps to determine the main problems, defined by the locals, and to localize the social sustainability concept in terms of parameters. The results of the main problems, highlighted by the local stakeholders in the AECB, are given in Table 2. As it is given in Table 2, the leading problems are air pollution, unemployment, water pollution and shortage, infrastructure problems, economic conditions, resettlement and land expropriation. Among these, the air pollution is a consequence of the lignite burnt power plants in the basin and the mining sector does not directly responsible from it. Thus, this is not considered in the indicator selection. In order to understand more about the impacts of the mining sector in the region, the locals are asked if they and their households are benefited or harmed specifically from the mining sector. The given answers are shown in Table 3. As it is given in Table 3, 20% of the locals say that they and their households are benefited from the mining sector. However, only 5% of these are benefited and the rest are both benefited and harmed due to the mining sector in their region. The main benefits, listed by the locals, are economical and educational improvement, and having social security. As the given answers to this question is evaluated based on the place of living of the participated locals, those, living in the town centers, have benefited more in terms of economic improvement but those, living in the villages, have benefited more by having social security and accessing to education.

Table 2. *The most significant problem, defined by the locals, in the case study region*

	Total (%)	**Years live in the region**			
		Since birth (%)	**≤5 years (%)**	**6-15 years (%)**	**≥16 years (%)**
Air pollution	37.70	27.21	1.09	2.88	6.45
Unemployment	25.40	18.27	0.70	2.28	4.17
Water pollution & shortage	13.50	9.73	0.20	1.09	2.38
Infrastructural problem and absence	11.20	8.44	0.40	0.60	1.69
Change in economic activities, loss of agricultural land and financial difficulties	4.10	2.98	0.20	0.10	0.79
Resettlement, land expropriation, victimization, immigration, uncertainty due to the mining operations	1.20	0.79	0.00	0.20	0.30
Corruption and problems on direct employment of locals	0.80	0.60	0.00	0.00	0.20
Others	6.10	4.27	0.20	0.20	1.59

Table 3. *The distribution of benefited or harmed stakeholders in the AECB with respect to the mining sector*

Have you and/or your household benefited or harmed from the mining sector?	Total (%)	Years live in the region			
		Since birth (%)	≤5 years (%)	6-15 years (%)	≥16 years (%)
Benefited	4.80	2.90	0.20	0.40	1.30
Both benefited and harmed	15.50	10.80	0.50	1.20	3.00
Neither benefited nor harmed	9.40	6.60	0.40	0.70	1.70
Harmed	70.40	52.00	1.70	5.10	11.60

However, 70% of the locals say that they and their households are harmed due to the mining sector as it is given in Table 3. The listed harms are increase of the environmental and health problems, and depreciation in the economic situation of the household due to the loss of traditional economic activities, which are agriculture and livestock breeding. Among these, the harm of environmental and health problems are observed in both town centers and villages. However, depreciation in the economic situation of the household due to the loss of traditional economic activities is chosen by the locals who lives or lived in the villages and also live in the region since their birth.

As it is given in Table 4, three groups are mostly mentioned as benefited parties from the mining sector in the AECB; these are subcontracting companies (approximately 51%), employees of the mining companies (17%) and the villagers, whose land have been expropriated by the mining companies. However, the answer of the locals to the question of who are harmed in Table 4 is correlated with the answer under the harmed local group that is given in Table 3. According to the locals in the case study region, the mining sector has negatively affected the locals more than its benefits. Therefore, the negative impacts, defined in Table 2, represent the way how the locals are harmed and also the mining sector has not been contributed to overcome these problems as it is also seen in the benefited section of Table 4. In addition to these, the strengthening the local businesses issue in Table 8 is considered as succeeded based on the answer of the locals about who benefited the from the mining operations in Table 4. 4% of the locals are mentioned that the local business owners and also 50% of the participated locals highlight that the subcontracting companies are benefited from the mining operations in the AECB.

Table 4. *The benefited and harmed parties with respect to the mining sector in the AECB*

	Who do you think have benefited and harmed most from the sector?	Total (%)	Years live in the region			
			Since birth (%)	≤5 years (%)	6-15 years (%)	≥16 years (%)
Benefited	Locals subcontracting companies	50.84	37.51	1.49	3.98	7.86
	The villagers, whose land was expropriated	15.52	11.74	0.30	1.09	2.39
	Employees of the mining companies	17.02	10.65	0.70	1.29	4.38
	Employee of the mining company, who immigrated from other cities	3.39	2.59	0.10	0.20	0.50
	Local business owners	4.18	2.69	0.10	0.20	1.19
	Other	9.05	7.06	0.10	0.60	1.29
Harmed	The locals in the region	72.36	53.10	1.75	5.45	12.06
	The villagers, whose land was expropriated	9.52	7.27	0.30	0.20	1.75
	Employees of the mining companies	5.45	2.85	0.30	1.10	1.20
	Local business owners	1.40	0.60	0.60	0.00	0.20
	Employee of the mining company, who immigrated from other cities	0.30	0.20	0.00	0.00	0.10
	Other	10.97	7.78	0.30	0.60	2.29

The last question about how the mining sector has affected the locals and if the locals are seen the mining sector as the source of the problems they experience, the question of how would be the region without the mining sector is also asked. The given responses are presented in Table 5. This question is asked for understanding the business image of the mining sector at the local-level and for obtaining information about the importance given issues by the locals in the AECB while evaluating the social sustainability in terms of the themes in Table 1.

Table 5.*Presumption of the local stakeholders if the mining sector would not be active in the AECB*

How would be the region if the mining sector would not be established in your region?	Total (%)	Years live in the region			
		Since birth (%)	≤5 years (%)	6-15 years (%)	≥16 years (%)
Strong agricultural sector in the basin	48.38	35.77	0.89	2.78	8.94
No environmental and air pollution, protected natural beauty and less health problems	21.98	16.48	0.60	1.69	3.21
Higher unemployment and poverty, less economic development	16.55	10.79	1.09	1.69	2.98
Other	13.09				

As a result of the given responses in Table 5, almost 50% of the locals in the AECB think that the mining sector has mostly affected the agricultural sector in a negative way and if the mining sector has not been active in the region, the agricultural sector would be developed. Therefore, the mining sector could not success either helping locals to diversify the economic activities or gaining new skills. Thus, the local communities still depends on traditional economic activity or believes the traditional economic activities would better-off their situation. Contrary to these, approximately 17% of the locals think that the unemployment and poverty would be higher and the current economic development would not be achieved in the AECB. Thus, the sector partially contributes to the overcome the unemployment and poverty in the region. Therefore, the themes, creating employment to the locals and improving the skills of the locals, should be considered in the assessment (Table 8) to evaluate how much the mining sector contributes. Approximately 22% of the locals also think that the environmental and health conditions would be better in the basin if the mining sector has not been active in the AECB. Hence, the degradation of the local environment (Table 8) should be considered while the indicators are selected.

Regarding the infrastructure theme, even the infrastructure related problems are mentioned in Table 2, this is not considered in the question in Table 5 by the locals. In order to understand this difference and also decide if the subject should be considered in the indicator selection, the infrastructure related questions are investigated. It is seen that the electricity, internet, telecommunication infrastructure is well established in the region. However, as the mining operations have caused changes in the motorway accessibility, and also due to resettlement from villages to town centers, number of schools and health service points has been dropped in the villages over the years. Therefore, only the related infrastructure sub-theme in Table 8 is considered for the indicator selection. In order to see if the information accessibility theme should be considered in the indicator selection, the question about the engagement procedures are asked in the survey and the results are given in Table 6. Additionally, the question about the employment process and also the profile in the mining sector is asked to the locals and the results are given in Table 7.

Table 6. *Accessing to information, management of resettlement and conflicts*

	Increase (%)	Decrease (%)	No change (%)	No idea (%)
Informing the locals about the potential future changes in the region related with the mining operations	2.13	11.52	85.79	0.56
Consideration of the needs and demands of the locals by the mining companies	1.68	11.51	85.92	0.89
Consideration and fulfillment of the needs and demands of the locals about the land expropriation	4.67	12.35	79.53	3.45
Conflict between the local communities and the mining companies	48.69	2.62	41.97	6.72

The given responses about information accessibility, stakeholder engagement to the planning, land expropriation and decision-making process shown in Table 6 that the mining companies or decision-making authorities do not implement or improve the information accessibility and engagement in the basin. Almost 50% of the locals think that the conflict between the locals and the sector has risen over the years.

Table 7.*The employment process and profile in the mining operations*

Who are employed in the mining sector, what qualifications and skills are needed to be employed in the mining sector?	**Total (%)**	**Years live in the region**			
		Since birth (%)	**≤5 years (%)**	**6-15 years (%)**	**≥16 years (%)**
Highly skilled individuals	10.60	7.14	0.69	0.69	2.08
Whose parents or relatives were working for the companies	0.30	0.20	0.00	0.00	0.10
Nepotism/favoritism/corrupted network	77.02	56.70	1.88	5.75	12.69
Individuals, whose land is expropriated	1.49	0.59	0.10	0.10	0.69
Individuals from other cities	0.25	0.24	0.00	0.00	0.01
Anybody	1.68	1.09	0.00	0.10	0.50
Other	8.65				

The employment procedure and the profile related responses indicate a significant problem about the issue. As it is given in Table 7, 77% of the locals believe that political, family or other interest-based favoritism is the way to be employed in the AECB. This is considered as a shortcoming and therefore the corruption related sub-theme in Table 8 is also signed as not succeeded. Regarding the succeeded and shortcoming social sustainability issues discussed and compared in Table 8, the social sustainability indicators should be selected to discuss the shortcoming issues quantitatively.

2.4. Selection of the social sustainability indicators

The indicator selection is conducted based on the expert judgment and the sustainability indicators are selected from the social sustainability indicator set, including 144 social indicators given in Yaylacı and Düzgün (2016). For the selection; the relevance, data availability and quantification specifications of the indicators are considered. Relevance of the indicator indicates the suitability to the focused sub-theme. As the data from the conducted survey is used, data availability is important parameter. Quantification connotes the ability of making quantitative analysis. In other words, none of the indicators, demanding explanation or description, are selected. The selected indicators are listed in Table 9.

Table 8*. Comparison of literature-based social sustainability issues with the situation in the AECB in the context of the mining sector*

Theme	Sub-theme	Situation in the AECB
Safety	1	✓
	2	✓
Health	3	x
	4	x
Human rights	5	✓
	6	x
	7	x
Information accessibility	8	x
	9	x
Infrastructure accessibility	10	x
	11	✓
Enhancing the local employment	12	x
	13	x
	14	✓
	15	x
	16	x

Table 9*. Selected social indicators for the sustainability analysis of the mining alternatives*

Theme	Sub-theme	The indicator
Health	**3**	**H1.** Percentage of local population think/ observe the mining sector as potential source of problems on the local level in terms of health and safety issues **(negative impact)**
	4	**H2.** Total number of health and safety complaints from the local communities **(negative impact)** **H3.** Percentage of local population think/ observe the mining sector as potential source of problems on the local level in terms of environmental pollution **(negative impact)**
Human rights	**6**	**HR1.** Total new land acquisition **(negative impact)** **HR2.** The number of households resettled due to proposed developments (Displaced population) **(negative impact)**
	7	**HR3.** Consideration and fulfillment of the needs and demands of the locals about the land expropriation **(positive impact)** **HR4.** Percentage of local population think/ observe the mining sector as potential source of conflicts on the local level in terms of environmental issues, including land use and land acquisition **(negative impact)**
Information accessibility	**8**	**I1.** Percentage of local population think/observe accessibility to information about land management, new mining plans is in place **(positive impact)**
	9	**I2.** Percentage of local population think/ observe ways of public consultation/participation are in place **(positive impact)**
Infrastructure accessibility	**10**	**IA1.** Percentage of local population considering the mining sector investment as potentially positive contributor to overcome local problems in terms of infrastructure **(positive impact)**
Enhancing the local employment	**12**	**LE1.** Percentage of local population considering the mining sector investment as potentially positive contributor to overcome local problems in terms of employment **(positive impact)**
	13	**LE2.** Vocational education opportunities provided by the mining sector **(positive impact)**
	15	**LE3.** Job opportunities in other fields except mines and power plants **(positive impact)**
	16	**LE4.** Number of filed complaints subject to any corruption; Percentage of local population to accuse any types of corruption **(negative impact)**

As some of these indicators measure positive impacts and others negative impacts, each selected indicators is also classified if it is measuring the negative or positive effect on the social sustainability at the local level. These are also given in brackets in Table 9. As those, signed with negative impact, degrade the sustainability, these are considered as the negative value while calculating the sustainability value of the indicators in Section 2.5. In this regard, these indicators are multiplied with -1 while calculating the sustainability value of the indicator.

2.5. Assessment of the alternatives

The assessment of the alternatives is conducted with the selected indicators in Section 2.4. For this, first the alternatives and then the method for the assessment is determined. In this study, as it is aimed to analyze if and how much the mining sector contribute to the local social sustainability at the AECB, the alternatives are determined as;

- Alternative 1: No mining activity in the basin – baseline sustainability level.
- Alternative 2: Continuing the mining operations in the basin

In addition to the alternatives, the assessment method is also determined in this phase. Due to the indicator use in the assessment, selection of either indicator set-based or index-based assessment is necessary. As indicator-set based assessment demands the use of indicators with the same unit and scales, index-based assessment is performed in this study. More than one indicator and aggregation of the indicators are necessary for conducting the index-based assessment (Ness et al., 2007). Transformation and weighting is completed in this section and valuation is given in the results.

Standardization (Eq. 1.) is performed for transforming the indicators.

$$Ii;\ std = \frac{Ii - \sigma}{\sigma} \qquad \text{(Eq. 1)}$$

where,

Ii, std standardized value of an indicator I,

Ii original indicator value,

σ standard deviation.

Equal weight (EQM) and analytical-hierarchy process (AHP) methods are two alternative methods for weighting the indicator for valuation. These methods are used to decide if all the indicators have the same importance or some indicators are more significant than others for the valuation. In this study, EQW method (Eq. 2) is used to minimize the subjectivity while conducting the pairwise comparison of the indicator for implementing and deciding the weights with AHP method.

$$Wi = \frac{1}{n} \qquad \text{(Eq. 2)}$$

where;

Wi weight of the each selected indicator

n total number of the selected indicators

The impact of each indicator in the evaluation of if and how much the mining sector contributes to social sustainability is calculated based on the positive or negative characteristic of the indicator, the standardized value and the weight of the indicator. This is named as indicator sustainability value (ISV) and ISV is calculated for each indicator as it is given in Eq. 3. The total sustainability score of the each indicator for valuation is calculated by adding all the ISV values of each alternative and these are given in the results.

ISV= (impact type +1 or -1) x Ii, std x Wi (Eq.3)

3. Results and Discussion

The results of the assessment for the alternatives are given in Table 10. According to these, the no-mining alternative (A.1) and the mining alternative (A.2) obtain 0.74 and -0.45 social sustainability scores, respectively. These results indicate that the social sustainability has been degraded in the AECB due to the initiation of the mining sector operations in the AECB.

Table 10. *The social sustainability scores in the AECB with respect to the mining sector*

Indicator	Unit	Weight	I_i A.1	I_i A.2	I_i, std A.1	I_i, std A.2	ISV A.1	ISV A.2
H1	%	0.07	0	21.98	-1.00	0.41	0.07	-0.03
H2	Number	0.07	0	13.5	-1.00	0.41	0.07	-0.03
H3	%	0.07	0	64.9	-1.00	0.41	0.07	-0.03
HR1	Ha	0.07	0	6896.73	-1.00	0.41	0.07	-0.03
HR2	Number	0.07	0	8000	-1.00	0.41	0.07	-0.03
HR3	%	0.07	20.47	4.7	0.84	-0.58	0.06	-0.04
HR4	%	0.07	0	90.7	-1.00	0.41	0.07	-0.03
I1	%	0.07	14.21	2.1	0.66	-0.75	0.05	-0.05
I2	%	0.07	14.08	1.7	0.61	-0.81	0.04	-0.06
IA1	%	0.07	11.2	88.8	-0.80	0.62	-0.06	0.04
LE1	%	0.07	83.45	16.55	0.76	-0.65	0.05	-0.05
LE2	%	0.07	54.1	45.9	8.33	6.92	0.58	0.48
LE3	%	0.07	90.2	9.8	0.59	-0.83	0.04	-0.06
LE4	%	0.07	64.7	77.02	6.43	7.84	-0.45	-0.55
TOTAL SUSTAINABILITY SCORE							**0.74**	**-0.45**

The followed approach, using the survey results to score the no-mining alternative, might have some shortcomings, such as the locals cannot be sure how the situation would be in the basin without the sector. However, it can be commented that the sector could not do its best on some sub-themes and therefore, the locals thinks that they would be better-off without the mining sector. Regarding the results in Table 10, the local communities think that the sub-themes that the mining sector could not contribute are strengthening the local employment, resettlement, information accessibility and environmental health and management. These are clearly seen in the quantified results in Table 10. The score gap between the no mining activity and with mining sector alternatives is significantly high in the indicators under human rights, information accessibility and enhancing the local economy themes.

Regarding the health related indicators (H1, H2, H3), the score gaps are also high. However, the environmental field works, focusing on the surface water pollution, water depreciation and soil pollution, indicate that there is no clear correlation between these and the mining operations (Düzgün et al., 2015). There are two reasons for the difference between the survey-based and field-based analysis. The first one is that the environmental and health related concerns are highly related with the thermal-power plants in the basin. However, the locals consider these two operations as one industry and so they stress the environmental issues during the mining sector focused survey. The second one is that the nationwide drought at the summer of the survey application affects the given answers in the survey. Therefore, the health theme sustainability results need to be restudied by considering the environmental parameters in order to differentiate the thermal power plant and mining industry effects.

In addition to Table 10, the sustainability scores of each theme are presented with a graph in Figure 5 in order to discuss the results for each theme separately. As it can be seen in Figure 5, the mining sector contributes only the infrastructure theme through strengthening the infrastructure in the AECB compared to the no mining activity alternative. As it is claimed by the mining sector as one of its positive contribution at the local-level, the local communities in the AECB also think that the mining sector positively impacts the infrastructure development in the basin.

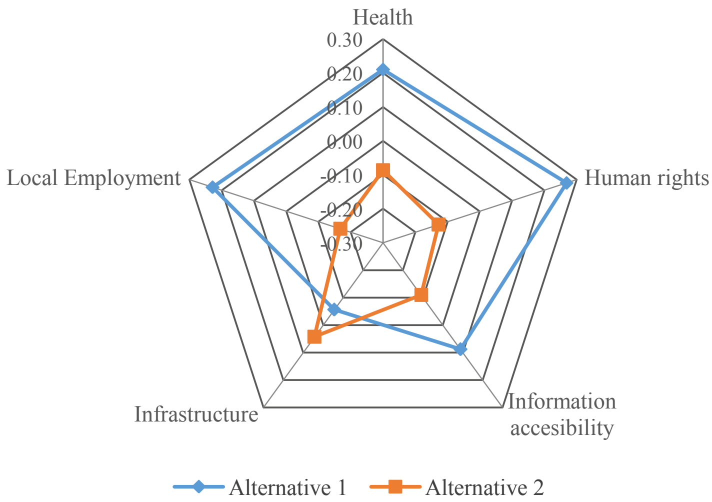

Figure 5. *The scores of the social sustainability themes in the AECB with respect to the mining sector*

As it is presented in Figure 5, other than infrastructure theme, all social sustainability themes have negatively affected from the mining sector operations in the AECB. Creating local employment, strengthening the alternative local economic activities and helping locals to gain new skills are the key issues for contributing to social sustainability at the local-level. However, as the assessment results indicate, this has not been achieved in the AECB. In addition to these, 70% of the locals claim that nepotism is the most significant problem in the employment process. Therefore, first the direct mining employment process needs to be more transparent due to the nepotism/favoritism accusations. Additionally, as the locals stress that the local business owners and subcontracting companies are benefited from the mining sector, it can be concluded that the sector has created employment and strengthened the local economy, mostly in the service sector. Nevertheless, this has not been extended to wider local population. Additionally, even though the vocational education background has strengthened in the region, the direct contribution and interaction of the vocational education in the mining sector has not been built yet.

Regarding the human rights theme, it is observed that the main issues are the land expropriation and resettlement in the region. Due to the wide surface area disruption due to the stripping mining method, the affected area is significantly high. As the underground mining method is not an option for minimizing the land degradation due to the economical reasons, the land expropriation is unavoidable if the operations will continue. Therefore, the decision-making authorities and the mining sector must focus on other related issues in order to improve the social sustainability in the basin. For this, the resettlement management based on accessible information and stakeholder engagement must be introduced.

The resettlement is performed in the AECB through the payment for the total expropriated land, based on the unit price defined by the government. However, according to the locals, this does not compensate to buy the same amount or the characteristic of the land and to build the house within the basin due the difference between the official unit price and the market price. Moreover, as the main traditional economic activity is agriculture, the family members, involving the parents and the son(s)'s family under the same household in most cases, work as unpaid family labor. Therefore, as this economic structure could not be built in the town or city centers by participating to the modern economic activities, the families face significant loss of income and even face poverty in many cases. Therefore, resettlement does not only mean for the locals in the AECB to change their place of living but also losing the traditionally gained vocational skills, which does not fit into the modern economic activities. Also, the women, lack of skills and it is traditionally not welcome, they could not participate to labor force actively in the town and city centers.

The information accessibility theme is another sustainability issue that the mining sector and also decision-making authorities need to improve in order to contribute to social sustainability in the AECB. The information accessibility is also highly related with the land expropriation issues as it improves the communication between the parties, which could help the local communities to be aware of the potential changes in the region Also, the obtained information through better stakeholder engagement can help the decision-makers to plan and manage the land expropriation, employment and health issues effectively.

The outcomes of this study can be also discussed for the mining sector operating in different countries and regions. In this respect, as Gibson (2006) indicates that the mining sector brings about a fast improvement in the local economic and social factors followed by a bust of severe environmental, social and economic negative effects at the local-level, which is mainly validated by the considered case study. Additionally, the proposed approach allows analyst to pin point areas of improvement (infrastructure in the case study) and degradation (all the other social sustainability parameters in the case study). This also provides identification of specific social sustainability parameters to be enhanced in order to continue mining in the region. In addition to this, the proposed approach can also help the mining sector to prevent business risks, rising due to the social unrest, by determining and focusing on the primary social sustainability issues, defined by the local stakeholders. The obtained information can be useful while developing the corporate social responsibility (CSR) projects and the community programs, such as the mining sector specific occupational education and co-op programs to increase the local employment in the mining operations in the case study region. In this way, as ERM (2016) report highlights that the potential economic losses due the delays of the mining projects can be prevented timely.

5. Conclusions

The mining sector has positive and negative impacts on local- and national-levels. Therefore, different tools and frameworks are in place for measuring and monitoring these impacts. In most cases, these are very effective for analyzing the environmental and economic impacts. However, due to the qualitative nature of the social parameters and phenomenon, these tools and frameworks are not effectively applicable to measure and monitor the social dimension of the sustainability. However, it is clear that the negative impacts affect locals that may initiate social unrest, which could cost for the mining sector as it is the primary cause of the delays in the mining projects. Therefore, integration of the parameters under the social dimension, which are relatively difficult to quantify, into the analysis is important for the mining sector in order to minimize the negative impacts on the local communities and to obtain the social license to operate. In this regard, a stakeholder engagement-based methodology is discussed with a case study for quantification and integration of the social parameters into the assessment and decision-making.

After application of the indicator-based social sustainability evolution based on the local sustainability criteria, it is observed that the mining sector contributes to development of the infrastructure in the AECB. However, the same assessment results indicate that the mining sector could not succeed creation of local employment and establishing successful communication with the stakeholders. Thus, these are three key social sustainability issues that the mining sector and decision-makers should focus on for improve the social sustainability in the basin. In addition to these, vocational education and improvement of the skills are two important issues that the mining sector should focus in order to overcome the limited direct employment of the locals. In this respect, some specially designed job training, co-op student and summer internship programs should be initiated. This could help to overcome the limited direct employment problem and hence prevent the nepotism accusations in the basin.

Regarding the outcomes of the case study, it is recommended and necessary to focus on the possible future effects of the new mining sector project proposals on the social sustainability. This could generate significantly valuable information for the decision-makers to plan and design the mining sector projects highly compatible with the social suitability themes and also minimize the business risks, depending on the social unrest.

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The Sustainable Child Development Index (SCDI) - A novel way to assess national achievement towards sustainable development

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Abstract

Children are the key stakeholders for shouldering and shaping societies towards sustainable development. However, an index assessing children development in the context of sustainable development is missing. To address this challenge, the framework of the Sustainable Child Development Index (SCDI) considering environmental aspect was firstly proposed and the indicators were collected and screened regarding data availability. As the following study, the research target of this study is to complete the establishment of the SCDI by selecting the representative indicator set, designing the normalization and aggregation methods, and determining the SCDI scores for countries. First, the 23 representative indicators addressing the five themes health, education, safety, economic status and environmental aspect are selected based on correlation analysis and the trade-off between the number of covered countries and considered indicators. The representative indicators are normalized according to the defined reference points regarding the Sustainable Development Goals (SDGs) and then aggregated into the SCDI for the 137 countries. The SCDI scores are classified into four levels (very high, high, medium and low) to group countries' progress towards achieving sustainable child development. The results show that a great regional inequality on sustainable child development achievement exists. European countries, especially Nordic countries, express their superiority in sustainable child development. On the contrary, 95% of the assessed African countries are evaluated as countries with medium and low achievement. Additionally, some OECD countries, e.g. Australia, Italy and Turkey, are evaluated as medium sustainable child development countries due to their weak performance in the theme environmental aspect, e.g. freshwater vulnerability and renewable energy consumption. Moreover, the correlation analysis of the SCDI, Human Development Index and Child Development Index shows that the SCDI can be applied as a complementary assessment to the existing development indexes in order to provide a more comprehensive evaluation on sustainable development by regarding children perspective and addressing relevant topics of sustainable development, such as environmental aspect and safety. Accordingly, the application of SCDI can contribute to establishing more comprehensive strategies on child as well as sustainable development policies, and to inform the condition on child development to stakeholders.

Keywords: Sustainable Child Development Index (SCDI), Child development, Sustainable development, Sustainable Development Goals (SDGs), Sustainable assessment, Inequality

1. Introduction

Children are an important stakeholder group for Sustainable Development (SD) as they represent the interface between current and future generations. As the needs of children and their susceptibility to external factors are different from those of adults (UNICEF 2013; Halleröd et al. 2013), indexes for evaluating SD from a child perspective, that is sustainable child development, are needed complementary to whole-population-oriented assessments.

To consider children as a key stakeholder group in sustainability assessment, several indexes for assessing CD have been already proposed, systematically aggregating the individual CD topics to a simpler layout (Chang et al. 2017a). For example, the Child Development Index (CDI) (The Save the Children Fund 2008; 2012) was proposed to evaluate the development of children considering the topics health, education and nutrition, mirroring the well-known Human Development Index (HDI) (UNDP 2016; Chang et al. 2017b). Other indexes address additional topics, e.g. relationships with family, school and community and safety. For instance, Bradshaw et al. (2007) proposed the index of child well-being on European level. The index considers the child rights and examines child well-being in eight topics (material situation, housing, health, education, relationships, civic participation, and risk and safety) with 51 indicators. Land et al. (2001) firstly constructed the Child and Youth Well-Being Index in order to track the trends in child well-being on national level across 28 indicators and seven different topics namely material well-being, health, social relationships, safety/behaviour concerns, productivity/educational attainment, place in community, and emotional/spiritual well-being. Later on they expanded the index to consider additional 16 indicators (Land et al. 2007). Breaking down from national to state level, the New KIDS COUNT Index was proposed for measuring and comparing the performance across states of the United States (The Annie E Casey Foundation 2012). The index applied 16 indicators classified to four topics: economic well-being, education, health, and family and community.

Though numerous indexes already exist for providing aggregated information of topics on CD on country or states level, some limitations remain. The limitations include the lack of a consistent classification of topics and indicators, data gap for the indicator set, and the neglect of topics related to environmental aspects (Chang et al. 2017b). To address the gaps, Chang et al. (2015) firstly proposed the Sustainable Child Development Index (SCDI) framework, which allows for comparing the national achievement towards SD with a focus on children and monitors the improvements and declines of the performance for countries as well as specific topics by continuously updating the indicators over time. The framework contains seven relevant themes: health, education, safety, economic status, relationship, and participation plus the newly recommended theme environmental aspects tackling resource accessibility. Each theme is specified by subthemes and criteria. Subthemes are further described by criteria, which are measured by indicators. Followed by Chang et al. (2017a), an initial indicator set based on data availability was proposed. This set consists of 66 indicators for which statistical data for at least 100 countries are available. The 66 indicators can support a quantitative assessment of sustainable child development with available statistical data. However, among the 66 indicators, one indicator may be highly correlated to other indicators within the same subtheme or theme. For example, the indicators neonatal-, infant-, and under-five- mortality rate within the subtheme child mortality could have a high correlation with each other. That means that one indicator can be treated as a representative one to substitute other highly correlated indicators within the same theme to simplify the indicator set, and hence fosters the implementation of the SCDI. This also avoids double counting (Chang et al. 2017b). Besides, among the 66 indicators, a trade-off between the comprehensiveness of topics and covered countries is found. Nevertheless, the covered countries of the 66 indicators are not the same. The number of mutually covered countries decreases while the number of considered topics as well as indicators increases. This trade-off also affects the implementation of the SCDI. Thus, apart from the correlation between indicators, the balance of the number of mutually covered countries and indicators shall be the other consideration to further simplify the initial indicator set (Chang et al. 2017b).

Based on the previous work (Chang et al. 2015; Chang et al. 2017a), this study aims at completing the establishment of the SCDI, by (1) developing a representative indicator according to correlation analysis and the trade-off of the number of covered countries and considered indicators to facilitate the implementation of the SCDI, (2) employing calculation methods (i.e. normalization and aggregation methods) to combine the representative indicators to the SCDI, and (3) comparing the results of the SCDI with existing development indexes such as the HDI and the CDI (Chang et al. 2017b). Besides, as an index for SD, the Sustainable Development Goals (SDGs) are used for defining the target values in indicator normalization. The succeeding sections present the research methodology (section 2), results and discussion (section 3), followed by concluding remarks (section 4).

2. Methods

In this section, the method for constructing the SCDI is presented. First, developing a representative indicator set is described, followed by designing the normalization and aggregation methods, and then comparing the SCDI with other development indexes (e.g. the HDI and the CDI).

2.1. Selection of a representative indicator set

A correlation analysis of the 66 indicators proposed by Chang et al. (2017a) was carried out to identify indicators that are highly correlated within an individual theme. Spearman correlation was used to perform the correlation analysis (Lehman et al. 2013); the value of the correlation coefficient varies between +1 (perfectly positive correlated) and -1 (negative correlated). A perfect Spearman correlation coefficient occurs when the variable is in a perfect association to the other. In this study, two indicators are identified in high correlation if the Spearman correlation coefficient is higher than +0.7 or lower than -0.7. If a pair-wise analysis shows a high correlation of the two indicators, the indicator which has statistical data for a higher number of countries is selected as the representative indicator and thus substitutes the other one. If the correlation analysis does not show a high correlation between the two indicators, both indicators are kept because one indicator cannot substitute the other (Chang et al. 2017b).

Next, the amount of the representative indicators was further reduced to address the trade-off between the number of the representative indicators and the number of countries in the SCDI for which data for the representative indicators are available. The representative indicator set was further reduced according to the two principles (regarding the authors' value choice): (1) the representative indicator set used in the SCDI shall address at least 50% of the topics (i.e. themes, subthemes and criteria) considered by the indicators selected from correlation analysis, and (2) the number of mutually covered countries in the SCDI shall represent at least 70% of all 195 countries listed in the UNICEF database. Then, the provision of representative indicator set was considered as the first step for constructing the SCDI in this study (Chang et al. 2017b).

2.2. Normalization and aggregation methods for constructing the SCDI

To combine the selected representative indicators to one index, normalization and aggregation of the indicators are required. The method development is presented in the following two subsections.

2.2.1. Normalizing the selected representative indicators

Normalization aims at transferring indicator values into a common range by the chosen reference points for further aggregating different indicators into a dimensionless index. In this study, linear scaling is used as the normalization method to transform the indicators scores into 0-1 rate. Linear scaling transformation requires reference points for each indicator. Thus, two reference points (i.e. minimum and maximum reference points) for each selected representative indicator were defined. One reference point represented the target value for the selected representative indicator. The other reference point was set based on the lowest or highest indicator values collected for the selected representative indicator. Since the SCDI intends to reflect SD, the SDGs are used as a guide to define the reference point (representing the target value) (Chang et al. 2017). If the target value for indicators cannot be derived directly from the SDGs, both reference points are defined based on maximum and minimum indicator values for the representative indicators.

Having defined the reference points for the representative indicators, their normalized scores can be calculated. The normalization method depends on the type of indicator. In this study, three types of indicator: positive indicators, negative indicators, and neutral indicators, were distinguished. For positive indicators (e.g. 'population using improved drinking-water sources'), a higher indicator value means a higher positive contribution to CD. For negative indicators (e.g. 'under-5 mortality rate'), a higher indicator value means a higher negative contribution to CD. The neutral indicators aim at reflecting equality topics (e.g. 'gender parity in school enrolment'), showing the relation between the indicator value and the equal state. In this sense, the closer the indicator value to the equal state of the topic (e.g. 1.00 for the topic gender parity in school enrolment), the higher the positive contribution to CD results (Chang et al. 2017b).

The normalized score (S_{i,I_p}) for a positive indicator I_p with data of a specific assessed country i was measured according to Eq.1. V_{i,I_p} denotes the value for I_p of i. R_{M,I_p} and R_{m,I_p} represent the maximum and minimum reference points for I_p respectively (Chang et al. 2017b).

$$S_{i,I_p} = \frac{V_{i,I_p} - R_{m,I_p}}{R_{M,I_p} - R_{m,I_p}} \qquad \text{(Eq. 1)}$$

The normalized score (S_{i,I_n}) for a negative indicator I_n with data of i was measured according to Eq. 2. V_{i,I_n} denotes the value for I_n of i. R_{M,I_n} and R_{m,I_n} represent the maximum and minimum reference points for I_n respectively (Chang et al. 2017b).

$$S_{i,I_n} = 1 - \frac{V_{i,I_n} - R_{m,I_n}}{R_{M,I_n} - R_{m,I_n}} \qquad \text{(Eq. 2)}$$

The normalized score (S_{i,I_u}) for a neutral indicator I_u with data of i was measured according to Eq. 3. V_{i,I_u} denotes the value for I_u of i. R_{M,I_u} and R_{m,I_u} represent the maximum and minimum reference points for I_u respectively. e_{I_u} denotes the equal state value for I_u (Chang et al. 2017b).

$$S_{i,I_u} = 1 - \frac{|V_{i,I_u} - \mathrm{e}_{I_u}|}{R_{M,I_u} - R_{m,I_u}} \qquad \text{(Eq. 3)}$$

2.2.2. Aggregating the normalized representative indicators to an index

Since there is no literature which objectively provides the relative importance for the relevant themes of sustainable child development, equal weighting on the theme level was assumed. Arithmetic average method was used for aggregating the scores from the indicator, criterion, subtheme to theme level (Chang et al. 2017b). The SCDI score ($SCDI_i$) for a specific country i was calculated by arithmetically averaging the aggregated scores for the themes $S_{i,T}$ with n_T signifying the total amount of considered themes in the SCDI (see Eq. 4). As the values for the considered indicators were transformed into 0-1, the SCDI scores were thus determined in between 0 and 1. The higher the SCDI score is, the better is the sustainable child development achievement for a country (Chang et al. 2017b).

$$SCDI_i = \frac{1}{n_T} \sum_{T=1}^{n_T} S_{i,T} \qquad \text{(Eq. 4)}$$

To facilitate interpretation, the SCDI scores for countries were classified into four levels of sustainable child development achievement: very high, high, medium and low. Taking the country classification approach adopted in the HDI as reference (UNDP 2014), the quartiles of the values for the considered representative indicators were first determined, and then normalized and aggregated into the three cut-off points by following the developed normalization and aggregation method. This country classification summarizes the progress of countries achieving sustainable child development, and thus helps researchers and policy makers to monitor the improvements or declines on the achievement of countries (Chang et al. 2017b).

2.3. Comparison of the SCDI and other development indexes

The country ranking assessed by the SCDI was compared with the country rankings assessed by the HDI (UNDP 2015) and the CDI (The Save the Children Fund 2012). This was done to clarify the similarity and difference from a statistical point of view. The comparison was conducted by using Spearman correlation analysis. Following the correlation analysis conducted for selecting representative indictors, the two indexes are identified in high correlation if the Spearman correlation coefficient is higher than +0.7 (Chang et al. 2017b).

3. Results and discussion

The following sections provide the results and the corresponding discussion: the representative indicator set for the SCDI, the SCDI scores for 137 countries including country ranking and classification, and an evaluation of the similarity of the SCDI compared to the HDI and CDI.

3.1. Representative indicator set for the SCDI

Based on the correlation analysis, 43 representative indicators were chosen from the original 66 indicators proposed by Chang et al. (2017a). The Spearman correlation coefficients for the 66 indicators and the 43 representative indicators are provided in Chang et al. (2017b). Then, a second indicator selection process was conducted based on the trade-off between the number of topics described by the representative indicators and the number of mutually covered countries. An overview on the relation between the number of indicators and the mutually covered countries is provided in Figure 1. The more indicators are considered in the SCDI, also the more topics are considered (see dotted lines in Figure 1). At the same time, the number of countries mutually covered by the indicators decreases. Only nine countries can be assessed by the SCDI when all the 43 indicators (as well as their considered topics, i.e. seven themes, 27 subthemes, and 38 criteria) are addressed (Chang et al. 2017b).

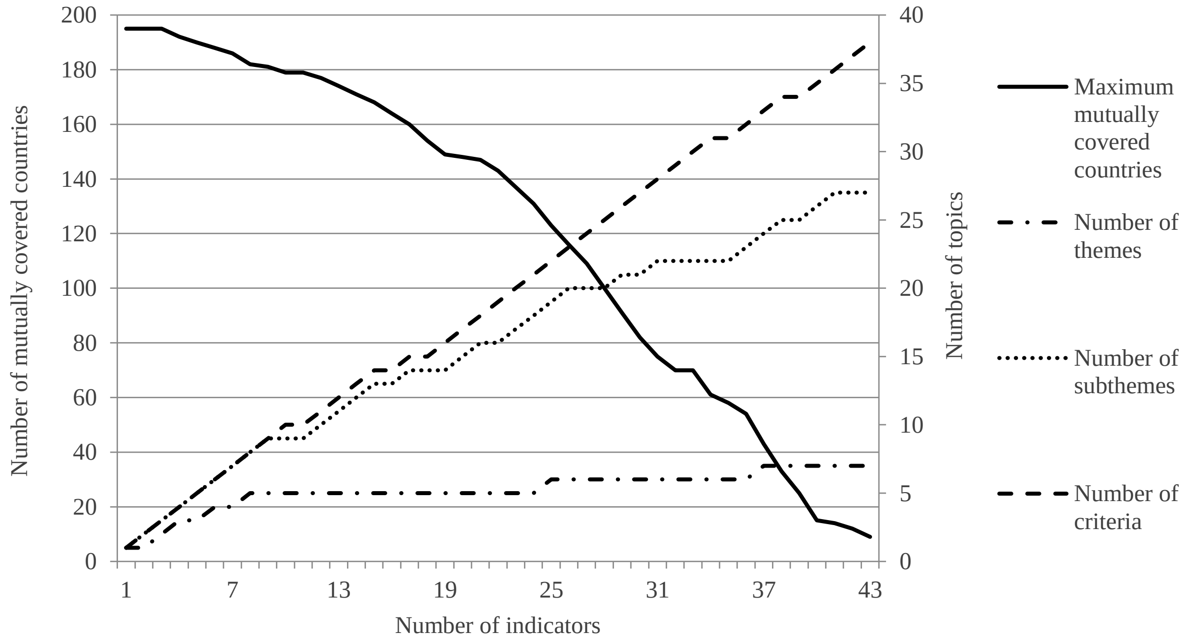

Figure 1. *Relation of number of representative indicators and coverage of topics and countries, adopted from Chang et al. (2017b).*

The second indicator selection follows the principles defined in section 2.1. According to the trade-off analysis, 137 countries (70% of the 195 countries listed in the UNICEF database) are mutually covered when 23 representative indicators are used for constructing the SCDI. Five themes (health, education, safety, economic status and environmental aspects), 17 subthemes, and 20 criteria would be addressed in the SCDI. The number of addressed topics is more than 50% of the topics considered by the 43 indicators while using these 23 representative indicators. Thus, the 23 representative indicators are used as the representative indicator set for developing the SCDI, listed in Table 1 (Chang et al. 2017b).

Table 1. *The representative indicator set considered in the SCDI including the covered themes, subthemes, criteria and data sources, adopted from Chang et al.* (2017b).

Theme	Subtheme	Criteria	Indicator	Data source
Health	Nutrition	Low birth weight	Percentage of infants born with low birth weight (< 2,500 g)	UNICEF (2017)
	Child mortality	Under-five mortality	Under-five mortality rate (probability of dying by age five per 1000 live births)	
	Mental health	Suicide	Suicide rate, 15-29 year-olds, per 100,000	WHO (2014)
	Hazardous pollutant	Household and ambient air pollution	Mortality rate attributed to household and ambient air pollution (per 100,000 population)	WHO (2017)
		PM2.5 air pollution	PM2.5 air pollution, population exposed to levels exceeding WHO guideline value (% of total)	
	Immunization coverage	Diphtheria tetanus toxoid and pertussis (DTP3) immunization	Diphtheria tetanus toxoid and pertussis (DTP3) immunization coverage among one-year-olds (%)	UNICEF (2017)
	Risk behaviour	Alcohol use	15-19 years old heavy episodic drinkers (population) (% by country)	WHO (2017)
	Oral health	Dental treatments	DMFT (decayed, missing or filled teeth) among 12-year-olds	Malmö University (2015)
	Health expenditure	Public health expenditure	Health expenditure, public (% of total health expenditure)	WHO & World Bank (2017; 2017)
Education	Attendance of education	Enrolment in primary school	Gross enrolment ratio, primary, both sexes (%)	UNESCO (2016)
		Enrolment in secondary school	Gross enrolment ratio, secondary, both sexes (%)	
	Early childhood education	Enrolment of kindergarten	Gross enrolment ratio, pre-primary, both sexes (%)	
	Gender equality	Gender equality in enrolment	Gross enrolment ratio, pre-primary, gender parity index (GPI)	
			Gross enrolment ratio, primary, gender parity index (GPI)	
			Gross enrolment ratio, secondary, gender parity index (GPI)	
			Gross enrolment ratio, tertiary, gender parity index (GPI)	
Safety	Violence and crime	Criminal victimization	Intentional homicide count and rate per 100,000 population	UNODC (2017)
	Demographic structure	Sex ratio	Sex ratio at birth (ratio)	CIA (2017)
Economic status	Housing quality	Electricity coverage	Access to electricity (% of population)	World Bank (2017)
	Macroeconomic situation	Youth unemployment	Youth unemployment rate (% of total labor force ages 15-24)	
		National debts	Public debt (% of GDP)	CIA (2017)
Environmental aspects	Freshwater vulnerability	Risk of depleting freshwater resources	Water depletion index (WDI) (ratio)	Berger et al. (2014)
	Renewable energy consumption	Consumption of renewable energy	Renewable energy consumption (% of total final energy consumption)	World Bank (2017)

3.2. Determination of the SCDI scores and country classification

Following the defined normalization and aggregation methods, the SCDI scores for 137 countries were determined. First, the reference points used for normalizing the 23 representative indicators were determined and can be found in Chang et al. (2017b). Second, according to the defined reference points and the normalization methods (Eq. 1-3), the values for the 23 representative indicators were transferred into scores between 0-1 and then aggregated into the SCDI scores for the 137 countries (see Eq. 4). The SCDI scores as well as the country ranking for the 137 countries can be found in Chang et al. (2017b). To get an overview on the results of the SCDI, Table 2 shows an extract from the country ranking (highest and lowest 20). It shows that Iceland, Norway and Estonia are the three highest ranked countries; on the other hand, Mauritania, Lesotho and Yemen are the three lowest ranked countries.

Table 2. *Country ranking based on the SCDI scores: an extract showing the 20 highest and 20 lowest ranked countries, adopted from Chang et al.* (2017b).

Ranks: highest 30	Country	SCDI score	Ranks: lowest 30	Country	SCDI score
1	Iceland	0.905	118	Egypt	0.645
2	Norway	0.877	119	Cape Verde	0.645
3	Estonia	0.842	120	Venezuela	0.637
4	Latvia	0.842	121	Central African Republic	0.631
5	Sweden	0.839	122	South Africa	0.623
6	Austria	0.838	123	Senegal	0.621
7	Thailand	0.838	124	Kazakhstan	0.620
8	New Zealand	0.832	125	Armenia	0.611
9	Bhutan	0.824	126	Gambia	0.609
10	Paraguay	0.823	127	Botswana	0.609
11	Finland	0.821	128	Iraq	0.608
12	Denmark	0.817	129	India	0.606
13	Uruguay	0.816	130	Sudan	0.600
14	Brunei Darussalam	0.815	131	Namibia	0.589
15	Costa Rica	0.814	132	Eritrea	0.581
16	Switzerland	0.810	133	Mali	0.572
17	Czech Republic	0.809	134	Niger	0.563
18	Lithuania	0.809	135	Yemen	0.536
19	Canada	0.809	136	Lesotho	0.507
20	Mauritius	0.808	137	Mauritania	0.499

The 137 countries were classified into four sustainable development achievement levels according to their SCDI scores and the three cut-off points 0.608, 0.783 and 0.896. 1, 35, 92 and 9 countries are categorized as countries with very high, high, medium, and low sustainable child development achievement level respectively. Also, countries were assigned to the five regions, namely Africa, Americas, Asia, Europe, and Oceania defined by United Nation (2016), to present the sustainable child development achievement not only on a country level but also from a regional perspective. The detail of country classification for the 137 countries can be found in Chang et al. (2017b).

The country classification significantly shows the great regional inequality on the progress of sustainable child development achievement. European countries have higher sustainable child development achievement in general. Figure 2 shows that 52% of European countries are classified as countries with very high and high sustainable child development achievement. Especially, the Nordic countries have leading positions. Several Central and South American countries, e.g. Uruguay and Costa Rica, show their good performance in sustainable child development achievement (see Table 2). On the contrary, 95% and 83% of African and Asian countries are assigned to medium and low sustainable child development achievement levels, as shown in Figure 2 (Chang et al. 2017b). Despites having the weak performance in the theme environmental aspects, these countries usually obtain lower performance in themes economic status and health. The results highlight the urgent need for improving the living condition related to sustainable child development topics for the most of African and Asian countries especially because children have the largest share of population in Africa. Children and youth under age 24 account for 60% of the population in Africa in 2015 (United Nations 2015). To be noticed, some OECD countries, such as Australia, Netherlands, Japan, Israel, Italy and Turkey, are evaluated as medium sustainable child development countries. One key reason is their weak condition in freshwater vulnerability and renewable energy consumption assessed for the theme environmental aspects (Chang et al. 2017b).

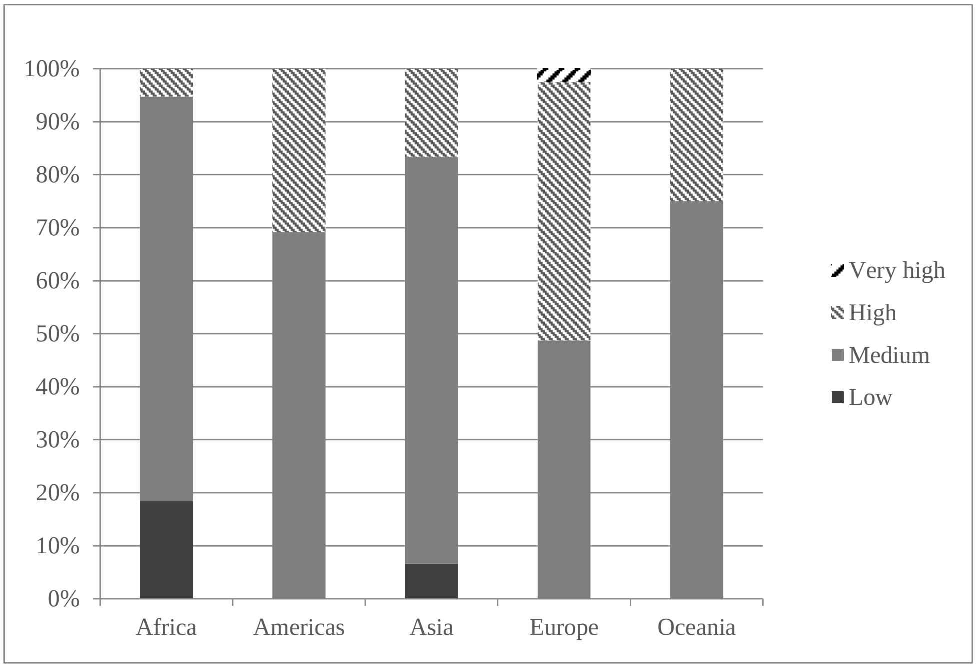

Figure 3. *Share of the sustainable child development achievement levels in different regions, adopted from Chang et al.* (2017b).

3.3. Assessment of similarity of the SCDI compared to the HDI and CDI

The correlation analysis shows that the correlation coefficient of the SCDI and HDI, the SCDI and CDI is 0.578 and 0.587 respectively (Chang et al. 2017b). The analysis implies some, but not high correlation of the SCDI to the HDI and the CDI, which means that the SCDI has no strong association with the HDI and the CDI. This outcome supports that the SCDI can assess a country's sustainable development achievement from a child point of view differently than a whole-population-oriented concept, such as the HDI. It shows that the SCDI contributes to the development index studies by treating children as key stakeholders in sustainable assessment. Moreover, the minor correlation of the SCDI to the CDI shows that although the SCDI and the CDI are both children-oriented assessments, addressing the environmental and additional topics (such as safety, environmental aspects and economic status) in the SCDI could lead to different sustainable development achievement assessed for countries than the CDI (Chang et al. 2017b).

Moreover, it is shown that the HDI highly correlates with the CDI (correlation coefficient of 0.925). Though the CDI was proposed as a development index to mirror the HDI, the two indexes have a high similarity. The results of the HDI can be used to image the outcome of the CDI, and vice versa. One key reason could be that the indicators used in the HDI and the CDI may have a high correlation because the considered topics (e.g. child mortality and life expectancy) between the two indexes have high association (Chang et al. 2017b).

4. Concluding remarks

This study constructs the Sustainable Child Development Index (SCDI) for assessing sustainable child development for countries. The SCDI considers 23 representative indicators that address the five themes health, education, safety, economic status, and environmental aspects and 17 subthemes. The SCDI scores for 137 countries are determined and classified into four levels. The results show that great regional inequality on the progress of sustainable child development achievement exists. 95% and 83% of African and Asian countries are classified as countries with medium and low sustainable child development achievement levels. The results reflect the urgent need for improving the living condition related to sustainable child development topics for the most of African and Asian countries. Besides, the sustainable child development achievement for some OECD countries, such as Australia, Netherlands, Israel, Italy and Turkey, is negatively affected due to their weak condition in freshwater vulnerability and renewable energy consumption. Moreover, the correlation analysis between the SCDI and the selected existing development indexes (e.g. HDI and CDI) supports that the SCDI can be applied as a complementary assessment to the existing development indexes by regarding children perspective and addressing relevant topics in the context of sustainable development. Furthermore, the SCDI is expected to support decision making in child development as well as sustainable development policies (Chang et al. 2017b).

The SCDI tackles some gaps of existing development indexes (e.g. lack of considering environmental aspects and other relevant topics related to sustainable development), and evaluates the national sustainable development achievement considering CD. However, the limited consideration of indicators due to low data availability affects the topic and countries considered in the SCDI. Data availability is a key factor that leads to the trade-off between the number of considered indicator (and topics) and covered countries in the SCDI. The limited inclusion of indicators in the current SCDI may lead to insufficient and biased evaluation of the sustainable child development achievement. Besides, this limited data availability also influences the amount of assessable countries in the SCDI. That means currently the SCDI can not yet be determined for all countries. This incomprehensive coverage of countries may bring about a restricted set of countries for comparing sustainable child development achievement between countries (Chang et al. 2017b).

In future, for continuing the SCDI development, the scheme, the indicators as well as the SCDI scores for countries will have to be revised and updated when additional topics, indicators and statistical data regarding sustainable child development become available. Further research could focus on the integration of the SCDI into current sustainability assessment approaches and databases (Chang et al. 2017b). Also, the practices of employing and developing the HDI related indexes can also treated as reference to initiate the applications of the SCDI for supporting decision making in development policies.

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Continuing professional education for engineering faculty: Transversal integration of Sustainable Human Development in basic engineering sciences courses

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The integration of sustainable development in higher education is increasingly recognised as a priority for a growing number of universities, nonetheless, barriers for change remain and particular attention should be given to the success factors fostering an effective integration. The present contribution analyses the extent to which a professional development programme, aimed at engaging and empowering faculty, has positive effects to integrate sustainable human development principles into existing courses of engineering. Specifically, the research focuses on the effects of the integration of sustainable human development in new teaching modules in a subject of basic engineering science, implemented in regular courses of the first year of the degree in engineering. The methodology includes i) a standardised test to assess sustainability literacy of the students; ii) a focus group conducted with the students of the engineering courses involved in the initiative; and iii) an in-deep interview conducted with the academic coordinator of the subject analysed. The results of the present case study highlight the relevance of professional development programmes addressed to academics with regard to the integration of sustainability principles specifically in formal science disciplines. The conclusions highlight relevant insights from the case study that are useful for supporting further integration of sustainable development in engineering disciplines.

Keywords: Engineering, Sustainable Human Development, Continuing Professional Development, Higher Education Policy.

1. Introduction

Engineering is recognised as a critical discipline to address sustainable development (SD) challenges (Davidson et al., 2010; Karatzoglou, 2013). The future engineers will be leaders and specialized professionals who will hold important positions in the economic and the political spheres. In both cases, they will play a critical role in the promotion of a more sustainable future, with the responsibility of making important decisions impacting the social, economic and environmental domains. For this reason, in the last decades, there have been many calls for a renovation of engineering competencies and a change in curricula and pedagogies integrating SD concepts and principles (Lozano and Lozano, 2014; Mulder et al., 2015; Segalàs et al., 2009). A number of technical faculties and universities have been reconsidering the content of their curricula adopting diverse strategies (Lozano and Lozano, 2014; Rose et al., 2015; von Blottnitz et al., 2015), but further efforts are needed in order to properly integrate sustainable development in teaching contents and pedagogies. Faculty members can be considered as the foremost contributors to curriculum renewal (Barth and Rieckmann, 2012). For this reason, building capacity of academics towards sustainable development is critical to foster the transformation of learning and training environments (Cebrián et al., 2015; Sammalisto et al., 2015).

Scientific literature reports different experience of capacity building of academics in SD, specifically focused on technical universities such as 'educate the educators' approaches aimed at integrating SD in regular courses (Barth and Rieckmann, 2012; Ceulemans and De Prins, 2010; Lozano García et al., 2008), or aimed at the development of new degrees (Lozano and Lozano, 2014). Other approaches, instead of focusing on the process of 'training' academics, are specifically aimed at fostering their personal contributions to SD, namely promoting reflection on how to help integrating SD in regular subjects starting from their expertise and disciplines (Holmberg et al., 2008; Svanström et al., 2012). Among the different approaches indicated to promote the integration of SD in curricular activities (Watson et al., 2013), intertwining SD as a concept within regular courses has been described as the most favourable approach for integrating SD (Lozano and Lozano, 2014), providing suitable chances to incorporate into professional practices the SD principles (Rose et al., 2015).

Furthermore, specific initiatives have been focused first and foremost on the integration of sustainable human development (SHD) in engineering curricula (Boni and Pérez-Foguet, 2008; Boni and Pérez Foguet, 2006; Pérez-Foguet et al., 2005). SHD has been defined as the "the expansion of the substantive freedoms of people today while making reasonable efforts to avoid seriously compromising those of future generations" (UNDP, 2011, p. 18). The concepts of SD and SHD do not present precise theoretical boundaries and are subjects to different interpretations. Specifically, in this contribution the concept of SHD is employed when emphasising the fulfilment of basic needs and the expansion of human capabilities within SD approaches.

Engineering approach to teaching and learning is characterised by technical paradigms and a strong disciplinarity (Halbe et al., 2015). Consequently, it is particularly challenging integrating the principles of inter-, multi- and transdisciplinarity characterising SD. This is especially difficult for those disciplines included in 'formal science', such as mathematics, logics and statistics, characterised by abstract structures and languages. These disciplines are commonly taught in the first year of engineering degrees and it would be especially important that students start their training integrating sustainability principles from the very beginning. For professors of formal science disciplines it is particularly challenging including SD into their teaching practices and professional development programmes are especially useful to provide them with pedagogical and practical resources to be used in their teaching practices. Literature presents very limited research focusing on educating the educators deepening on formal science disciplines and SD; specifically evaluating the impacts of specific training programmes addressed to academics.

Due to the challenges highlighted earlier, the purpose of this contribution is to describe a professional development programme on SHD focused on engineering faculty, assessing the degree to which such programme has positive/desired effect on both academics and students, especially focusing on formal science disciplines. Specifically, the research focuses on the effects of the integration of SD in new teaching modules in a subject of basic engineering science, implemented in regular courses of the first year of the degree in engineering. The specific objectives of this study comprise the analysis of:

- the perception of a group of students of the subject analysed in the present case study;

- the perception of the academic coordinator of the subject incorporating SD concepts.

This contribution seeks to explore these research objectives through the analysis of a case study of professional development of academics, specifically focused on basic engineering science courses, in the framework of a continuing professional education programme addressed at engineering faculty implemented at the Polytechnic University of Catalonia (UPC) (Spain).

To accomplish this task, methods include: i) a test, aimed at assessing student knowledge of SD before the exposure to the subject modules; ii) a focus group, aimed at deepening students' perception of their learning experience; and iii) an in-depth interview, specifically aimed at exploring learning acquisition and factors related to motivation an academic involved in the training;

2. Methods

2.1 Context of the case study

The present contribution focuses on a professional development programme aimed at engaging and empowering faculty of the Polytechnic University of Catalonia to integrate SHD concepts into their existing courses. This initiative, started in 2016 with duration of two years, has been funded by Barcelona City Council involving different profiles of engineering faculty, including academics with little or no previous experience in SD/SHD along with professors that already integrate them in their academic functions. Faculty has been engaged through diverse training activities aimed at improving the competencies and attitudes of academic staff towards sustainability, such as periodical workshops, engaging all trainees, and individual coaching sessions. Furthermore, the training approach promoted the development of case studies dealing with SHD issues but landed to the local scale, as an effective way to increase the perceived relevance of basic sciences courses within engineering studies, and complement traditional approximations focused mainly on courses focused on technology. The final goal of the programme was engaging faculty to propose and develop teaching contributions to SHD based on their own discipline and expertise and apply them in real teaching situations, ideally in regular courses.

The methodological approach driving this professional development initiative was founded on previous relevant experiences of faculty capacity building promoted in technical universities across Europe. On the one side, the European initiative Global Dimension in Engineering Education (GDEE, 2015a), coordinated by the authors, developed with the aim of mainstreaming SHD in engineering education, specifically improving the competences of faculty of engineering universities to effectively integrate SHD as a crosscutting issue in teaching activities. On the other side, the meaningful training experiences promoted by Svanström et al. (2012) and Peet et al. (2004), respectively in Chalmers and Delft universities of technology. In both cases, the main focus of the professional development initiatives is exploring how lecturers can contribute to SD from their own disciplines with an open approach, rather than traditionally training academics on how they should incorporate sustainability concepts. Following the mentioned initiatives, the training programme specifically combined workshop sessions, including training and discussion activities, with individual coaching sessions. The purpose of this method was twofold. First, workshops aimed at fostering discussion on relevant topics related to the embedding of SHD in engineering courses, finding common grounds between respective disciplines and contents related to SHD. A part from specific contents related to SHD, workshops included discussions on active learning pedagogies, competencies articulation and outcomes assessment, successful experiences, etc. Furthermore, one or the purposes of the workshop activities was to foster a supportive learning environment and group engagement, giving the possibility to share personal experiences and discuss on relevant sustainability topics and how they can be reflected in respective courses. Second, individual coaching sessions aimed at engaging the most motivates professors to embed SHD in real teaching modules and subjects. Academic were supported in the process of exploring potential topic to be included in their regular subjects, the most appropriate pedagogies, student assessment etc.

2.2 The case of Lineal Algebra

In the framework of the professional development programme, a professor of the UPC proposed to embed elements of SHD into a regular subject of Lineal Algebra – of which she was academic coordinator – through a new teaching project focused on the 'Long-term viability of a possible construction of a dam'. Specifically, it was decided to integrate and assess UPC transversal competence 'sustainability and social commitment' aimed at fostering different competencies of engineering students: i) knowledge and understanding of the complexity of the welfare society economic and social phenomena; ii) the capacity to relate well-being to globalization and sustainability; and iii) the ability to use technique, technology, economics and sustainability in a balanced and compatible way.

The pedagogical approach of the teaching project was based on Project Based Learning (PBL) including aspects of collaborative learning. In PBL – an approach particularly suitable for integrating SD into the engineering curriculum (Lehmann et al., 2008) – students are provided with complex authentic situation problems as well as guidelines on how to solve them. The learning process of participants is enriched through the analysis of the different approaches and perspectives applied to solve the problems. This methodology enables working on different competencies in a collaborative way allowing students to understand environmental and societal problems as a whole (De Graaff and Kolmos, 2006).

The students had to work in small groups on the project "Long-term effectiveness of a potential construction of a dam", described elsewhere (Garcia-Planas and Taberna, 2017), for this research it is worth mentioning the general design of the activity. Specifically, it was proposed the possibility to build a dam to regulate the basin of one of its rivers with the objective of satisfying the needs of water for irrigation. Student were provided with the maximum capacity of the dam, the amounts required for irrigation and the amount that must be left to maintain the water quality standards for other uses, provided that the water level of the dam plus the weekly contribution of water of the river does not reach a minimum preventing the provision of water. Using lineal algebra, students should assess the viability of the dam analyzing, on the one hand, its stability under the given conditions and, on the other hand, considering the variation in time of the water contribution to the river, taking into account different variables, such as climate change effects. In addition, they were asked to assess of the social benefit of the dam by counterbalancing the benefits obtained by the irrigation versus potential social conflicts caused by land expropriations and consequent displacement of the inhabitants of such area. Finally, they were asked to discuss in small groups with the objective to agree if building or not the dam.

2.3 Data collection

A mixed approach was used to collect data for the research. First of all, a standardised questionnaire was conducted to assess student general knowledge on sustainability issues. Secondly, a qualitative approach consisting of a semi-structured interview addressed to the professor involved in the professional development programme promoting the teaching initiative, and a focus group, conducted with students of lineal algebra.

2.3.1 Sustainable literacy test

In order to assess the general knowledge of the students involved in the subject of Lineal Algebra, at the beginning of the subject a standardised test was conducted using the 'Sustainable Literacy Test' (available at http://www.sulitest.org/). This web-based tool is designed to measure individual current knowledge on SD through a multiple choice questionnaire aimed at covering the main issues of SD. Core or specialised modules can be included in the test. The former comprises 30 international questions, identical for all users throughout the world, which allow to benchmark and identifying trends at global level; while the latter comprises a battery of local focused questions including regional and cultural specificities. The core module, which was expressly used in this research, aims at assessing students' knowledge on four main themes: i) sustainable humanity and ecosystems; ii) global and local human-constructed systems; iii) transition towards sustainability; and iv) role to play, individual and systemic change. The overall test architecture is fully explained elsewhere (Sulitest, 2016).

2.3.2 Focus group

The focus group is a qualitative research method aimed at obtaining, commonly from small groups of people, their perceptions, attitudes and opinions towards a specific area of interest (Krueger and Casey, 2009). An informal, interactive and non-threating environment encourages an open group discussion, providing the opportunity to deepen specific topics (Sharma et al., 2017). In this research, a focus group were specifically employed to get detailed perceptions of students about a learning experience promoted in the framework of the professional development programme of academics. Data were transcribed verbatim and subsequently reviewed by two researchers independently.

The focus group was aimed at assessing the overall perception of students on the subject of Lineal Algebra described earlier, and specifically focused at assessing the following issues:

Organisation and approach of teaching proposal

- Organisation of the subject (modules, activities, assessment, etc.)
- Novelty and impact of the pedagogical approach
- Relevance of the learning experience (connection with previous experience and/or future expectations).

Contents of the teaching proposal

- Relevant issues studied/discussed
- Issues that should have been deepened

Individual competencies acquired as citizens and future engineers

- Cognitive: relevant knowledge, concepts, etc.
- Non-cognitive: empathy, solidarity, compassion, intercultural sensitivity, etc.
- Professional: team work, innovation, multidisciplinary work, etc.

2.3.2 Semi-structured interview

The qualitative interview is a research tools that aims at identifying the personal vision of the interviewees in relation to a specific topic through their way of capturing the complexity of a given situation through their own perceptions and experiences, as well as with their own words and terminology (Patton, 2014). The semi-structured interview, starting from a guide comprising the main issues that have to deepened, is flexible and allows freedom to both the respondent and the interviewer about which topics deepening.

Based on previous relevant experiences (Brockhaus et al., 2017), a guide to be used for interviews was developed to guarantee consistency and later validated by a panel of experts, after including suggested modifications, according to Charmaz (2006). The interview was conducted on site and lasted approximately one hour. It was recorded and transcribed verbatim and then analysed by two different researchers. Following the research of Barth and Rieckmann (2012), the interview was aimed at exploring diverse issues related to the professional development initiative:

Individual competencies - Increased knowledge, competencies and skills related to SHD:

- Cognitive: knowledge, concepts, relations, etc.
- Non-cognitive: awareness, motivation, values, etc.
- Professional: knowledge of different teaching strategies and methods.

Issues related to the professional development of academics – The research aimed at identifying changes in the teaching routine, specifically if professor look for appropriate/innovative pedagogical approaches in the classroom. Alongside the ability and motivation of each participant as a result of the training activity, interviews were aimed at exploring, within this framework, specific factors that favour or limit the changes in teaching practices, such as:

- Students' expectations
- Curriculum requirements
- Time investment of academics
- External factors (coaching, availability of teaching resources, etc.)

Potential impact in the organization - Beyond the change strictly related to the teaching function of academics, another important aspect to consider is the potential involvement of teachers in disseminating and promoting SHD principles in their university organization. Possible contributions in this regard may have different levels of involvement, from the personal to the institutional sphere:

- Dissemination of professional activities with the colleagues
- Promote changes in curricula
- Encourage political / institutional strategies promoting SHD

3. Results and Discussion

3.1 Sustainable Literacy Test

The test was conducted through the webpage of the 'Sustainable Literacy Test' at the beginning of the semester. Students were invited by a test coordinator and they must sign up and access to the test through an access code. The tool provided both global and individual results. In total, 26 students over 49 completed the core module questionnaire, representing the 53% of the students of the subject.

As presented in Figure 1, the overall results of the student's respondents are, compared with both national and international sessions conducted within the application, lower in every one of the four themes explored.

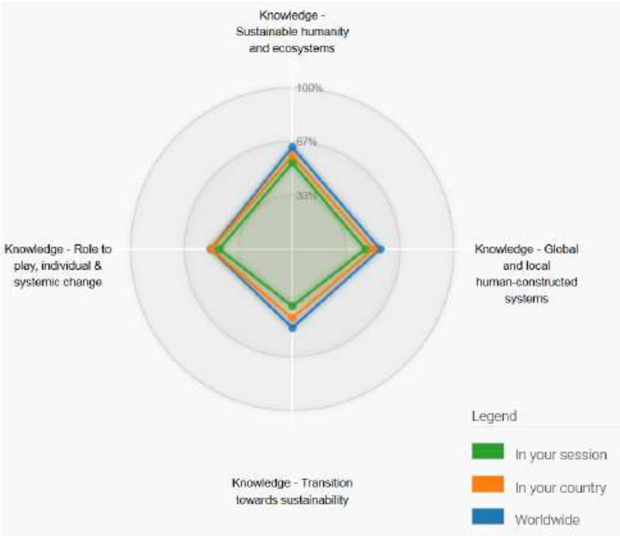

Figure1. Results of the sustainability literacy test

3.2 Focus group with the students of Lineal Algebra

In this section the results of the focus group conducted with the students of the subject of Lineal Algebra are presented and discussed.

Overall, students show a very good acceptance of active learning pedagogies employed and of the topics integrated in the subject. Initially students minimized the importance, in the context of the subject, of those embedded topics related to water use and socio-environmental aspects, focusing primarily on issues related to the mathematical resolution of the problems raised in the case study. Possibly, mathematical aspects were perceived as the most important.

> "The subject assessment was in mathematics, the sustainability part came from the mathematical problem. You had to draw the conclusions… I mean, at the social level, but what it was assessed and the most important and difficult issue was the mathematical problem."

Subsequently, during the group discussion, gradually emerged perceptions related to the specificity of the problems studied as well as personal considerations on the potential applications in the real world of an abstract matter such as linear algebra. Furthermore, more general aspects related to the professional role of engineering came up in the discussion.

> "I could not think that linear algebra had such a direct application .... At the moment I like to see that it is useful what you are doing and that they are not just numbers and can have a social application. It is quite different from the other subjects…"

> "Eventually it has a real application…, for what we have seen so far it is the only subject that has some application for our future of engineers and, apart, algebra is a subject that when you first see it you say ... what is it for? Well, any initiative like this one is welcome".

Despite the markedly mathematical nature of the subject it can be noted that the content and teaching methodology favoured important reflections of the students, which came up from group dynamics and discussions on various topics raised in the subject, embedding both mathematical and environmental/social issue related to the sustainability of a dam. The students, divided into small groups of 5 people, had to find an agreement for the solution of a problem with different variables to keep in mind that included mathematical elements (balance/water efficiency of a dam), environmental (water as a natural resource, ensure sufficient water supply for irrigation, etc.) and social (the possibility that the residents need to move to other areas, with consequent social tensions). The need to find a mutually agreed solution on the possible construction of the dam, among the members of the group, stimulated discussion and comparison of different points of view and perceived priorities on sustainability issues. It is worth highlighting that this was the only subject of the first year of the degree on which students worked mainly in group.

> "Working in group, we were forced to debate what we were going to decide [about the dam construction] and you can't agree with every one of the group so we had to debate about the water problems in order to find a solution, this has been very different from the others [subjects]. Besides, I knew that engineering has a lot of applications but an example so clear that I see in first year…., well, I liked it."

This confirms that these group activities can be an effective way to promote interactions with people with different views and paradigms (Halbe et al., 2015); they cannot replace but they do prepare students for future working experiences with real-world stakeholders in a group project (ibidem).

These group activities, conducted predominantly outside the classroom, have favoured a better relationship with peers in the group, even with the other classmates. However, the work outside the classroom entailed an extra important effort, which students considered excessive if all the six annual subjects had the same characteristics. The students agreed that, if this were the case, all the subjects of the first year should reach an agreement to develop a common project, an event that students consider unlikely. Students' commentaries emphasise two of the main challenges for effectively integrating SD in university curricula, namely overcrowded curricula and existing disciplinary boundaries (Holm et al., 2015; Sammalisto et al., 2015).

It should be noted that some groups carried out additional and time-consuming activities for their blog, which were not required in the subject programme, for example the creation of short videos focused on global issues, with special reference to water. These initiatives started from the students' need to understand the global challenges in a more visual and straightforward way. It can be argued that this deepening on issues related to SD is related to an increased interest in global challenges arisen within the subject.

What appears to be missing, in the opinion of the majority of the students involved in the focus group, it's a final discussion at the end of the course with professors and classmates. This would have allowed an overall discussion on the issues studied during the course and favoured a deeper reflection on the decisions taken by the different groups on the dam construction. Through the methodology of the portfolio each group had developed its own blog and the different conclusions could be consulted online. Nonetheless, the students reiterated that the discussion would have facilitated the sharing and discussion of ideas and decisions.

> "Actually, I also consider that professors should do a closer follow-up of our works, right? So, after having delivered the conclusions, debating them in class among all students and share all the conclusions".

> "I think that you can look at it [the presentations and conclusions in the blogs of the other groups] but it would have been better to discuss it in class to know the opinions of each group…. I don't know, it is better in class".

It is important to reflect on the considerations of the students on the 'social' role of the engineer. Their comments emphasize how the engineer's professional role is commonly associated with the world of the industrial production and the maximization of the profit of private enterprises. Students recognize the social role of this professional profile and identify themselves professionally as bearers of change more than profit. The social value of engineers is widely recognised in academic literature (Davidson et al., 2010; Karatzoglou, 2013) as well as in international institutions (UNESCO, 2010).

> "I believe that society has a very selfish concept of the engineer and we have to be the ones who see that we can help other people and not just working in a company for economic profit, it is thanks to projects like this one that we start believing in ourselves that yes… we can change things."

Consequently, they were claiming higher education to be less abstract and more centred into real-world problems. Contextually, they highlight the need to be educated as 'persons', implicitly recognizing the presence of values in educational practices although primarily abstract, as can be linear algebra. This contrasts with most of the paradigms and educational models commonly used in engineering studies (Halbe et al., 2015).

> “... I think that besides learning to do calculous it is important to be trained as an engineer and also as a person and this I think that contributes to provide a more critical vision… let’s say… about everything I have, the global society and the water, for example...”

Finally, students claim that, along with water topics, they are interested in other SD issues such as waste, pollution and labor exploitation.

3.3 Semi-structured interview

In this section the semi-structured interview conducted with the academic coordinator of the subject of Lineal Algebra is presented and discussed. The interview was conducted in the professor’s office with duration of approximately one hour.

The professor acknowledges the usefulness of the training process, especially highlighting the benefits in terms of professional competencies. She remarks that, after identifying the potential topics to be integrated in the subject, the real challenge was how to embed these concepts into the subject. For this reason, the training process and especially the interchange of experiences with the colleagues participating in the programme are described as constructive and rewarding. On the one hand, she partially ascribed the difficulties encountered to the fact that linear algebra is a scientific discipline characterised by abstract structures that does not offer many examples to integrate sustainability related concepts. On the other hand, the professor claimed to believe in the need to integrate SD concepts in regular subjects at the very beginning of engineering studies, in order that students begin to actively reflect on such issues since the early subjects without having to postpone these deepening in future regular subjects or with a specific course on SD. This perspective confirms prior research on the incorporation of SD in universities curricula, specifically that intertwining SD concepts in regular courses contribute to the raising of students’ awareness on such principles increasing their opportunities to integrate them into their professional life (Kamp, 2006; Lozano and Lozano, 2014).

The interviewee describes some activities conducted during the training programme in a particularly positive way. First of all, the use of a set of contextual case studies based on real SD projects, jointly developed by academics and practitioners of Non-Governmental Organizations (GDEE, 2015b), aimed at providing academic staff with specific materials to be used in the classroom. The usefulness of these cases is described specifically in terms of providing examples of ‘what can be assessed and how to assess SD issues’, although cases might deal with issues not directly related with the expertise of the professor. This confirms that the lack of appropriate material as a problem to integrate SD (Peet et al., 2004), as well as the fact that the availability of practical teaching resources is valuable and useful for embedding SD in engineering subjects (Boni and Pérez-Foguet, 2008; Pérez-Foguet et al., 2005). Another issue emphasised as a relevant group exercise for professional competencies of academics was the joint creation of a general rubric to assess UPC transversal competence ‘sustainability and social commitment’, which would stand beside and complement the regular subject’s disciplinary assessment. Despite reporting the relevance of this activity in terms of training, however, the final result was described by the professor as not entirely applicable to the subject of Linear Algebra. Specifically, the assessment rubric developed was described as complex and time consuming, especially considering that it should assess the transversal competence of a basic science subject.

The professor expressed great satisfaction with reference to students’ commitment on SD issues presented in the subject. She reported that the vast majority of the students has been engaged in developing reflections into their works and portfolios on water issues as SD challenge. Although some of the students’ contributions might be considered as too general or with insufficient deepening, she emphasizes the fact that it must be taken into account that first year students are commonly struggling with some of the most demanding subjects of the course, some of which they often do not recognize any practical usefulness. In this particular teaching project, the perception of the coordinator is that students, a part from gaining insight on SD topics, have understood the importance of abstract languages such as mathematics, recognising their potential for real problems resolution.

The preparation of the teaching project represented a considerable investment of time for the professor. The main difficulty to overcome was described as the process of identifying a complex problem embedding SD that was mathematically resolvable with students’ knowledge of lineal algebra and, at the same time, that the solution was not obvious, stimulating students’ motivation to take up the challenge. In other words, the problem should not be resolved by simply applying a mathematical formula, instead it should remain open for different positions, fostering reasoning and discussion among students. Noticeably, the preparation of this educational project was a challenge primarily for the professor who, after dedicating a great deal of effort into this project, is currently working on a second one addressed to repeating students for the following semester. The considerable engagement of this professor highlights that, although the engagement of academics with SD is commonly favored by appropriate incentive structures at university level (Krizek et al., 2012; Stephens et al., 2008), often the efforts towards the integration of SD emerge from personal motivation and narratives, which outline a different and individual manner to engage with SD (Wood et al., 2016).

Different barriers hindering a broader integration of issues related to SD in university courses have been highlighted during the interview. First of all, resistance to change by academics has been mentioned, specifically, the integration of innovative topics in the curriculum, such as SD, as well as appropriate assessment methods, which involve the need to rethink the teaching routine of professors, student assessment methods, specific professional training etc. This represents a disincentive for potential interested academics. Furthermore, the professor emphasizes the lack of a clear and consistent message from the institution regarding SD; specifically, she claims that “sustainability should not remain only in the institutional statements” and its integration should be actively fostered in the curriculum, even with top down coercive strategies. This validates the extensive literature on the barriers for the integration of SD into the university system (Lozano, 2006; Lozano et al., 2013; Velazquez et al., 2006; Verhulst and Lambrechts, 2014). The academic is aware of the fact that her involvement can be a wasted effort if permanent structures of the university, a part from recognising the importance of SD principles in communication and declarations, do not actively support the integration of such principles into their different functions. It can be argue that the interviewee does not fully perceive the complexity of the process of institutionalisation of an innovation. In fact, as properly reported by Lozano (2006), coercive strategies “generates conflicts and the innovation is bound to lose strength with a change of authorities”. Nonetheless, she acknowledges that the integration of SD concepts into courses and curricula requires a concerted effort among different university stakeholders (Lozano-García et al., 2009).

Finally, the professor asserted that she will follow with and further deepen the integration of SD issues, exploring potential new topics to be incorporated into the subject of Lineal Algebra. Contextually, she reported that her involvement will not be limited to her teaching function, believing in the importance of promoting SD issue also at the institutional level, for example, by disseminating and discussing with colleagues teaching innovation related to the integration of sustainability with particular focus on mathematics. Currently, her dissemination activities are not limited to the sphere of UPC, in fact this case study was recently presented by the professor in a contribution for a national congress on 'University and Sustainable Development Goals' (Garcia-Planas and Taberna, 2017). Moreover, she claimed to be firmly convinced of the need to actively promoting changes in engineering curricula to include effectively the transversal competence 'sustainability and social commitment', and that she will be personally engaged in this goal. As highlighted in other research focused on continuing education of academics (Barth and Rieckmann, 2012) this case study confirms that faculty professional development on SD has positive effects that go beyond teaching function, fostering transformative changes towards a sustainable university.

In conclusion, the approach employed to facilitate the integration of SHD produced positive effects on faculty involved, reinforcing previous experience based on similar methods (Holmberg et al., 2012; Peet et al., 2004). Specifically, in the case study analysed, involved positive effects for both students of engineering – which, beyond the acquisition of specific concepts, have developed important insight and reflections on the engineer profession and the social benefits to which they could contribute at once finished their studies – and the professor promoting the educational practice in a regular course. Particularly, it is important to highlight that students involved recognised the social utility for the promotion of SHD not only of engineering but also of an abstract discipline like Linear Algebra. Besides, the lecturer intervieweed was positive and strongly motivated about the integration of SHD, as well as engaged in further promoting sustainability concepts in formal and informal university spheres.

4. Conclusions

This research was aimed at assessing the effects of the integration of SHD in regular subjects of basic engineering science, implemented in the first year of engineering studies. Specifically, the perception of the students involved and the academic coordinator of the subject integrating SHD were analysed.

Among the lessons learnt arisen from this initiative it is worth emphasising:

- The results of professional development initiatives on SHD have positive effects not only on students' knowledge and specific competencies related to sustainability, but also on their vision as future professionals of the engineering field, engaged with sustainability in its multiple dimensions.
- The integration of SHD in regular courses is a complex process involving academics mostly with a strong disciplinary expertise. Professional development initiatives based on bottom-up approaches aimed at fostering personal opportunities of integration of sustainability principles, starting from personal expertise of academics, are effective approximations to train and engage faculty in SHD.
- Professional development activities usually involve a large investment of time and effort for academics, specifically regarding abstract disciplines, such as those comprises in formal science. Individual coaching, as well as specific teaching materials and contextual case studies, can help faculty to embed SHD in their subjects. Furthermore, group activities conducted with lecturers are effective to stimulate interest and sense of community among academics.
- Professional development initiatives focused at integrating SHD into teaching can have positive effect beyond teaching practices. Specifically, once academics are sufficiently involved and have acquired self-reliance on the effectiveness of their teaching, they can further engage in promoting SHD in other functions and spheres of the university.
- In order to foster academic engagement, permanent structures of universities should actively support the integration of SD principles into their different functions, not only acknowledging SD commitment in institutional declarations, but also effectively implementing SD throughout the system.

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Towards conceptualizing, designing, and evaluating transgressive learning spaces for socio-ecological sustainability

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Abstract

This paper addresses the emerging calls for more radical learning-based transformations in Education for Sustainable Development (ESD). At a time when profound socio-ecological challenges are facing humanity, there is increasing importance being placed on exploring innovative learning approaches, in formal (higher) education and informal contexts, that equip learners to responsibly respond to urgent sustainability challenges. Addressing this need, this paper reports on the work being carried out by the Colombian case study which makes up part of the ISSC funded international project 'T-Learning.' The goal of this case study is to develop community-based 'transition labs' (T-labs) in various regions of Colombia so as to stimulate transgressive learning (radical forms of learning-based change) which contribute to context-based sustainability solutions. Building on the educational traditions of critical pedagogy - as a means to address deep-seated assumptions and norms contributing to (un)sustainability - and place-based education - so as to connect such learning to the ecological places people actually inhabit - the Colombian case study demonstrates the importance of working towards a 'critical pedagogy of place' (Gruenewald 2003) which combines place-based learning with critical thinking. This exploratory paper will present the overall methodology of the Colombian case study, the various methods being used, and the indicators that are emerging from the first T-labs that have been developed. We argue that although much attention is directed towards how academia can contribute to societal transformations, there is a reciprocal role for grassroots sustainability initiatives to contribute to innovative, inclusive, and place-based models for ESD in higher education.

Keywords: ESD, Transgressive Learning, Higher learning, Colombia, Community-based education

1. Introduction

The changing nature of socio-ecological challenges facing societies around the world are confronting traditional forms of higher education in their quest to serve society (Bodorkós & Pataki, 2009). With the increasing recognition that sustainability challenges have a 'wicked' nature - in the sense that they can be explored from multitude perspectives and are ambiguous as they involve various interconnected factors (as environmental, social cultural, ethical and other factors) - there is no agreement on standards for successful outcomes or on single solutions (Rittel & Webber, 1973). Inevitably, higher education is challenged to equip learners with appropriate knowledge, skills and attitudes to respond to sustainability challenges (M. Barth & Rieckmann, 2016; Buckler & Creech, 2014; Ferrer-Balas et al., 2010; Lozano, 2006; Rieckmann, 2012; Wiek, Withycombe, & Redman, 2011). This includes identifying new forms of education and learning that are less elitist, more inclusive, and more relevant to local realities of communities and their real life challenges. This is nowhere more evident than in Latin America, in which the modern project of education has transformed learning into a consumer good in which market competition is the strategic driver of 'quality' in the form of 'objective' indicators such as exams, standards, and accreditation benchmarks (Walsh, 2010a).

In their attempt to move towards more innovative sustainability learning, institutions of higher learning are embarking on various community outreach and engagement activities through developing working partnerships between universities, local citizen groups, municipalities and grassroots communities (Wals, 2014). Examples can be seen in the increasing prominence of civic ecology in the city combining multiple stakeholders methodologies (Krasny & Tidball, 2012), and rural ecological communities acting as campuses for sustainable education (Greenberg, 2013). Such initiatives can be described as employing a place-based pedagogy, focussing on connecting learning to the ecological places people actually inhabit (Sobel, 2004). In addition is an increasing focus on decolonisation of knowledge through intercultural learning - understood as a dialog between different cultures (Walsh, 2010b). This can be seen in the increasing focus on travel-abroad programs to facilitate transformative learning (Gill, 2007), as well as the emergence of intercultural education to include often marginalised groups in higher learning, as seen by intercultural programs and universities in Mexico (Schmelkes, 2009).

What is becoming increasingly clear, though, is that more fundamental changes must take place in educational systems to address structural barriers to change. In the educational tradition of critical pedagogy, this is conceptualised are being critical to the deep-seated power relations which maintain the status quo in society (Freire, 1970). Yet although there is increasing attention to theories and practices that appreciate more disruptive (Wals & Heymann, 2004), experiential (Kolb & Kolb, 2005), and even slow pedagogies for transformative learning (Payne & Wattchow, 2009), these approaches to learning remain under-developed and under-theorized in the socio-ecological sciences (SES); there is limited research into what type of learning this may be, how such learning emerges through methods and indicators, and the potential for scaling up such learning so as to strengthen human agency for sustainability transformations at multiple levels (D. Kronlid, 2014; Lotz-Sisitka, Wals, Kronlid, & McGarry, 2015; Wals, 2007a).

In response to this gap in the literature has emerged the international research project 'Transgressive Social Learning for Social-Ecological Sustainability in Times of Change' (referred to as the T-Learning project). Funded by the International Social Science Council (ISSC), this multi-case study project has the goal of investigating the "emergence and qualities of transformative, transgressive learning processes and their role and contribution to sustainability transformations at the food-water-energy-climate-social justice nexus" (Lotz-Sisitka et al., 2016, p. 53).[1] The T-Learning project is based on the recognition of the important roles of education and learning in leading human development and societal transformations (Engeström & Sannino, 2010) and the importance of more radical forms of learning-centered transformation to address stubborn sustainability challenges (Wals, 2007b).

[1] See www.transgressivelearning.org for more information on the T-Learning project.

The T-Learning project addresses the many different 'T' terms emerging from the literature into socio-ecological change: transition (Ferrer-Balas et al., 2010; Geels, 2010; Van Poeck et al., 2015); transformation (Baker-Shelley, van Zeijl-Rozema, & Martens, 2017; D. O. Kronlid & Lotz-Sisitka, 2014); transdisciplinary (Lang et al., 2012; Mauser et al., 2013); transcendental (Gunder, 2006). An especially interesting term which this paper will explore is emerging concept of transgressive learning (Chaves, Macintyre, Verschoor, & Wals, 2017b; Lotz-Sisitka et al., 2015; Macintyre & Chaves, in press; Peters & Wals, 2016). Transgressive learning is a form of transformative learning based addressing structural barriers towards sustainability, where the factors of collaboration, reflexion, and action-based change are promoted in intercultural learning spaces (Macintyre & Chaves, in press).

This paper will present the work being carried out by the Colombian case study of the T-Learning project, which is exploring how to develop a framework for transgressive learning, with the longer-term goal of bridging community-based learning and formal (higher) education in the post-accord context of Colombia. The outline of the paper is as follows: Section 2 will present the methodology behind the Colombian case study, design principles and methods for transgressive learning, as well as a conceptualization of transformation through the figure of the spiral of the change. Section 3 will present the results that are emerging from initial fieldwork in terms of mapping of initiatives, experiences from first T-labs, and reflections on indicators of transgressive learning. We finish with section 4 presenting the discussion and conclusion, where we focus on the lessons learnt so far in conceptualising, designing, and evaluating transgressive learning, and the possibilities of bridging such community-based learning with institutions of higher education.

2. Methods

This section will describe the context of the Colombian T-Learning case and the methods being used. Section 2.1 will begin by providing the context of the Colombian case study both in terms of research methodology and work carried out so far. Section 2.2. will describe the design principles for developing transgressive learning spaces. Section 2.3 presents the 'spiral of change' which is a visual conceptualisation of change and transformation. Section 2.4. describes the methods that are being used in the investigation, and how they relate to the goals of this paper which relate to working towards developing a transgressive methodology.

2.1. Methodology

The Colombian T-Learning case builds on four years of fieldwork by the two authors of this paper. This began with the authors becoming active members of the sustainability network CASA Colombia (Council of Sustainable settlements of the Americas, see CASA ("CASA," 2016)), which supports low-impact lifestyles in Indigenous, afro, and ecological settlements in Colombia. The authors engaged in a methodology guided by Participatory Action Research (PAR), with a particular focus on inclusive and collaborative knowledge production, which has a long Latin American tradition (Fals-Borda, 1987) Streck (2014). Beyond the methodology of action research - characterized as an "inquiry that is done by or with insiders to an organisation or community, but never to or on them" (2014, p. 3), and its orientation towards reflexive/action learning loops (Kemmis, McTaggart, & Nixon, 2013) - Fals-Borda (2001) emphasises the added 'participatory' involvement of the researcher in PAR in what he as describes as 'praxis-inspired commitment.' In PAR, the researcher goes through a process of decolonization from the dominant expert-based institutional logic, and instead assists intellectual and political movements for people's self-reliance and empowerment.

This process of research decolonisation began with one year of ethnographic research in the intentional community of Atlántida, in the Southern region of Cauca, exploring the role of social learning in bringing about transformative sustainability processes among individuals and communities (see Chaves, Macintyre, Riano, Calero, & Wals, 2015) Through positioning themselves as active members of the community - alongside their roles as researchers - and generating interest for two of the residents to act as co-investigators, research into the complicated dynamics of the community demonstrated the fundamental importance of conflict and dissonance in catalysing transformative learning in an intentional community setting. Expanding their work into the network setting of Hare Krishna, Indigenous, Afro and ecovillage communities which make up the network CASA, the investigation explored the role of endogenous meanings of the good life - *buen vivir* - in articulating alternatives to development in the Colombian context (see Chaves, Macintyre, Verschoor, & Wals, 2017a). Through participatory methods such as participatory photography, this work noted the importance of CASA members envisioning and practicing territorial relations through intercultural knowledge exchange and experimentation into alternative lifestyles.

The importance of dissonance and conflict in generating transformative sustainability changes, and the role of the diversity in the CASA network, led this research to actively participate in the annual CASA gathering called *El Llamado de la Montaña* (The call of the Mountain). Bringing together around 400 Indigenous elders and businesspeople, urban permaculturalists and peasants, and Hare Krishna devotees and academics, to name just a few, 'The call of the Mountain' has the aim of articulating and forging alliances between diverse grassroots movements in Colombia around pressing socio-ecological concerns such as food sovereignty, mega-mining, and post-conflict reconstruction. Ethnographic research illustrated how this seven-day event promotes 'ontological encounters' between different ways of seeing and being in the world, which resulted in transformative and even transgressive learning amongst participants in terms of disrupting stubborn routines, norms and hegemonic powers which tend to accelerate *un*sustainablity (Chaves, Macintyre, Verschoor, & Wals, 2017b).

This earlier research has demonstrated the possibilities of CASA member initiatives and workshops to provide what we consider to be transgressive learning spaces - spaces which promote critical thinking and action-based change which transcend stubborn, ingrained *un*sustainable behaviour. Based on an 'ecologies of knowledge' (de Sousa Santos, 2007) this takes a decolonising epistemology whereby different and often marginalised groups and knowledge systems are not just given a voice, but play a collaborate role in developing innovative and inclusive new lifestyle models. An acknowledged challenge in the CASA network, however, is transmitting these experiences and learning outcomes to wider audiences beyond its sphere of influence. The aim of the Colombian T-learning case study, therefore, is to design, facilitate and evaluate transgressive learning spaces through 'praxis-inspired commitment' (Fals-Borda, 2001), creating a methodology which can be universally replicated in local contexts.

2.2. Design principles

This section will describe the conceptual contour lines of designing a methodology for transgressive learning spaces. These principles are inspired by the work into designing multi-stakeholder partnerships (MSP), which generate frameworks for collaboration between government, civil society, business and science (Brouwer, Woodhill, Hemmati, & Verhoosel, 2016). However, while MSP focuses on facilitating partnerships between diverse stakeholders for addressing complex sustainability challenges, transgressive design principles are primarily focussed generating *learning-based change*, albeit through MSP type environments. For the reader to gain a better understand of what transgressive learning is, below in figure 1 are the five characteristics developed by Macintyre and Chaves (in press).

1. Ethics of transgressive learning is based on a philosophy of caring which balances the warrior stance of activism with the empathic pose of vulnerability.
2. Transgressive learning is a form of transformative learning based on disrupting structural hegemonies of power.
3. Transgressive learning addresses wicked sustainability issues characterized by their complex, fluid, and transient nature.
4. Transgressive learning methodology is normative and characterized by ecologies of knowledge.
5. Transgressive methods are viewed as performative, thus placing importance on participatory, reflective and narrative approaches.

Figure 1*. Five characteristics of Transgressive learning taken from Macintyre and Chaves (in press)*

As a means to begin thinking about how to operationalise transgressive learning, and evaluate and monitor its processes, we have developed five design principles roughly based on the five characteristics above, as well as insights from MSP. The following principles are exploratory in nature, open to different interpretations, but provide a starting point for understanding and critiquing transgressive learning, as will be carried out in results section 3 and 4. The authors consider that transgressive spaces need to incorporate the following:

1. **An ethical commitment to activism:** Activism is understood as political actions carried out in day-to-day lives, and it is of vital importance that transgressive spaces make an ethical commitment to fostering the acknowledgment that all our actions are political, and can make a difference to society. As Macintyre and Chaves (in press) note, however, it is important that such activism balances the desire to aggressively change the status quo through dissonance, with the need to take an ethical stance of care for human and non-human relations.

2. **Emphasis on disrupting the status quo:** In line with O'Brien (2013), the authors believe that change begins from the inside, and personal transformation in terms of habits and worldviews are needed before changes to broader society can take place. That said, transgressive changes demand disrupting the status quo at the level of societal structures, and so it is important to consider how transformations can act on multiple levels (Geels, 2010).
3. **Capacity building for living in uncertain times:** New competences must be developed which equip the learner to responsibly respond to urgent sustainability challenges. Although rational head-based knowledge will always play an important role, it is important to support the development of other heart- and hand-based competencies, which provide a more holistic and place-based set of tools to the learner (Singleton, 2015).
4. **Generation of spaces inclusive for other worlds and knowledges:** Transgressive learning focuses on cognitive justice between modern and non-modern worlds. This has a strong intercultural element - bringing together people of different backgrounds, cultures and beliefs, in settings which creates dialogue for the design of what Escobar (2011) describes as the pluriverse.
5. **Employing methodologies which are innovative, participatory and reflexive:** Generating learning spaces that transgress societal boundaries means employing methodologies which manage to include diverse stakeholders, voice marginalised groups, and give space for reflective and innovative processes (Brouwer et al., 2016).

2.3. Spiral of change

To aid in the understanding of transgressive learning, this section we will present a visual diagram of understanding transformation through the spiral of change (SoC) (see diagram 1 below). This will place the emerging concept of transgressive learning in a perspective of change, and aid the later sections identify possible indicators of learning which have or might lead to transformation and transgression. SoC is an emergent, and fluid representation of how the T-learning team understand change and transformation. Based on the ecological symbol of the spiral - witnessed in the seeds of a sunflower, and the unfolding of a silver fern - the spiral symbolises the unfolding and transformation of life. Beginning at the roots - at the bottom of the diagram 1 below - we can observe the cultural-historical context. Such roots merge Indigenous and traditional knowledge, along with the roots of modernity. Moving up the diagram are the sprouts and shoots which represent small actions and changes. Some of these evolve into the stems which twist and turn in a spiral fashion, moving the process forward. At this stage the processes encounter moments that are either conducive to change, or act as barriers to transformation. Barriers are represented by the symbol '//' which must be overcome for the budding of leaves. Such moments require deep reflection and collaborative thinking to overcome. Moving upwards, the organic budding of leaves represents outcomes, sustainability actions, and robust change, and at this stage arises the challenge of how to replicate these actions. If successful, the blossoms represent the outcome that produce new seeds (that are replicated), with the dotted lines representing invisible processes and new resources, processes or outcomes that either provide pollen, fruit or seeds. Pollen is shared and stimulates and fertilizes other processes/contexts, fruit are resources, methods, new insights, skills, networks that can provide needed nourishment to other projects/contexts, and finally seeds can be stored, and contain with them the ‘genetic’ history/narrative of the process, learning and the outcomes.

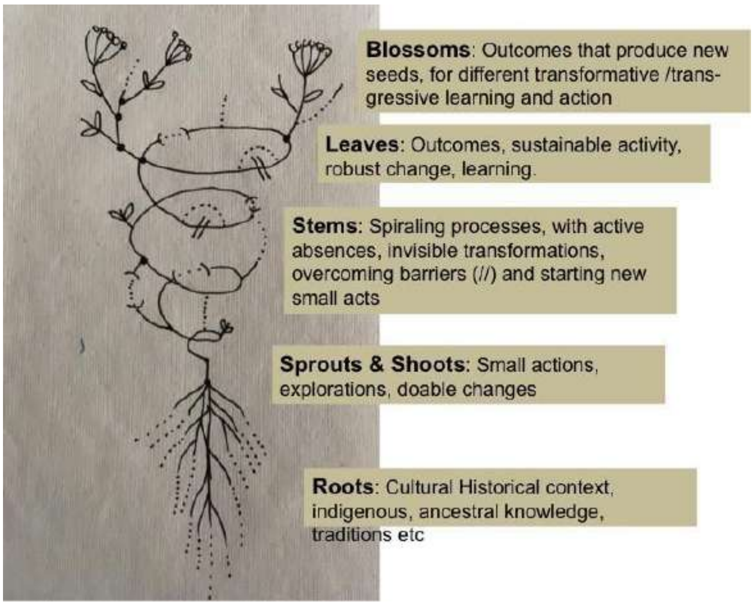

Figure 1. *Spiral of change. Developed by Martha Chaves, Dylan McGarry, Heila Lotz-Sisitka and Gibson Mphepo during the T-Learning workshop in New Delhi, India, November 2016.*

2.4. Tools for promoting change

Method deals with how the researcher goes about collecting the information which constructs knowledge. Methods in PAR are based on negotiating the three interconnected areas of: *participatory* life in society, *action* through experience, and *research* through mind and knowledge construction (see figure 2 below). In this respect, knowledge co-production is an important aspect of the Colombian T-Learning project which involves a transdisciplinary research team based on employing co-researchers from the studies communities. Co-researching are participating in the communities they themselves live in, experiencing directly the realities they are researching, while employing a critical research oriented perspective. Employing such co-researchers has proven to be useful in involving the community in the research project, thus generating knowledge which is more relevant to the community itself (Chaves et al., 2015).

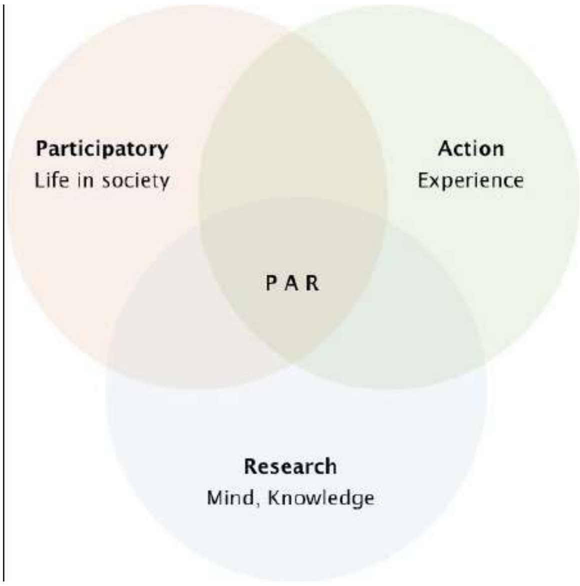

Figure 2*. Diagram of Participatory Action Research. Taken from Chevalier and Buckles (2013).*

Ethnographic methods will be the predominant means of collecting information. Participant observation is being employed during CASA network events, as well as by co-researchers in their respective communities. This includes conducting semi-structured interviews with community members as well as participants to the transition labs held in each community. An important aspect is that of reflection by all researchers, in what Tedlock describes as 'observation of participation', in which ethnographers "both experience and observe their own and others' coparticipation within the ethnographic encounter." (2011, p. 69). Such reflexive attention will also manifest itself in narrative methods of autoethnography, whereby researchers explore their own assumptions and constructed realities, and how these influence the research project (Spry, 2001).

3. Results

This section will describe the results of Colombian case study so far. Section 3.1. will start by presenting the initial mapping of initiatives undertaken in this study, and the steps of co-designing the Colombian T-Learning study. Section 3.2 will describe the experiences of the first T-labs held by two of the regional initiatives. Section 3.3. will present the results of the possible indicators for evaluating these transgressive spaces.

3.1. Mapping of initiatives

Research methods began with the participatory mapping of initiatives participating in the CASA gathering *The Call of the Mountain* in the community of *Anaconda del Sur*, in July of 2016. Fifty-two (52) representatives of initiatives filled out small forms providing contact information and the focus of their initiative. These forms were taped to a large map of Colombia providing a visual representation of the location of initiatives. With this information, the Colombian T-Learning team convened during the event and discussed the different initiatives, identifying twelve (12) initiatives which had a special focus on learning-based change, and which were considered potentially transgressive in nature. These initiatives were interviewed (and recorded with audio and/or video) with semi-structured questions related to the the activities of their initiative, and their understanding of learning and transformation.

Findings have shown the presence of a diverse set of (mostly) informal learning networks anchored in grassroots communities throughout Colombia. Addressing socio-ecological challenges such as Indigenous rights, water and food sovereignty, and the deleterious impacts of mega-mining, these initiatives share a strong focus on education and learning, expressed through challenging traditional educational models and practices through action-based projects. With the CASA gathering *The Call of the Mountain* acting as national T-lab, three initiatives were thereby chosen to participate in the project (see table 1 below for the details of the elected initiatives).

The next stage of the research was to co-design the vision, goals and roadmap for putting in place transgressive learning in community-based initiatives in Colombia. This was realised through a group-building workshop held in the Indigenous community of Atánquez, in Northern Colombia, between 20-24 January 2017 (see Macintyre, 2017). Through exercises employing the facilitation tools of Sociocracy - a decision-making and governance method (see Buck & Endenberg, 2010) and Dragon Dreaming - a collaborative tool for envisioning futures (see Croft, 2014), the group recognised its niche capacities in intercultural community-based learning, based on participation in grassroots social movements, and practical projects working towards social change. Recognising the need for upscaling these processes, the Colombian T-Learning group decided to work towards constructing a pedagogical T-Learning program based on its own community resources and needs - with material generated through T-labs in these communities. The long-term goal is to share these experiences through an online educational program offered by higher-learning institutions, whereby contextualized community learning experiences can be shared with students in higher learning.

Name of initiative	**Location**	**Description**	**Focus**	**Methods used**
El Llamado de la Montaña (The Call of the Mountain) https://xn--llamadodelamontaa-uxb.org/	Held in a host community that changes every year.	A yearly gathering bringing together around 400 people from grassroots communities and initiatives from all over Colombia and abroad	Generation of sustainable settlements	A methodology called 'vision councils' in which participatory, inter-generation learning is promoted in various sustainability topics. (see Chaves et al., 2017b)
Ecovillage Aldeafeliz (aldeafeliz.com/)	San Francisco, Cundinamarca	An intentional ecovillage focussed on promoting sustainable settlements, alternative education, and agro-ecology.	Water sovereignty Agro-ecology Non-violent communication	Ancestral practices such as offerings to Mother Earth, combined with facilitation methods of Sociocracy (Buck & Endenberg, 2010)
Centro Experimental para la Sustentabilidad (UBUNTU)	Isla del Rosario, Bolivar	A center based in the afro-Colombian community of Isla del Rosario. This center will hold workshops into 'Designing sustainable communities for peace'	Indigenous/afro rights Sustainable settlements	Methods based on Ecovillage Design Education (EDE), with a focus on combining appropriate technologies with traditional knowledge systems.

Nuh Jay: Corporacion art and social innovation (nuhjay.wordpress.com)	Pasto, Nariño	An organisation specialising in collaborative methodologies with an emphasis on social innovation for children, youth and adults.	Water sovereignty Women's rights Youth empowerment	Dragon Dreaming Art of hosting

Table 1. *Name and details of initiatives participating in Colombian T-Learning case study*

Section 3.2 Experiences from first T-labs held by two of the regional initiatives.

The next stage in the Colombian T-Learning project was to hold T-labs in the participating initiatives. The rationale is to reflexively develop the transgressive methodology from the experiences of the T-labs. This section will therefore present two of the initiatives that have held T-labs, and explore how their experiences can have develop the Colombian case study.

Corporacion Nuh Jay and the project MinkaYaku

Led by the Corporacion Nuh Jay (see table 1 above), in collaboration with other organisations, the project *MinkaYaku* is a social laboratory focused on the integral management of water in the region Panamazónica, where the Pacific, the Andes and the Amazon region converge, in the department of Nariño. The goal of the set of five (5) T-labs is to contribute to transforming beliefs and practices around the culture of water useage - away from current wasteful practices towards a culture of care and conservation. This is being realised through empowering youth (between the ages of 18 and 35) to think systemically through collaborative actions, innovative design of agroecological systems, and capacitation in non-violent communication across cultures and institutions. Through a *dialogo de saberes* (knowledge dialogue) *MinkaYaku* invites the four sectors of public, private, academic and society civil society to join together to become 'waterpreneurs' and through ancestral practices, and art and social innovation, to influence public policy in the department of Nariño, towards more responsible use of water.

With two T-Labs having been completed, certain successes and challenges have emerged in the project *MinkaYaku*. Tania Laisuna, T-Learning representative in the corporacion Nuh Jay, noted a successful aspect of the T-lab was the methodology and facilitation of the *dialogo de saberes*, whereby participants reported surprise and appreciation at being able to work on water issues outside the normal, institutionalised settings of the office. Through employing methods from the arts - such as singing and playing music - and having deep conversations in themes that people normally do not talk about - such as the rights of *Pachamama* (Mother Earth) - a feeling of cooperation was generated. Such spaces demonstrated elements of vulnerability, where participants cried and expressed anger. Expressing emotions in a 'safe space,' participants expressed, is something which is not provided by formal structures.

Figure 3*. Dances of Universal peace with participants in T-lab.*

The challenges faced so far has to do with the number of participants, funding, and time. Although the first T-labs demonstrated a diversity of participants, the numbers were lower than hoped for. Working on the margins of mainstream institutional projects also means difficulties in obtaining funding for workshops. Many institutions pledged economic and presential support, had their logos added to the workshop fliers, but representatives did not show up and neither did the money. Lastly, as part of a bigger event, the workshops only had a duration of two hours. This proved too little time to go into depth and create a reflexive process amongst participants.

The ecovillage Aldeafeliz,

Located one hour from the capital of Bogota, *Aldeafeliz* is an intentional community based on ecological values and living in community. The community is basing its T-labs on a similar methodology of *dialogo de saberes* (knowledge dialogues), which is manifested in the space of the communities traditional ceremonial house. The community understand this ceremonial house to be a *Casa de pensamiento* (House of thought), which brings together different ways of being in the world - both human and non-human.[2] The first T-lab was held in the *Casa de pensamiento*, bringing together residents, neighbours, representatives from the municipality, and Indigenous elders to generate *dialogos de saberes* around the issues of water in the municipality and region. The goal was to generate a conversation between the different stakeholders, with further T-labs working towards political incidence through influencing public policies on water.

As noted by T-Learning representative of *Aldeafeliz,* Tatiana Monroy, the T-lab was an overall success. The communication of the workshop was well disseminated in the municipality, with representatives from the municipality participating in some of the activities, and a number of close neighbours brought friends demonstrating a growing interest in the topic and the work of the community *Aldeafeliz*. The *olla comun* (pot-luck) was a particular success, with Tatiana Monroy noting how " food is fundamental to the fabric of the community. It generates a closeness between us because we all eat - from the peasant to the

[2] See Macintyre *et al* (2017) for a practical educational example of the methodology of the *Casa de pensamiento.*

mayor" (personal communication, translated from Spanish).

Figure 4*. The* olla comun *(pot-luck). Each participant brings food which is prepared and consumed together around the fire.*

The challenges to the T-lab were centered around difficulties of logistics and participation in the more 'heart' spaces during the T-lab. The initial activity was to hold a *mambeo* (ceremonial conversation around the fire) in which Indigenous elders were invited to share their wisdom and words, about the relations of the territory. The elders did not show, however, and so this activity was not held. The other aspect was the method of the *pagamento* (offering) involving a ceremony directed to *Pachamama* (Mother Earth). Despite managing to convene municipal representatives to the workshop, the representatives did not participate in the *pagamento*, which Tatiana Monroy noted was probably due to the activity being too strange for the representatives.

Section 3.3. Possible indicators for evaluating transgressive spaces.

Indicators are means of measuring changes over time, and the success of sustainability oriented initiatives are often measured by the realization of project goals and outcomes. Dlouhá et al (2013) note, however, such measures often ignore effectiveness from a learning point of view. The authors put forward a framework of indicators which moves away from an *individualist* focus on education, towards more *social* learning, where interaction between participants and the social environment generates the need for negotiation, and where a common solution is reached. Dlouhá et al. (2013) build on the work of Wals (2007b) to identify four indicator themes from which to research: 1) *Communication*, which is a pre-condition for social learning so as to develop a shared understanding of the issue at hand; 2) *cooperation*, a collaborative approach which might reveal tension between consensus or dissensus, and where a diversity of stakeholders can provide multiple perspectives in an inclusive environment (Brouwer et al., 2016); 3) *action*, a shared challenge is collectively addressed through a specific actions; and 4) *reflection*, where participants evaluate their own actions and draw conclusions on personal and collective transformations.

Through conversations with Tatiana Monroy and Tania Laisuna concerning their completed T-labs, as well as with other members of the Colombian T-Learning Team, certain aspects are appearing in terms of indicating change and learning. The following are the markers, or flags we can use as indicators which herald potentially transgressive changes, and are placed in the four social learning aspects mentioned above (based on Dlouhá et al. (2013). The following indicators are in their early stages of development, and have not been given numerical numbers, but provide

1) Cooperation.

Number of actors: From a quantitative point of view, a clear sign that change is occurring is when the number of people who participate in the T-labs increase. This was the case with *Aldeafeliz* through the increasing number of neighbours who came to participate demonstrating an increase interest, or an increase in trust or recognition of the work the community is carrying out.

Diversity of stakeholders: Another factor is the diversity of sectors of society. Intercultural workshops rely on participation from people of diverse backgrounds and beliefs to generate *dialogos de saberes*. If we take the four aspects of the multi-stakeholder partnerships outlines in Brower et al. (2016) - business, civil society, science and government - this provides a rough categorisation of different stakeholders, which could be counted and given a numerical measurement. It would be interesting to think about how other actors such as Indigenous elders and peasant farmers would fit into such groups.

2) Communication forms

Forms of communication: Creating a shared purpose is vital for garnering collective participation, and different forms of communication are needed. These include visual material such as videos, verbal communication through word-of mouth, and face-to-face conversations.

3) Action

Capacity building: Problem solving and the development of new skills are obvious examples of learning. Yet what came out as a strong factor in the above T-labs was empathy - paraphrasing Tatiana Monroy: the ability to to see what we do not like around us in ourselves, to see the factory farm in ourselves helps us to make changes. The other important skill is that of empowerment through participatory leadership. As Tatiana Monroy notes, the T-lab provides a facilitated space for deep conversations and the opportunity for all voices to be heard. But it is up to the participants themselves to enact changes in their own circle of life. These new changes - representing the new seeds of the spiral - represent a strong indicator of change. The number of learning realized (e.g. empathetic learning) can be measured.

Number of learning approaches: The types of action carried out depend on the learning approaches used. Such approaches include online learning, collaborative learning, practically-oriented learning, theoretically-oriented learning, intercultural learning, intergenerational learning, and project-oriented learning. The number of learning approaches can be measured.

4) Reflection

Subjective personal transformation: The ability for participants to question who they are and the assumptions, for example, of reframing modern narrative on what it means to live a 'good life'. Important for this are the “Ah-Ha!” moments – signs of reflexivity - where participants gain insights into our own belief systems and those of others. Such transformations can be elicited through questionnaires and/or interviews with participants after T-labs to question these potential changes. These reflections can be measured through a survey as well as semi-structured questionnaires, and analysed using loops of learning (Chaves et al. 2015).

Recognising Invisible changes or absences: Invisible changes refers to feeling something unspoken, new or not there. What is not being said? Who is not present? What are the power relations governing these spaces? For both T-labs, the institutional participation was minimal, while at the same time some participants stated that they did not believe change could happen through the institutions of the municipality. Yet from the position of *Aldeafeliz* there is a recognition that it is vital to work together with the municipality to enact changes at the level of the territory. There is a lack of literature into how to measure this type of reflection.

4. Discussion and conclusion

The role of science in society is increasingly being questioned as new 'wicked' challenges of sustainability emerge. With a supposed climate-change sceptic holding the top office in the United states of America, and peer-reviewed, evidence based science under attack in a 'post-truth' world (Norman, 2016), it is clear that the scientific community needs to question its role in providing relevant, inclusive and transformational knowledge to society.

The Colombian T-Learning project is attempting this through Participatory Action Research (PAR) whereby co-researchers from studied communities have been invited, and are actively investigating learning processes taking place in their own communities. This participatory focus is contributing to collaborative knowledge construction as a means to make knowledge more relevant to the community itself. Yet as Klocker (2015) notes, PAR can be a very emotional experience, putting a lot of responsibility on the PAR team leader, with Maguire (1993) also pointing out the challenges in terms of workload and funding. To an extent this has been true; working with co-researchers is logistically difficult in terms of coordinating all the activities taking place, developing common investigative methods, finding funding, as well as the blurred boundaries between researcher and research subject. However, an interesting development in the project is how the community initiatives themselves are taking the lead in developing and designing their own T-labs, and searching for funding. This truly gives the project a collaborative feel, and provides important inputs for developing a shared methodology.

The two major challenges currently facing the project is understanding what transgressive learning really is, and developing indicators for its evaluation and monitoring. As listed in figure 1 above, transgressive learning has certain characteristics such as being a transformative form of learning dealing with changes in beliefs and habits through an encounters with multiple forms of knowledge (epistemology) and ways of being (ontology). An important aspect of transgressive learning is the appreciation that simply being exposed to other ways of seeing the world is not enough: in a 'post truth' world one has to experience and reflect on other ways of being in the world to truly transform. This is supported in both T-labs above, with a special focus on the role of empathy in bringing about personal transformation. It is much less clear, however, in what ways such personal transformation can lead to more structural change. It is suggested that this can be done through including institutions to the workshops and work towards inclusive partnerships. However, in both T-labs, institutions proved difficult to include. This could be because of the radical difference between spaces such as the *Casa de pensamiento* and institutional spaces. With transgressive learning positioning itself as a disruptive approach to transgressing unsustainability norms in society, further research needs to be carried out into what Wals (2011) describes as situated and personal 'optimal dissonance' which represents the important balance between conflict and dissonance in social learning, and people's comfort zones or dissonance thresholds.

In terms of developing indicators, the two T-labs have identified certain aspects which indicate change and transformation. In addition to quantifying the number of participants attending, and their respective spheres in society (business, science, government and civil society), work needs to be carried out in terms of developing learning indicators which can measure subjective transformation, especially in designing frameworks for empathy (see Kouprie & Visser, 2009). Another important indicator to develop is the enactment of individuals who consider themselves empowered during the T-labs. This could be accomplished to following up on participants in their own communities and exploring changes that have been made.

To conclude, what this paper contends is that community-based initiatives have the potential to provide characteristics of relevant, inclusive and transformational learning through facilitated learning spaces which focus on *dialogos de saberes* (knowledge dialogues). Such spaces are place-based in that they involve actors from the region of the challenges being addressed, but also critically question the roots of the status quo. Such a 'critical pedagogy of place' (Gruenewald, 2003) decolonization of knowledge through including voices normally not heard in traditional academia or institutional settings, as well as a 'reinhabitation,' emphasising local lived experiences connected to the place where people actually live. Such skills and competences are normally not found in institutionalized higher learning, and there therefore a vital role for the Colombian T-Learning project to contribute collaborative and action-based experiences to higher-learning. However, much work remains in developing a methodological framework for transgressive learning, and elaborating indicators which can track changes which transgress current unsustainability practices in society.

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Is the target for in-land conservation suggested by the convention on biological diversity adequate for Colombia?

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Abstract

The persistence of the biota is a fundamental element of sustainable development; it is impossible for us to survive without other species. Natural parks or reserves are fundamental pillars of any conservation strategy. They prevent the complete conversion of natural ecosystems and, in that way, provide intact habitats for wildlife. However, if conservation areas are not selected rigorously, gaps may lead to a species extinction. To be effective, reserves must include viable populations of all the species present in the territory as well as all the ecosystem components and processes that species may require in order to survive and persist. Guaranteeing minimum areas is important as well because of their impact on the size of populations. The Convention on Biological Diversity (CBD) suggested a minimum extent of 17% of in-land ecosystems to be protected and 10% of marine areas. Nevertheless, it did not explain how to achieve these targets. Do these values represent the minimum extent for each ecosystem type? Establishing a general target like this might over or underestimate the real level of conservation needed for each type of ecosystem. Perhaps these values are just meant to be the result of a portfolio of conservation areas selected by applying other targets. In this article, targets are calculated for all in-land ecosystems of Colombia, a gap analysis is done and two portfolios of priorities for conservation are constructed using FOCALIZE: a decision support system that selects groups of spatially related ecosystems using minimum targets calculated based on the requirements of umbrella species. The first scenario considered the existing national parks whereas the second did not include them starting the selection from a hypothetical situation where no parks existed. The results highlight the importance of using effective selection methods including science-based minimum targets. Although the 17% of the in-land territory of Colombia could have been enough to reach the correct size of conservation areas and to cover all the variety of in-land ecosystems, the national parks selected in an *ad hoc* manner in the past overrepresented some ecosystems and added more area than necessary. Now this political target is not enough.

Keywords: Conservation planning, FOCALIZE, minimum targets, political targets.

1. Introduction

Since the 1970s, biologists, ecologists and other scientists have tried to find ways to select effective protected areas. Many methods were proposed to do so using either ranking procedures; for example the works of Ratcliffe (1971), Tans (1974), Gehlbach (1975) and Wright (1977), or systematic conservation planning starting with Kirkpatrick´s first selection algorithm (Kirkpatrick 1983) and following with many other outstanding contributions

(McDonnell *et al.* 1994, Noss and Cooperrider 1994, Cowling *et al.* 1999, Pressey 1999, Margules and Pressey 2000).

The minimum size of the reserves has been present in these discussions from the beginning by its effect on the size of the populations (Wilcox 1984, Soulé 1991, Burgman and Possingham 2000) but, in most cases, its application to reserves selection has been limited to a sort of arbitrary target. This is the case of the Convention on Biological Diversity signed in Río de Janeiro in 1992. It proposed that 17% of the continental area and 10% of the marine zones of the signatory countries should be assigned to biological conservation increasing in that way the representativeness of ecosystems in protected areas. But the Convention did not explain how to achieve this goal. Is this value the extension of a portfolio of new conservation areas selected using other targets or, on the contrary, does it pretend to be a general target applied to all ecosystems in the same way? For some countries and ecosystems such values may be too high and for other, too low.

In this article, I assess the sufficiency of the CBD target (17%) for the in-land part of Colombia. It is very important to do this. Policy makers will accept this political target without questioning its effectiveness. How can so many experts attending the Convention be wrong? They won´t realize the difference between a political target and a scientific-based target. The fact is that the CBD opens a unique opportunity to do things well and we, conservation scientist, should use it with responsibility.

I here start with a gap analysis. Then I evaluate the sufficiency of the 17% target for the in-land ecosystems of Colombia. I do so executing two simple exercises: I calculate the Minimum Representativeness (MR) values for all ecosystems to compare them with the CBD target and present two portfolios of priorities for conservation (new parks needed) comparing their total extent with that of the in-land part of the country to determine whether is more than 17% or less. The first scenario includes the current national parks in the calculations; the second, does not.

The current situation: gap analysis

The Colombian inland-area´s extent is 1,140,433.53 km^2. It contains 333 in-land ecosystem types (Fandiño-Lozano and Wijngaarden 2005). At present there are 59 national parks, 55 of which contain in-land ecosystems. The total area of the national parks is 129,708.36 km^2 equivalent to 11.4% of the territory.

In the middle of the last decade, the ecosystems were mapped at a scale of 1:100,000 (Wijngaarden and Fandiño-Lozano 2005). On that base, a gap analysis was made crossing the ecosystem and the park maps to obtain the representativeness values (Fandiño-Lozano and Wijngaarden 2005) expressed as the percentage protected in relation to the original extent of each ecosystem. At that time about half of the ecosystem types were completely out of the national parks. Now it is slightly less, but the situation is still shocking (table 1).

Table 1. Number of ecosystems per representativeness classes.

Representativeness	Ecosystems	
%	number	%
0.0	137	41.1
0.0 - 2.0	49	14.7
2.0 - 5.0	21	6.3
5.0 - 10.0	15	4.5
10.0 - 17.0	12	3.6
17.0 - 30.0	31	9.3
30.0 - 50.0	30	9.0
50.0 - 99.9	33	9.9
100.0	5	1.5
Total	**333**	**100.0**

41.1% of the ecosystem types continue to be excluded from the parks system and many other show very small values of representativeness.

2. Methods

I used the Software FOCALIZE to build the two scenarios. This is a park planning tool developed as a heuristic algorithm on the following reasoning (Fandiño-Lozano 1996, Fandiño-Lozano and Wijngaarden 2012).

What to conserve?

Selecting reserves based on target species is very time consuming and impossible to achieve in a reasonable time; moreover, in very biodiverse countries which are often poorly described. Instead, the use of land-surrogates is more efficient capturing many species in the reserves without having to study them one by one. Even better may be to use groups of spatially related ecosystems as a sort of extended land-surrogate. Grouping ecosystems to be included together in conservation areas, would provide better habitats to wildlife. I used the *chorological type* concept to denote this broad habitat unit (Fandiño-Lozano 1996). The term chorological comes from landscape ecology referring to those patterns and processes that involve more than a single landscape unit (Zonneveld 1988). The ecosystems are assigned to the chorological types using the boundary length in cluster or indirect gradient analyses (Wijngaarden and Fandiño-Lozano 2005).

How much to conserve of each ecosystem?

To provide complete habitats, chorological types should maintain in the parks the original proportions between the ecosystems. That balance may have an impact on survival and population numbers. For the same reason, each ecosystem should have a minimum size or minimum representativeness (MR). Umbrella species can be used as a biological surrogate to calculate the MR because if a viable population of one or more umbrella species (large carnivores or herbivores) can survive in a group of ecosystems, each having a carrying capacity for the umbrella species and a minimum area, it is likely that the smaller species, demanding less area, will survive too. This can be written as follows:

$MVP = cc_1 * area_1 + cc_2 * area_2 +...+ cc_i * area_i$

MVP=minimum viable population of the umbrella species

cc_i = carrying capacity of ecosystem i

$area_i$ = minimum area of ecosystem i needed

Details of this expression are available in previous publications (Fandiño-Lozano and Wijngaarden 2003, 2005, 2012).

The MVP can be estimated by any method depending on the information available. The carrying capacities can be also calculated for all ecosystems, even for those where the umbrella species considered do not occur. The minimum area of each ecosystem remains the unknown variable. But since the proportions between the ecosystems belonging to a chorological type are known, the area of one ecosystem can be expressed in the area of another (e.g. the area of ecosystem b is 2 times the area of the ecosystem a). Then, replacing those equivalencies the equation can be solved to find the minimum area of one ecosystem. The equivalencies are then used again to find the minimum area of the other ecosystems belonging to a same chorological type. This, given the reason stated above: the proportion between the ecosystems of a chorological type should remain in the conservation area as it was in the original landscape.

For the in-land part of Colombia, *Panthera onca* and *Puma concolor* were used as umbrella species. In those cases in which the two species occur in the same territory, the minimum areas were added because these large carnivores may compete for preys.

Where to start the selection of new reserves?

Following the logic of the land-surrogate used, the selection starts as close as possible to the center of the chorological types which would act as a preselected unit (cell) to maximize compactness. It is reasonable to start the selection in natural areas, following with fragmented or, even, with transformed ones in order to restore them when needed to reach the targets. Social variables can be used too as preferences either positive (e.g. a forest which conservation is needed anyway to regulate water) or negative (e.g. a highly populated area used intensively in agriculture). These preferences are similar to the cost function built in MARXAN (Ball *et al.* 2009). In this assessment I didn't use this option because the purpose is just to show simple results to be compared with the 17% CBD target.

3. Results

The minimum representativeness varied a lot (table 2); from 1.1 - 100% of the original extent of the ecosystems and for 55 of them, equivalent to 16.5%, is higher than 17%.

Table 2. Targets in % of the original extension of the ecosystems.

Target	Ecosystems	
%	number	%
1.1 - 2.0	36	10.8
2.0 - 5.0	83	24.9
5.0 - 10.0	82	24.6
10.0 - 17.0	77	23.1
17.0 - 30.0	25	7.5
30.0 - 50.0	14	4.2
50.0 - 99.9	13	3.9
100.00	3	0.9
Total	**333**	**100.0**

These results add relevant information to the gap analysis for the current national parks. Not only is it relevant to know which ecosystems or how many of them are in or out, but to find out if they may be too small to provide proper habitat (table 3). That can be determined by comparing the area currently protected with the MR per ecosystem.

Table 3. Achievement (in % of the MR) of the ecosystems in the current national parks.

Achievement	Ecosystems	
%	number	%
0.00	137	41.1
0.0 - 10.0	40	12.0
10.0 - 50.0	32	9.6
50.0 - 100.0	19	5.7
100.0 - 200.0	22	6.6
200.0 - 500.0	48	14.4
500.0 - 1000	19	5.7
> 1000.0	16	4.8
Total	**333**	**100.0**

Only 31.5% of the ecosystems have already large enough extension in the national parks to reach the MR target calculated based on *Puma* and *Panthera*. On the contrary, some are overrepresented. 4.8% or 16 ecosystems reach a value of more than 1000 which means an over-representation of 10 times the minimum target.

Portfolios and total area selected

In the first portfolio, including the existing National Parks, 23.5% of the inland territory of Colombia, equivalent to 268,196 km^2 was selected which means doubling the area of the system at present (figure 1).

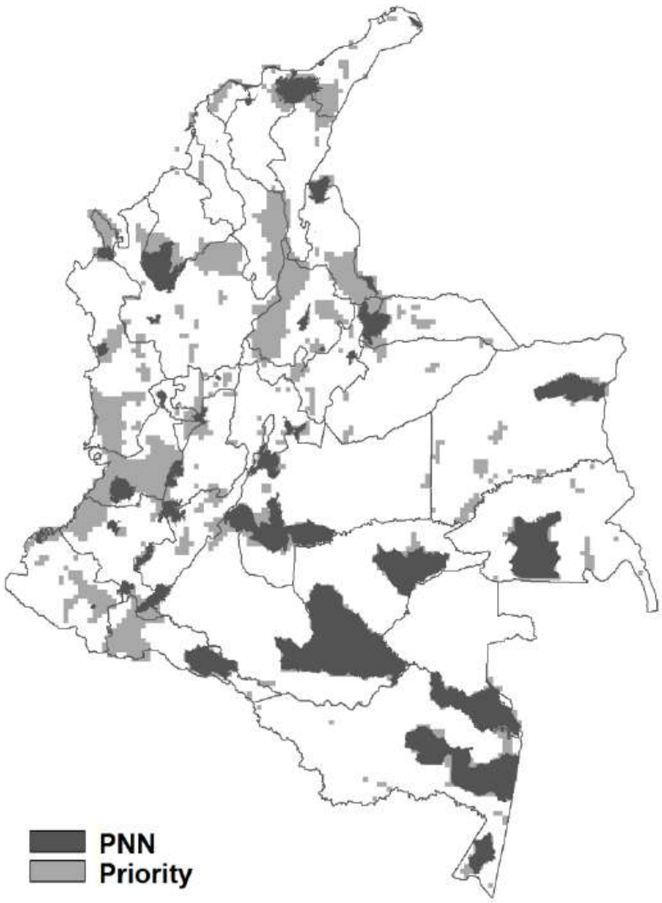

Figure 1. Current national parks (PNN) and additional priorities for conservation.

In the second portfolio, obtained without considering the current system of national parks, only 14.9% of the inland territory, equal to 169,663 km^2, was selected as priority for conservation (figure 2). The difference is huge.

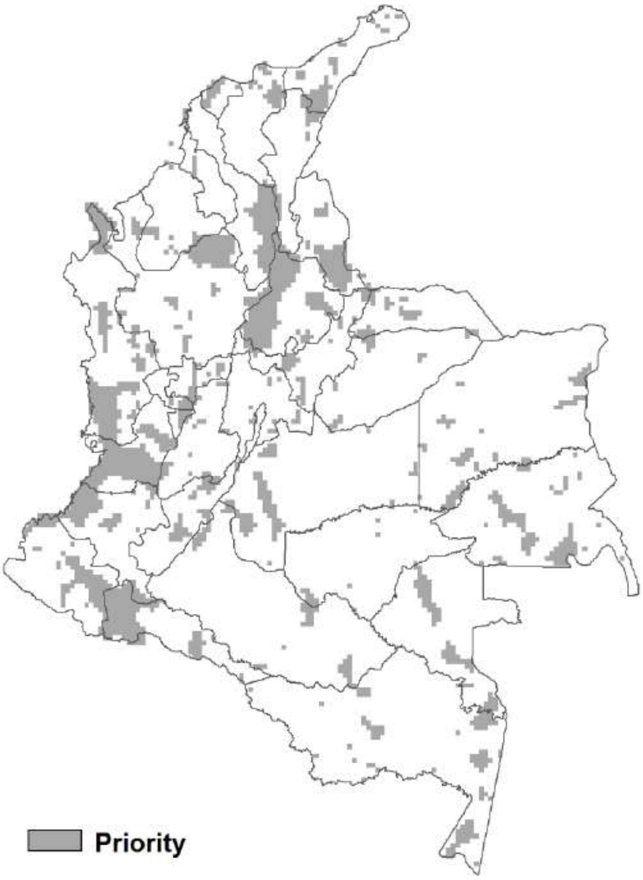

Figure 2. Priorities for conservation without existing national parks.

When considering the current national parks, the CBD political target won´t be enough for Colombia. What I would recommend is to set the missing conservation areas based on an overlay of the national parks as they are now with the portfolio built from scratch in a way that the areas selected add what is missing without the effect of the current parks during the selection process. They actually act as preselected cells altering the selection around the center of the chorological type.

4. Discussion

This simple exercise shows how important it is to deal with minimum targets carefully. Good information, valid methods and proper techniques are needed to come to a result in which all the variety of living forms in nature get properly protected. The approach used in this analysis makes the broad habitat concept operative in conservation planning. At the same time, it offers a method to calculate minimum targets with scientific meaning. This is what makes the results interesting and useful for decision making.

The 17% of the in-land extent should be kept in mind, no doubt, but simply to gear the effort of nations in one globally accepted direction and to show their achievements in the coming meetings of the CBD. That is, in my view, the main value of the political targets.

For the case analyzed, the over cost emerging from the *ad hoc* decisions made in the past is evident (Pressey 1994). Instead of 14.9%, we now need 23.5% of the in-land portion of the country. This without counting other types of conservation areas that will be strategic for the protection of target species, or for providing humans with resources and services. Corridors and buffer zones will add even more area to the system. So a lot of scientific work and political effort is still coming. That is why it is essential not to err while selecting the priorities for conservation. Once the 17% target is reached, to recommend too many new parks will become unrealistic.

If the results presented here are not convincing, a constructive debate is welcome. Many details of the method and data were omitted because they are available in previous publications. I am aware of some refinements that would improve the results. For instance, the carrying capacity of the ecosystems was calculated here based on food requirements of the two carnivore umbrella species. It would be better to include also variables such as territorialism and other uses of the habitat. Regarding the minimum viable population, a lot of work has to be done in genetics and in ecology.

But given the state of the art, these results give a good insight to deal with the process of setting new areas in Colombia and to give the CBD target the right place in the process till the park system is complete.

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Biodiversity Offsets: case studies in Limestone Mining Sector in Brazil

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Abstract

Biodiversity is responsible for maintaining benefits that society obtains from ecosystems. Economic activities such as mining often cause loss and fragmentation of habitat, with consequences for the functioning of ecosystems. In response to the increasing loss of native vegetation and biodiversity, a growing number of countries have adopted "offsetting" policies that seek to balance local habitat destruction by restoring, enhancing and/or protecting. In this context, biodiversity offset is a mechanism that counteracts adverse effects of projects, and is applied to adverse effects that can not be avoided by applying the mitigation hierarchy, as recommended by guidelines such as IFC's Environmental and Social Performance Standards. Although the offset is already a consolidated instrument in the environmental licensing process in Brazil and in other countries, there are questions about the effectiveness of the compensatory measures regarding the ability to offset the losses in terms of biodiversity. Looking to analyse whether the compensation practiced in Brazil is able to compensate losses of biodiversity, three offset projects practiced by limestone mining enterprises, located in Atlantic Forest, Southeast of Brazil. The projects are discussed in the light of international recommendations for biodiversity offset to verify the possible adherence or to identify gaps regarding the international principles and recommendations of good practices in biodiversity offset. Results suggests that, although Brazilian offset is focused on protection, replacement and restoration of affected habitat, there is some equivalency between compensation and international recommendations for biodiversity offsets. However, improvements are needed in terms of stakeholder participation in offsets design, which could result in gains for the affected beneficiaries of ecosystem services, which were impacted negatively by the project. The results of the research indicate that the offset practiced by the analysed cases do not guarantee the biodiversity loss, because focus only on government determinations, lack of consideration of species richness or monitoring of biodiversity practices.

Keywords: biodiversity, offset, Atlantic Forest, limestone mines.

1. Introduction

Activities with high potential for negative impacts inevitably lead to loss of ecosystem capacity to provide benefits to society, so-called ecosystem services (Alcamo, 2003). The mining sector has the potential to affect biodiversity through the life cycle of a project. Direct impacts may result, for example, from the suppression of vegetation and water bodies, causing and / or propelling activities of habitat loss and fragmentation. The potential for these impacts is greatest when mining occurs in remote areas, as mineral resources can be found in sites of conservation importance, often making habitat suppression unavoidable.

Considering the impact of engineering projects under biodiversity, the evaluation of these impacts has been incorporated as a requirement of the IFC's Socio-Environmental Performance Standards, expressed by the Equator Principles, which deals with Biodiversity Conservation and Sustainable Management of Living Resources (IFC, 2012). Equator Principles is a project finance mechanism that prioritizes standards of sustainability standards and procedures, in line with the guidelines of IFC, the World Bank's financial arm.

The Performance Standard (PS6) states that customers "should seek to avoid impacts on biodiversity and ecosystem services. When impacts can not be avoided, measures should be implemented to minimize impacts and restore biodiversity and ecosystem services."

In addition to the requirements of these funding agencies, a growing number of countries have adopted "compensation" policies that seek to balance the suppression of local habitat, restore, improve and / or protect habitats in response to increasing loss of native vegetation and biodiversity (GORDON et al, 2011). The legal framework of many countries, including the Brazilian, establishes that ventures that generate significant environmental impact must offset for the damages caused (TEN KATE et al, 2004; GORDON et al, 2011; MORANDEAU et al, 2012).

In this perspective, biodiversity compensation is defined as “practices that trigger measurable outcomes in terms of biodiversity conservation, actions to offset negative residual impacts from development plans or projects, after prevention and mitigation measures have been taken” (BBOP, 2012).

Biodiversity offsets aim to ensure that negative environmental impacts are counterbalanced by environmental gains, with the overall objective of achieving a neutral net result or positive outcome (TEN KATE 2004; MCKENNEY, 2005). The basic approach to the concept of compensation is to quantify the losses of biodiversity caused even after the implementation of measures to reduce impacts (according to the concept of mitigation hierarchy) and then to assess the benefits to biodiversity resulting from compensatory activities.

According to the concept of a mitigation hierarchy, in the assessment of project impacts, entrepreneurs must adopt measures to eliminate, reduce or repair their adverse environmental impacts in this order of preference. However, certain impacts whose mitigation is insufficient or even impossible, called residual impacts, should be offset. Among the environmental impacts considered "non-mitigable", many are related to the loss of biodiversity and ecosystem services, for which compensation measures can be taken.

Biodiversity compensation measures aim to neutralize biodiversity losses through initiatives to avoid, restore or restore habitat. Thus, it is agreed to formulate the objectives of biodiversity compensation programs in terms of achieving "net loss" or, ideally, "net gain" (BBOP, 2012a), in which case biodiversity actions more than counterbalance the inevitable losses and result in a positive balance over time.

It should be noted that the objective of the net loss is conceptualized and implemented within the mitigation hierarchy. No previous application of the hierarchy, conservation actions would not qualify as offsets in most definitions of the term (ICMM, 2013).

Despite the fact that offset is already a consolidated instrument in the environmental licensing process in Brazil and in other countries, there are questions about the effectiveness of the compensatory measures in relation to the capacity to actually counterbalance losses in terms of biodiversity (TEN KATE et al., 2004; GORDON Et al., 2011; MORANDEAU et al, 2012).

The hypotheses, approaches, and methods of calculating biodiversity compensation offsets have been controversial (BULL, 2013) although it is suggested that the introduction of offsets has prevented biodiversity loss. (GIBBON, 2010). Much controversy surrounds the notion that biodiversity loss will be accepted in return for uncertain gains. Maron *et al* (2012) propose that current political expectations of restoration to achieve ecological equivalence are often not supported by evidence and that compensation policies that depend on ecological restoration are problematic.

In this scenario, the present study investigated whether the compensations for biodiversity loss or offset practiced in the mining sector in Brazil, in the Atlantic forest area, are to the point of counterbalancing the losses arising from the implementation of these projects or generating net gains for biodiversity.

2. Methods

The research was based on case studies conducted in limestone mines, chosen intentionally based on the following criteria: (i) location in the Atlantic Forest, (ii) availability and access to documents, data and information and (iii) access to areas, with preference being given to more recent cases for allegedly representing the most current practices.

The Atlantic Forest, the study area of the present research, is the Brazilian biome that occupies a large part of the Brazilian coastal region, in an area of approximately 100,000 square kilometres (Myers et al., 2000, Galindo-Leal & Câmara, 2005). This biome was chosen because, unlike other Brazilian biomes, legislation explicitly requires the application of the mitigation hierarchy and establishes guidelines for compensation.

The research was structured in steps (Figure 1), the first one aimed at identifying the types of offset to which the mining enterprises in Brazil are subject, comparing them with the international recommendations for biodiversity offset. In the results, regulatory differences were identified, thus, the analysis of these data consisted of the ordering of Brazilian legal requirements and classification in pre-determined categories, followed by ordering and comparison of the recommendations proposed in the bibliography and legal requirements.

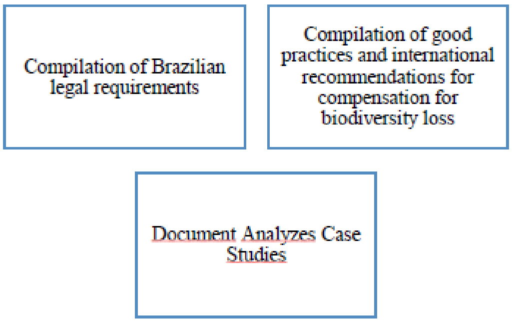

Figure 1. *Search steps.*

The second step consisted in the analysis of offset programs practiced in selected cases, in order to verify if the actions are able to balance the losses of biodiversity caused by the implantation and operation of mining projects. Data analysis was performed by comparing the compensation actions practiced by the entrepreneur with the international recommendations.

Subsequently, the difficulties and limitations of environmental entrepreneurs and agencies in realizing compensations focused on biodiversity losses were identified, whose data collection was carried out through interviews with key actors.

3. Results

The offset practices under analysis refer to limestone mining ventures of the same company, headquartered in Brazil that operates in the construction materials sector since the 1930s.

The three selected cases refer to environmental compensation in the "forest replenishment" modality, resulting from the deployment or expansion of open pit mine activities. Figure 2 shows the location of the mines. Table 1 presents basic characteristics of the projects under study.

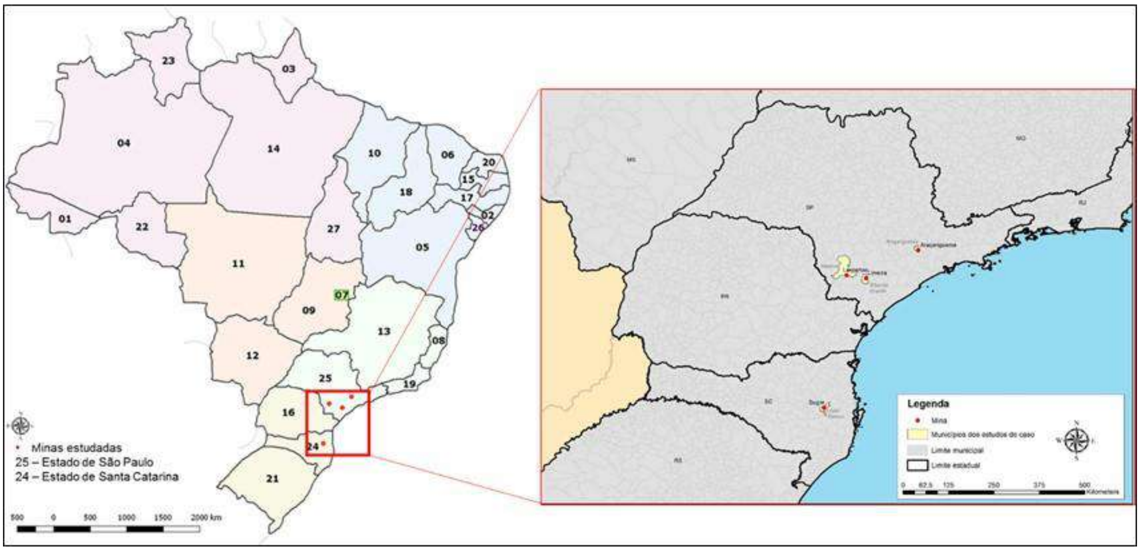

Figure 2. *Location of mines.*

Table 1. *Characteristics of the projects under study*

Project	Pit final area (ha)	Year of Start of operations	Extended life (year)	Capacity (tonne/ year)
Limeira Mine	73,9	2009	40	1.440.000
Bugre Mine	32,6	2010	35	1.608.486
Araçariguama Mine	44,4	1953	37	1.500.000

According to the EIS (Environmental Impact Study) of these projects, some negative impacts of high magnitude are due to the suppression of vegetation, since it triggers diverse and complex impacts on the components of biodiversity, including the loss of the availability of resources and habitats, Changes in flora and fauna composition and potential loss of genetic material.

Offset resulting from the suppression of primary or secondary vegetation in the middle or advanced stages of regeneration of the Atlantic Forest biome are required by Brazilian legislation, however some states and municipalities have specific instruments that regulate them. To understand how these instruments are organized, we did a general survey of legal requirements, not restricted to mining projects. This analysis is presented the detail applied to the case studies (Table 2).

The search for legal norms was done using CAL® Software, a web system that identifies the legislation applicable to the project / project. Considering the key word "compensation", 140 legal rules were identified.

In the general survey, in Brazil there are four types of compensation that could counterbalance biodiversity losses: (i) suppression of native vegetation; (ii) occupation of permanent protection areas; (iii) intervention in natural cavities; and (iv) suppression of protected plant species.

These standards were grouped according to the following categories, according to their regulations:

i. Financial resources of the offset: when the norm that referred to financial mechanism that aims to counterbalance the environmental impacts anticipated or already occurred in the implementation of the enterprise. It is a kind of compensation for degradation, identified in the licensing process are incorporated into the overall costs of the entrepreneur;
ii. Forest offsett: when the norm gave compensation guidelines due to the suppression of vegetation of the Atlantic Forest;

iii. Conservation of speleological heritage: legal provisions related to offset, as well as general guidelines on the allocation of financial resources derived from speleological compensation and environmental compensation.
iv. Environmental regularization of the property: when the norm dealt with the environmental regularization / adequacy of the areas of permanent preservation and legal reserve.

In the general survey, in Brazil there are four types of compensation that could counterbalance biodiversity losses: (i) suppression of native vegetation; (ii) occupation of permanent protection areas; (iii) intervention in natural cavities; and (iv) suppression of protected plant species.

The survey was evidenced the predominance of the topic related to financial resources, which deal with the regulation and application of Federal Law 9,985/2000.

Brazilian legislation requires compensation before the damage is done, it imposes on projects potentially causing significant and non-mitigable environmental impacts the duty to support, with financial resources, the creation and implementation of integral protection conservation units as a way to counterbalance The damages (BECHARA, 2009)..

With regard to forest offset, which has some similarities with compensation mechanisms for biodiversity loss, Brazil has well-defined legislation for flora species threatened with extinction and related to the suppression and interventions in the Atlantic Forest biome. The offset required in the projects studied are in Table 2.

Table 2 *- Compensations required in the projects studied*

Standard	Classification	Requirement Description
Federal Law 9,985/2000	Financial resources	Payment of up to 0.5% of the value of the enterprise in the maintenance or creation of a conservation unit.
Federal Law No. 11,428/2006 (Law of the Atlantic Forest)	Forest offsett Environmental regularization of the property	Forest offset in the minimum ratio of 2: 1.
Federal Law No. 12,651/2012 (New Forest Code) CONAMA Resolution No. 369/2006	Forest offset	Offset for minimum intervention in a permanent protection area (APP) at ratio of 1: 1.
Normative Instruction IBAMA nº 06/2009 CONAMA Resolution no. 300/2002	Forest offset	Suppression of individuals of protected or immune species of cut of the flora. Planting 20 individuals, every 1 suppressed.
Resolution no. 07/2017 - State of São Paulo	Forest offsett	According to the location of the enterprise in relation to the "Priority Areas for Increased Connectivity", the equivalent area compensation scale is provided
Resolution no 28/2010 – State of São Paulo	Forest offset	Offset resulting of degraded by mine at ratio 2:1
Normative instruction No. 46/2007 - State of Santa Catarina	Forest offset	Criteria for the definition and application of countervailing measures under the Federal Law 9,985/2000

The cases studied refer only to the offset made due to the suppression of Atlantic forest, which falls within the concept of a mitigation hierarchy, unlike compensation for conservation units, which does not follow the hierarchy. Table 3 summarizes the areas of suppression resulting from each project, compensation areas implemented and the type of compensation.

Table 3 shows the type of offset applied in the cases studied, according to the modalities presented by BBOPa, 2012, Vilaysack, 2012, ICMM, 2013; Ekstrom, Bennun and Mitchell, 2015, they are:

- Protection or loss avoided: Preservation through measures of protection and sustainable management of existing natural resources;
- Restoration: Restoration of areas (due to factors unrelated to the development project in question) through positive conservation management interventions such as forest restoration or enhancement of biodiversity components.

Table 3 *- Areas of native vegetation suppression, compensation and classification of the offset modality*

Projetc	Norm applied	Area interfered (ha)	Area compensated (ha)	Ratio	Type of offset
Mine Limeira	Deforestation Atlantic Forest	25,26	126,3	5 : 1	Restauration
	Intervention in a permanent protection area	1,34	6,7	1 : 1	
	Total	**26,6**	**133**		
Mine Bugre	Deforestation Atlantic Forest	56,7	56,7	1 : 1	Protection/ Restauration
	Intervention in a permanent protection area	16,3	16,3	1 : 1	
	Forest Reposition	-	5,7		
	TOTAL	**73**	**78,7**		
Mine Araçariguama	Deforestation Atlantic Forest	57,27	57,27	1 : 1	Protection
	Intervention in a permanent protection area	18,45	18,45	1 : 1	
	Deforestation Atlantic Forest (Connectivity)	7,17	14,34	2 : 1	
	Mines Offset	11,9	23,8	2 : 1	
	TOTAL	**94,79**	**113,86**		

Following the predisposing forest legislation, compensation occurs in the form of the destination of an area equivalent to the extension of the deforested area, with the same ecological characteristics, in the same hydrographic basin, whenever possible in the same hydrographic basin (BRASIL, 2012).

Therefore, the predicted criteria of the legislation are aligned with some concepts recommended in the good practices, regarding the principle of equivalence, that is, located in the same biome, with similarity of species, habitats, ecosystems or ecological functions in relation to those of impacted areas.

In order to choose the compensation area in all the analysed cases, the company studied the availability of adequate areas for compensation, through: (i) analysis of land regularization, (ii) checking the existence of mining rights of interest in the area or areas of Interest for exploration, and (iii) presence of environmental attributes, such as springs, streams and fragments of native forest.

The offset was made in the same watershed of the project, except the compensation of the Araçariguama Mine, which was carried out in another basin. The main argument used by the entrepreneur for the reallocation of the compensation area was that the available area in the property of the enterprise did not fulfill the functions of maintenance of biodiversity, since exotic species predominate and the environment did not present significant fragments of native vegetation. On the other hand, the proposed compensation area already had vegetation in the middle to advanced stage of regeneration and limits with conservation unit, located in priority areas of conservation. In this way, the environmental agency was in favor of compensation in another river basin, being carried out with the rural environmental register of the property.

It was verified that the entrepreneur, in his environmental licensing process, through the presentation of the environmental impact study, made propositions compatible with the legal determinations, proposing areas of compensation that were equivalent to the areas suppressed (or of greater wealth, in the case of Mine Araçariguama).

4. Discussion

With the analysis of the technical materials of the licensing of mine expansion projects, the analysis of adherence to good practices and international recommendations for biodiversity offset was carried out. Table 4 presents the steps regarding the implementation of compensation for biodiversity loss, according to the BBOP (2012) and Table 5 shows compliance with the BBOP principles.

The analysis of the case under study in the light of international recommendations allows us to conclude that although the compensations required in Brazil do not explicitly address biodiversity, but only through some of its component (habitat or protected individuals); there are equivalences with the principles of biodiversity offset.

Difficulties in following the *like-for-like* principle, uncertainties as to the success of compensation and inefficiencies in the impact assessment process make it difficult for compensation to result in a net loss of zero biodiversity. On the other hand, no compensatory measure was adopted that could promote gains for the beneficiaries of the services negatively affected by the project, either because they are not involved in compensation planning or because the compensation is focused only on the recomposition and replacement of habitats and species of flora threatened.

It can be concluded that there are equivalents between the Brazilian compensation required by law and the recommendations for biodiversity offset, however, this does not imply gains in terms of biodiversity. It is necessary for the actors to set the non-negotiable limits for each theme so that it is agreed in advance between them that significant losses for none of the agendas represented will be accepted by the group of decision makers, nor that there will be incoherent compensation.

Table 4 presents the analysis made on each case based on adherence to the principles of compensation and then on table 5 if the projects followed steps similar to those recommended by the good practices.

The Mine Limeira has the greatest adherence to the criteria, probably due to the project having a biodiversity plan following some international recommendations, and also due to its location in an area of great relevance for the conservation of the Atlantic Forest. In this case, it is observed that the environmental agency responsible for environmental licensing also made greater requirements and requirements.

The other cases, despite following Brazilian norms, are still far away to reach the biodiversity offset objectives as proposed by in the literature.

***Table 4** - Adherence to steps of biodiversity loss*

Steps in the implementation of biodiversity offset BBOP (2012)	Limeira	Bugre	Araçariguama
Design review and the legal framework for biodiversity offsets			
Involvement of stakeholders and consultation with experts			
Assess impacts and apply mitigation hierarchy			
Assess residual impacts and determine compensation needs based on the calculation of biodiversity losses			
Review potential shift locations			
Calculate offset gain and select appropriate offset areas			
Implement, adapt and improve compensation			
Monitor for no net loss maintenance or net gain			

Table 5 *- Adherence of the analysed cases to the BBOP principles.*

Principle of BBOP (2012)	Limeira	Bugre	Araçariguama
P1 - Mitigation Hierarchy			
P2 - Limits on what can be compensated			
P3 - Landscape Context			
P4 - No Net Loss (NNL)			
P5 - Additional conservation results			
P6 - Stakeholder participation			
P7 – Equity			
P8 - Long-term results			
P9 – Transparency			
P10 - Traditional Science and Knowledge			

5. Conclusions

The Brazilian legislation recognized the importance of egetation for the conservation of natural resources and for the maintenance and recovery of connectivity between fragments aiming at the conservation of biodiversity

It is concluded, through the evaluation normative requirements, that the legal system in Brazil establishes well-defined procedures for authorization to suppress vegetation both for permanent preservation areas and for Atlantic forest vegetation, as well as for compensations resulting from the suppression of Vegetation and intervention in areas of permanent protection.

On the other hand, it is observed that there are gaps in the effectiveness of the compensatory measures, since the standards do not yet systematically provide for the verification or evaluation of the results of the implementation of the compensatory measures adopted by the entrepreneur.

The results show that the majority of projects do not follow the mitigation hierarchy, and that compensation practices are restricted to the provisions of the law ("equal-to-equal" principles) and that the environmental regulatory body does not follow the Effectiveness of the practices applied by the entrepreneur.

Also, it can not be said from the results that the compensations resulted in zero net loss or net gains.

Finally, it was found that it is a consensus in the literature and also in consultation with the entrepreneur that the compensations can help to conserve areas of greater value for biodiversity than those that are being lost.

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Genetics Resources of Wheat – Way Back or Promising Future in Sustainable Development of Organic Farming

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Abstract

Approximately seven thousand plant species have been cultivated and one hundred and twenty of them have retained their importance in national economic systems. The selection of varieties has been crucial in the breeding of cultured forms from wild ones - the varieties have adapted to environmental conditions (Evans, 1981). Therefore, the previous landraces were very varied and stable. The modern forms have been bred over a short period and they have made important progress; nevertheless, they have not respected local environmental conditions. The varieties are usually adapted to farming technologies and they are not able to respond to unfavourable environmental conditions (drought, weed and disease pressure, etc.) (Lammerts van Bueren, 2002). In case of genetic resources of cereals is important to be adapt to changing environmental conditions. Therefore, the most valuable varieties should be conserve by the on-farm method which assures a dynamic process (Laliberté et al., 2000). Such a method of conservation of genetic resources is carried out in nature-friendly farming systems and it may bring interesting market opportunities. Our results are composed from more studies made in organic farming system from 2006 till now. We have been working with more than ten neglected wheat species. Evaluation of landraces was oriented to analysis of morphological, biological and economic characteristics. The most important part was oriented to evalution of technological and nutritional quality of grain. Our results show potential of some landraces of neglected wheat species to be grown in organic farming system. In many case was main advantage high resistance to common wheat diseases (eq. Triticum monococcum L., TriticumTimopheevi L. or Triticum diccocum Schrank). On the other hand – resistence was crucial problem of some species (eq. Triticum sphaerococcum L.). A lot of landraces had a higher competition ability against weed plant in case of non chemical weed management. Interesting findings also came from evaluation of yield. Generally – landraces had lower yield potential than modern varieties of Triticumaestivum L. Different situation was on less quality soils or very low nutrition of field. In this example could be in some landraces yield higher than modern varieties (eq. Triticumspelta L.). But the main advantage of landraces was quality of grain. There was very high protein content (einkorn or emmer we found accesions with more than 20% of protein). However, the diploid and tetraploid landraces may be difficult to use for common baking (low Gluten index and sedimentation value). Advantage was also high share of nutritionally valuable Albumins+Globulins and Unsoluble rest protein fractions in comparrison with modern control varieties of bread wheat. We found more unique quality parameters in grain of different wheat species. Landraces have potential to be grown in organic farming and used for the preparation of local high quality products. In this case there will be combination of two important aspects – unique value of genetics resources and added value of organic growing methods.

Keywords: Wheat, Landrace, Organic farming, Growing, Quality

Introduction

Over the last decades, the humankind has been increasingly addressing the matter of sustainable development in connection with the protection of the environment and its components. The most common sustainable farming method is organic farming. Organic farming often uses original/regional or also hulled wheat species (e.g. spelt, einkorn and emmer wheats) that were, due to their low yield potentials in conventional farming, replaced by hybrids with higher yields (Šarapatka, 2006), (Moudrý, 2007a). Despite the lower yields, these species are interesting for farmers for several reasons. Given the complicated legislation regulating organic farming (prohibition of using industrial fertilizers, pesticides and herbicides and, in some countries, also prohibition of cultivation of certain crops, e.g. GMO), the farmers find it more convenient to grow species showing greater ecological plasticity (higher resistance to diseases and pests, better ability to take up nutrients, tolerance to less favourable climatic conditions, etc.). Their cultivation has a minimal negative impact on the environment, and they give lower but stable yields (Čurná 2016).

Genetic resources and their importance for the humankind

In the history of agriculture, the cropping pattern changed considerably, particularly in connection with the arrival of new crops, changes of cultivation technologies and intensification of agricultural production. In a majority of agricultural crops, intensive and one-sided breeding results in narrowing the genetic base of the current range of varieties, which creates potential risks (occurrence of diseases and damage resulting from biotic stresses, and lower stability of yields and quality of production). This process is called genetic erosion and was confirmed by a number of studies (Dotlačil, 2002). The decreasing agrobiodiversity in farming systems is connected with the increasing demands on the inputs of agrochemicals and energies. The final consequence is the deepening of negative impacts of agriculture on the environment (Konvalina 2005). Old regional varieties are irreplaceable because they are the carriers of genetically determined properties which are absent in modern wheat species. They are the outcome of the prevailing effect of the natural conditions of a certain area with the grower’s contribution (Graman, 1997). Therefore, the protection of their gene pool constitutes essential part of sustainable farming systems. They constitute a unique and irreplaceable resource of genes and gene complexes for further genetic improvement of the biological and economic potential of cultural crops. Losses or damage of the genetic base of those resources are connected with reduction of possibilities of further genetic improvement of agricultural crops and their adaptation to the changing conditions and needs (Anonym, 2011).The modern varieties which are resistant to diseases and other stresses and give high yields were mostly obtained by improving the current properties by the genes of wild species (Hanák, 1996). The protection of the gene pool takes place on two levels – in situ (on site preservation) and ex situ (off-side preservation) (Primack, 2011).

Cereals

The wheat genus triticumL. is a member of the family Poaceae. The basic chromosomal number of wheat is 7. Depending on the number of homologous sets of chromosomes in a cell, called ploidy, we divide wheat into three groups: diploid (2n = 14) – einkorn wheat, tetraploid (2n = 28) – emmer wheat, and hexaploid (2n = 42) – spelt wheat (ZIMOLKA, 2005). Wheat was domesticated in the Neolithic Age, i.e. approximately ten thousand years ago, probably in the Tigris river valley. Its breeding closely followed the success of its domestication (Chloupek, 2000). Cereals are the most prevalent group of agricultural crops grown worldwide. Wheat is one of the four most significant crops in terms of caloric consumption of humankind (Dalgaard, 2006). In arable land ecosystems, they have a dominant position. In the temperate zone, they are grown on more than 50% of arable land. This ranks them first among crops in terms of significance for the nutrition of the human population of the temperate zone. An advantage of cereals is their appropriate ratio of basic nutrients (glycides and proteins) for human and animal nutrition (Konvalina, 2005).

Hulled wheats

The cultivated hulled wheats – Triticum monococcum, dicoccum and spelta are the oldest cultivated wheat species. At present they are known under the Italian universal name “farro”. This is a strictly ethnobotanical name originating from Italian traditions (Marconi, 2005). Hulled wheats rank among often ignored crops which, however, have a potential for future utilization in food industry. The oldest hulled wheat species is einkorn wheat, which is also the first domesticated wheat species. However, it was pushed out by more productive tetraploid and hexaploid wheat species. Due to their low demands on the environmental conditions, they are suitable for cultivation in areas less favourable for agriculture (Konvalina, 2014).

Specific quality

Generally, hulled wheats give lower but stable yields of high quality production (Konvalina, 2014).The high quality of the production is interesting particularly with regard to healthy nutrition. In general, hulled wheats have a thicker aleurone layer (Konvalina, 2010) than modern common wheat. For this reason, the flour made from hulled wheats has a higher content of vitamins, minerals and antioxidants.

It has been proven that hulled wheats have a generally higher protein content (Table No. 1) than common wheat when grown in the same agronomic conditions (Čurná, 2016). Spelt wheat grains have a provable high protein content (13 – 20%). The results from Italy (Marconi, 2002) show that spelt wheats with a high protein content of grains can also be used for the production of pasta. The protein content of emmer wheat ranges widely from 9 to 18% (Blanco, 1990). According to Marconi, 1996, even up to 20.6 – 21.9%. The protein content of emmer wheat is very variable and depends on the given site conditions. Einkorn wheat contains 13.2 – 22.8% proteins (Borghi, 1996). The composition of amino acids, if related to the same content of proteins in grains, is virtually identical to that in common wheat (Galterio, 1994; Ranhotra, 1996). The amino acid composition of emmer wheat is very similar to spelt (Marconi, 2005). However, emmer wheat is interesting for its higher lysine ratio (Arzani2011). A study (Ruibal-Mendieta, 2005) shows that compared with common wheat flour, wholemeal spelt flour is richer in fats, namely unsaturated fatty acids. The highest content of unsaturated fatty acids is found in einkorn wheat. The content of gross fat is 2.7% in einkorn, 2.3% in emmer wheat and 2.4% in spelt (Suchowilska, 2009). In a number of samples of spelt wheat, particularly in the aleurone layer of the caryopsis, ahigh content of ash, copper, iron, zinc, magnesium and phosphorus was also found (Ruibal-Mendieta, 2005). Einkorn and emmer wheat as well as spelt are significant sources of minerals (Hussain, 2010). Grela (1993) found quite a high content of vitamin E in spelt. Spelt also contains more carotenoids, which leads to a darker colour of baked products than is the colour of products baked by using common wheat flour (Grausgruber, 2004; Schmitz, 2006). Einkorn wheat is also rich in carotenoids (Kierchmaier, 2012).

The content of edible fibre is lower in hulled wheats than in naked species (Grausgruber, 2004). The overall fibre content in einkorn wheat is lower than 10%, which is lower than in common wheat and durum wheat. This difference is caused by the insoluble component of fibre (Konvalina, 2012).Because of the lower quality of gluten, which is rather running, the einkorn wheat flour is not suitable for the production of yeast doughs and yeast products (Brandolini, 2008). Low values of SDS and Zeleny test and worse rheological properties are also typical of emmer wheat (this is also true for einkorn wheat) (Grausgruber, 2004). For this reason, we need to search for alternative uses of these species. For example, einkorn wheat is suitable for the production of children’s and special food due to the good transmission of properties connected with high protein and carotenoid content (Brandolini, 2008). Einkorn wheat can also be used for the production of non-yeast products, biscuits and flakes. In macrobiotic diet, its germinated grains are used (Moudrý, 2011). The only exception is spelt wheat, which is used for the production of yeast products in a mixture with common wheat. In their study, Marconi, 1996 described a high baking quality of spelt wheat despite that fact that the spelt gluten is less firm and the dough has worse rheological properties. The rheological parameters and values of the gluten index, wet gluten, SDS test, Zeleny test, protein composition and insoluble fibre are shown below in Tables No. 1 and 2.

Global vs. regional products, local economy

One of the foundation stones of ecologic production and idea is the production and distribution of foods on a regional scale. When observing the principles of regionality, the energy needed for the transport of foods over large distances is saved and the local economy is supported. Regionality is in direct contrast to globalization (Hardtert, 2008). The evaluation uses LCA (life cycle assessment) method. LCA is defined as the comparison of the impact on the environment. LCA includes ascertainment of the energy consumed for each process from the beginning to the sale to the end consumer (Schlich, 2000). If products are produced on a regional level, the consumer can be certain of their origin, quality and freshness, and money is not drained off from the region. Moreover, the society may regard as a benefit that food is produced in an ecological manner, which also brings some other effects not reflected in the price of the products. Such effects may include the water quality or diversity of species in the farm surroundings (Šarapatka, 2005). The lower production of organic farming is compensated by lower costs and higher purchase prices (Moudrý, 2008).

Transport distances and negative aspects of transport (CO2, etc.)

Negative aspects are associated with the transport of the mentioned raw materials. In environmental terms, transport plays quite a significant role as it contributes to the generation of greenhouse gas emissions, thus increasing the emission footprint of the transported goods (Hickman, 1999; Wakeland, 2008). For example, Svendsen (2011) and Morán and del Rio Gonzalez (2007) state that within EU, the greatest polluters include power engineering, industry and transport, while transport itself accounts for 19.5% of anthropogenic emissions of greenhouse gases. From the anthropogenic emissions from food production, transport constitutes up to 50% (Foster, 2006).The mode of transport, which has been undergoing significant modifications due to the globalization of the food market, accounts for the major part(Knudsen, 2010).The transport of organic farming products where we can expect longer routes resulting in increasing the environmental load due to the lower concentration of producers and supply centres for organic farming products can be regarded as a separate chapter(De Backer, 2009). Moreover, a large part of organic production is imported. When transporting products of organic farming, higher environmental loads often arise due to the transport of a smaller quantity of products. However, with the continuing development of the organic farming sector, improvement and greater equalization with conventional production can be expected. In terms of emission savings in the field of transport, it is appropriate to prefer regional production. By preferring regional production, it is possible to intensify reduction of anthropogenic emissions (Smith, 2008 and Moudrý jr., 2013).

Aim of the study was to evaluate the combination of yield and quality parameters of genetics resources of wheat and assessment of their value for use as source for the preparation of local food products. The second objective was to evaluate its value for sustainable development of rural regions and decrease of environmental impact during food transport, if local product replace global product.

2. Methods

Data related to the einkorn, emmer, spelt and bread wheat production potential and quality of grain comes from our field experiments from the Czech Republic. Used varieties: mean values of four varieties of einkorn, eight varieties of spelt and seven varieties on spelt. As controll we used two varieties of bread wheat (SW Kadrilj and Jara). All the varieties are spring form.We use small plot trials in randomized plot design. Experiments were carry out in organic farming system. We use four varieties of einkorn. The protein content of harvested grain was tested by The International Association for Cereal Chemistry (ICC) method. Gluten content was measured by ELISA Technologies. Protein fractions were measured according methodology developed by Osborn.

Calculation of emission load during product transportation was calculated by software Sima Pro with integrated database Ecoinvent. For the einkorn transportation we use mean distance in the Czech Republic – 180 km. For the rice import we use following: 250 km by track in Thailand, 9422 km by boat from Thailand to Hamburk port and 636 km from Hamburk port to the Czech Republic and 180 km mean transport within the Czech Republic. Boat transport was calculated for container 33.2 CBM = 21.8 t of rice.

Data were processed by the Statistica 9.0 (StatSoft. Inc., USA) programme.

3. Results

Table No. 1 shows the average vales of protein content, wet gluten quantity, gluten index, SDS test and Zeleny test. In our conditions, all the tested hulled wheat species showed statistically provable higher values in respect of the content of proteins and wet gluten than the control species, which was common wheat. As expected, the values of gluten index, SDS test and Zeleny test were statistically provably higher in the control common wheat. According to the statistical evaluation, einkorn and emmer wheats show demonstrably similar qualities in these parameters. In statistical terms, spelt wheat differs from them particularly in the values of SDS and Zeleny tests. These methods identify the qualitative viscoelastic properties of the gluten protein. They have a provable positivecorrelationcoefficient to the volume of baked products and to the gross protein content of grains. The high value of the sedimentation index correlates with the high ability to retain gases in the spatialnet, being directly proportional to the volume of the baked product. In most cases, the wet gluten content positively correlates with the protein content. GI also has a positive effect on the development of dough. GI indicates the strength and elasticity of gluten, and its higher valuesshow the dough’s resistanceto mechanical processing.

Table 1: Baking quality characteristics of different wheat species (mean and SD, three localities; four years)

Species	Protein content (%)	Wet gluten content (%)	Gluten index	SDS test (ml)	Zeleny test (ml)
Einkorn	15,59b	36,45bc	14,39a	29,04a	14,07a
Emmer	16,04b	38,04c	15,43a	33,15a	15,81a
Spelt	15,74b	42,26d	35,68b	57,35b	34,35b
Bread wheat	12,79a	30,87a	68,75d	65,38c	42,36c
Remark: Within column values followed by the same letter are not significantly different at P < 0.05 (Tukey HSD test).					

Table No. 2 shows the average values of the content of gluten and main protein fractions (soluble albumins and globulins and insoluble gliadins and glutenins + insoluble residue) of which wheat starch is composed.

As for these values, einkorn wheat is not in statisticalagreementwith emmer wheat, as it was the case in Table No.1. The gluten content is the highest in the control common wheat, followed by spelt without any statistically provable difference. The lowest value was found in einkorn wheat. Albumins andglobulins – soluble and nutritionally most valuable proteins werecontained most inhulled wheats (26.67 – 28.69), while the control common wheatfell behind them considerably in this parameter (21.38). In contrast, as for insoluble gliadins andglutenins, the control variant of common wheat showed the highest values. In these parameters, no statisticalagreement was found between the studied species. This was also the case for the last parameter – insoluble residue where the lowest values were found in the control common wheat and the highest values in einkorn wheat. For more details see Chart No.1 below.

Table 2: Baking quality characteristics of different wheat species (mean and SD, three localities; four years)

Species	Gluten content (mg.100g-1)	Albumins + Globulins (%)	Gliadins (%)	Glutenins (%)	Unsoluble rest (%)
Einkorn	153,45a	26,67a	27,93a	27,64a	17,76d
Emmer	194,86b	28,67b	30,06b	27,70a	13,67c
Spelt	248,17c	27,04b	31,03bc	29,95b	12,12b
Bread wheat	248,52c	21,38c	34,67d	36,96c	6,99a
Remark: Within column values followed by the same letter are not significantly different at $P < 0.05$ (Tukey HSD test).					

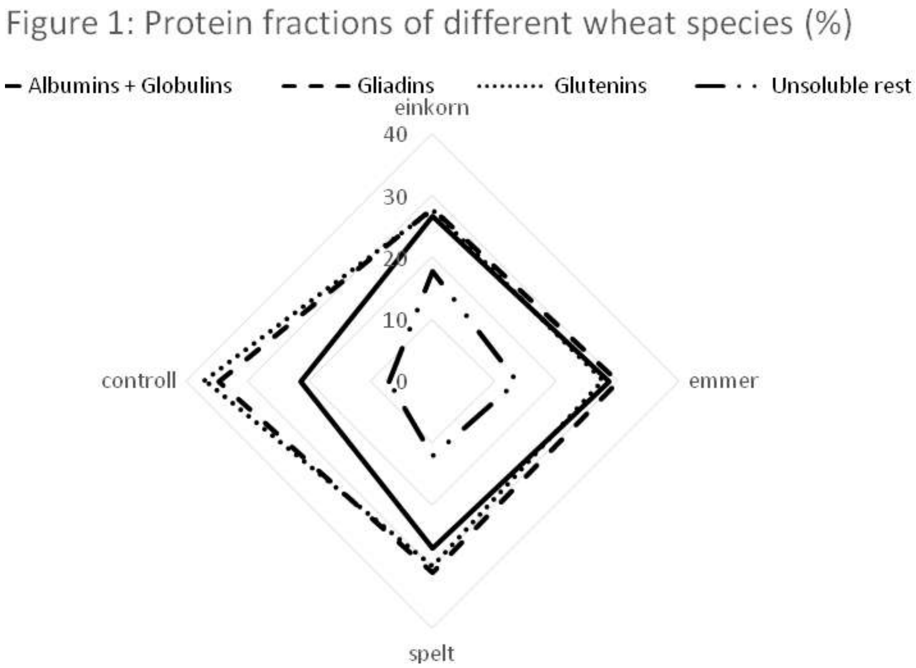

***Chart 1.** Is based on Table No.2. It is a graphic display of the relationship between individual protein fractions in our studied samples.*

Chart No. 2 shows the relationship between the grain and the quantity of proteins (in metric tons) gained with a certain yield per hectare and the average total protein content of a grain. The upper thick line represents the average protein content, which is relatively equal in hulled wheats and declines in the control common wheat. The chart shows that in an organic farming system the control common wheat reaches, on average, the yields that are 1,83 t/ha and 1.04 t/ha higher than the yields of einkorn wheat and emmer wheat, respectively. Spelt wheat has the yields lower by 0.51 t/ha but alsohas a high yield of proteins per hectare. Therefore, in this view it comes out asthe best for growing in organic farming.

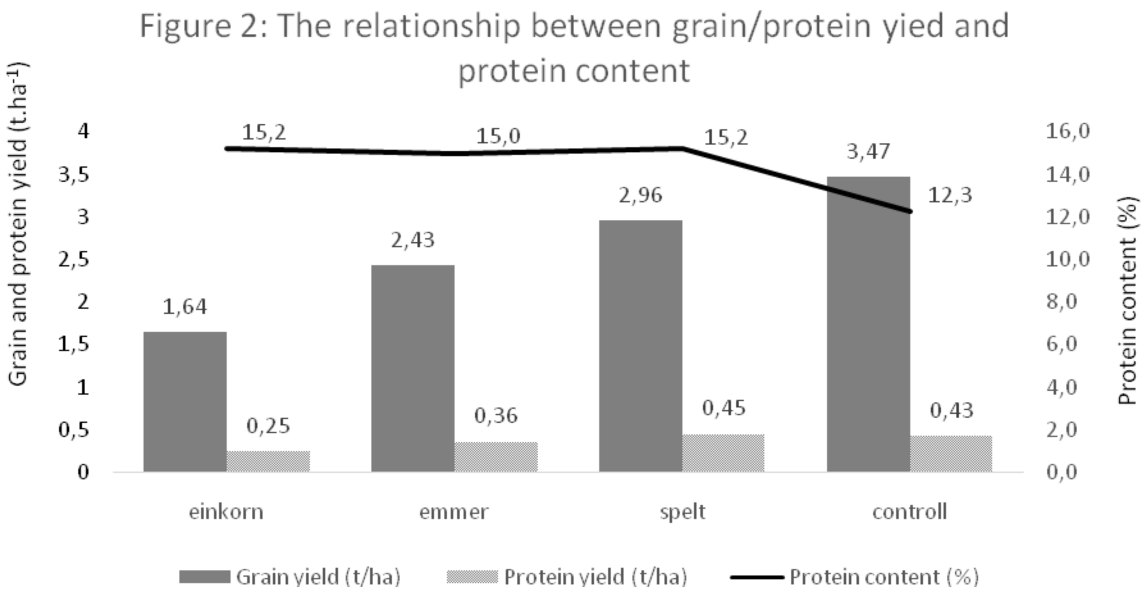

Chart 2. *The relationship between grain/proteins yield and protein content*

Related to environmental aspects of growing we can expect practically the same field emmisions of CO2 during growing. But the most important aspect is trasportation of rice. From the table3 is possible to see 6 times higher CO2e emissions per tone of transported product (rice) than locally produced einkorn wheat.

Table 3. *Transportation emissions – comparisson of rice and einkorn*

Commodity	Eincorn	Rice
Kg CO_2e/t of transported comodity	24.2	149.3

Discussion

Our results show that hulled wheats have, on average, a higher protein content than the controlled sample of common wheat. See Chart No. 2. This is confirmed e.g. by Borghi, 1996 who found out in his study that hulled wheats grown in the conditions of organic farming always have a higher protein content than modern varieties. However, according to Piergiovanni, 1996 those species should not be considered as a better resource of proteins for conventional use, because modern common wheat species compensate their lower protein content by high yields. But this does not apply to organic farming systems where the differences are largely removed. As for the nutritional quality, hulled species can be regarded as having a higher nutritional value due to their more favourable protein content (albumin and globulins) and a lower content of gluten which burdens the gastrointestinal tract (Prugar, 2008). In less developed countries, those species (especially einkorn wheat) could be used for the nutrition of children who need a larger amount of quality proteins for their growth and development. However, einkorn and emmer wheat varieties are less appropriate for usual technological processing, because their gluten and protein fractions are not suitable for conventional use for the preparation of yeast products. The low baking quality of einkorn wheat is due to the low strength of gluten, low sedimentation values and worse rheological properties (D´ Edigio, 1993) – see Table No. 1. Despite that, varieties with better baking properties, such as a higher volume of the baked products, were found. (Borghi, 1996).Those varieties have currently been registered in Italy and are available on the market under the umbrella name Monlis (Konvalina, 2014). That is why einkorn has currently been used for non-baking purposes, in particular. See Moudrý, 2011. Konvalina, 2014mentions biscuits, non-yeast bread or bulgur as some of the possible uses of einkorn wheat. In emmer wheat, the baking quality of proteins is also lower than in common wheat. Emmer wheat shows low values of SDS a Zeleny tests and rheological properties of the dough, see Table No. 1 (Grausgruber, 2004) (Piergiovanni, 1996). A higher volume of the dough can be achieved by using a conventional bread-starter when preparing the dough or by baking the bread in a higher baking pan (Grausgruber, 2002). Despite its lower baking quality, it is suitable for the production of pasta (Marconi, 1996) or cereals, pastries and non-yeast products, according to Konvalina (2014).

An exception among hulled wheats is spelt wheat, which has better baking properties than the other hulled wheats despite having a weaker gluten than common wheat, thus also worse rheological properties (Marconi, 1996). This also corresponds to our results – see Tables No. 1 and 2 that show a higher value of GI and total gluten than the other hulled wheats. It can be used for the production of bread, baked products, pasta and extruded products as well as a coffee substitute (Konvalina, 2014). In spite of a high protein content, the grain is also suitable for the production of beer (Krieger, 2004). As stated above, hulled wheats are mostly cultivated in organic farming systems (Moudrý, 2007, a, b). Based on Table No. 2, we can come to the conclusion that protein fractions and their composition are strongly dependent on the genotype and are less influenced by the environment. As a matter of course, the selection of the variety is also important.

4. Conclusions

Hulled wheats constitute an interesting alternative for cultivation in organic farming. Due to the lower requirements for growing conditions, they may also be grown in water protection zones or in conditions generally less favourable for the cultivation of cereals. In addition to the production aspect itself, the cultivation of hulled wheats in an organic farming system shows a large number of other positives which are further studied.From the results is evident lover CO2emmisions during the transportations if eq. einkorn "rice" substitute imported rice from long distances. The most important positives include the effect of organic farming on the landscape or landscape restoration after an area disturbance, e.g. opencast mining of brown coal. It also has a positive effect on the quality of surface and underground waters and the biodiversity of all elements of the food chain, and increases the water and nutrient retention ability of the landscape. When observing the principles of regionality, organic farming can have a beneficial effect on the regional economy – this is important especially in marginal rural areas where it creates new jobs. Moreover, in many cases, this farming method is also a life style which is pursued by young people, in particular. This also has a favourable effect on the rural areas which are rejuvenated this way. The people who are engaged in organic farming or who consume organic products also realize their responsibility for the environment much more and may motivate and influence people around them more. For these reasons, organic farming is supported in the EU countries. More generally, this idea attempts at "sustainable development". The use of hulled wheats in nature-like farming systems not only contributes to sustainable development but can also help the regional economy due to the processing of products right at the place of origin. So a part of the profit can remain with the local farmers. At the same time, it is an interesting alternative e.g. in the current development of agrotourism at farms (a tourist is also a purchaser of products). In this respect, organic farming, including the cultivation of hulled wheats, is an irreplaceable element of this large chain.

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The Mapping of Resources and Development Potentials of Food-Secure Region in Kupang District, Province of Nusa Tenggara Timur

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Abstract

Indonesia Food Sustainability and Vulnerability Assessment (FSVA) 2015 by the World Food Programme (WFP) categorized Province of Nusa Tenggara Timur as severely vulnerable to food-insecurity (priority 1). The aim of this program was to develop partial and spatial map of current condition, problems, threats, potentials, and strategic policies to develop food security in this area. The program was focused on Kupang district, Province of Nusa Tenggara Timur, through: 1) literature study; 2) identification and mapping of natural resources; 3) Focus Group Discussion; 4) field trip and data collection; 5) data analysis; 6) development of program; 7) workshop. Kupang district had three sub-districts that were most vulnerable to food insecurity (priority 1), namely Semau, South Semau, and Takari. The determining factors of vulnerability to food-insecurity were: (1) high poverty rate, (2) high prevalence of underweight among children, and (3) low access to clean water. The characteristic of the hilly areas in Kupang is dry-land on karst region with very low land-productivity. The limiting factors are low rainfall, low water availability, high temperature, low moisture and low fertility. Livestock were still raised traditionally on natural pastures. Some of the programs needed to enhance food-security in Tanini village are: (1) Improvement of land productivity, including infrastructure, facilities for intensive livestock farming systems, and optimization of dry land's potential; (2) Water management trough the construction of water reservoirs and the preservation of watershed and groundwater basins; (3) Capacity building for communities including farmers, the education on food consumption and processing, society empowerment by improving soft skills and hard skills. The analysis and estimation of World Food Programme showed that after intervention, the composite score of Kupang district changed from 91.18 (priority 3) to 66.54 (priority 5). The map of food-insecurity was ideal as a reference in planning an effective and efficient program.

Keywords: food-insecurity, mapping, food, food-security

1. Introduction

The core meaning of food-insecurity reduction focused on the condition to be achieved, namely the creation of sustainable food-security. According to FAO (1996), food-security exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food which meets their dietary needs and food preferences for an active and healthy life. Food Security and Vulnerability Atlas (FSVA) 2015 produced by World Food Programme (WFP) and Indonesia's Food Security Council (DKP) covered 398 districts and categorized them into six priority levels based on nine indicators that measured food availability, food access, and food utilization.

Nine indicators related to chronic food-insecurity were then combined into a composite score to describe the overall food-security conditions of the districts and categorized them into six priority groups. Based on FSVA 2015, Kupang district was in priority group 3, which mean it was vulnerable to food-insecurity. This study aimed to develop partial and spatial map of the conditions and potentials of the food-insecure areas, and define the problems, constraints, challenges, and strategic efforts to build food-secure region. Indonesia, with its high potentials of food resources (agriculture, livestock, and fisheries) and with an optimal management, should be able to provide enough food for the communities locally, regionally and nationally, and even contribute to exports. The fact showed that not all regions had equal access to these potentials.

The conceptual framework underlying the development of food-secure region was necessary, as well as technical efforts to exploit the region's potentials, including; (1) Agro-production intervention with joint management of lands on the basis of high innovation and synergy in agriculture, animal husbandry, forestry, veterinary, and agricultural technology in an integrated and comprehensive way; (2) Agri-business intervention with a unified business management so people can participate in modern way (not the traditional way where they function as the subsystems of a bigger system), and to make people more prosperous (not being exploited for other economic sector's benefit); (3) Agro-technology intervention with applicative technology and biotechnology that leads to a new revolution for the benefits of many people. (4) Agro-industry intervention by using the research results to develop agricultural products so the harvest fluctuations which are detrimental to farmers can be handled, and the agricultural products can be upgraded into priority commodities; (5) Agro-tourism intervention with edu-tourism to improve local community's condition and to educate people to protect the environment; (6) Agro-consumption intervention with food diversification and local food processing; (7) Agro-distribution intervention with storage, distribution, and administration.

2. Method

Strategies and methods of implementation

This was a qualitative study and performed with a method that consisted of several steps:

1. Literature study by examining the documents at national and regional levels as secondary data such as food-insecurity parameter, policy directions, development strategy, program plan, and others.
2. Identification and mapping of potential resources in food-insecure regions, as shown in Figure 1.
3. Focus Group Discussion (FGD) to collect the data, where the participants were the representatives of ministries, higher education institutions, related Local Government's Working Unit (SKPD), farmer groups, the communities in food-insecure regions, and social institutions.
4. Fieldwork for primary data collection and the ground check of the site's conditions.
5. Comparative analysis of primary and secondary data with the calculation of composite score.

6. Workshop to discuss the results of the study, which was expected to enhance them.

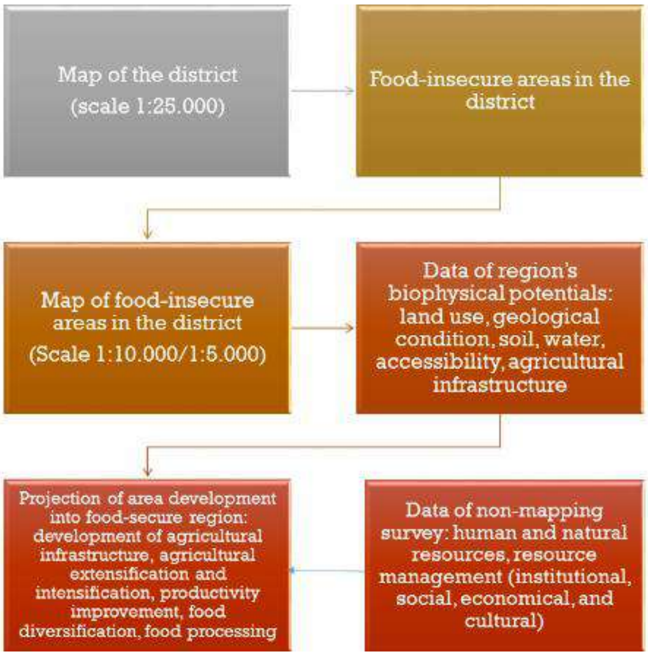

Figure 1. Identification and mapping of food-insecure region's resources and potentials

Data types and data collection

This study was conducted using qualitative approach, and analytical descriptive method was applied in the description of phenomena studies to explain the aspects of who, what, when, and how of a topic (Donald and Schlinders, 1998). The study used primary and secondary data. The primary data was taken with observation method (the observation of the objects of research), interview using a questionnaire, and Focus Group Discussion (FGD). The secondary data involved Publication Documents from Central Bureau of Statistics (BPS), Profiles and Program Plan from regional body for planning and development (Bappeda), Strategic Plan from Local Government's Working Unit (SKPD) of Kupang district, and documents from related other institutions. According to Handari (2005), primary data includes information and facts about potential areas, while secondary data includes regional documents, research results, publications, and arguments related to the question of investigation. Therefore, the primary data in this research was the main focus of the analysis, and the secondary data was its complement.

Data analysis

The data was analyzed by making comparison between the reality on site and the standards that applied nationally, regionally and globally in terms of agricultural productivity in meeting the needs of food and nutrition. The results of the analysis were expected to show the gap or insufficiency in food-security factor of a region. The next step was to determine the target and the projection in the future to address the identified issues. The target was determined by considering the potential and support of the region. The final stage analyzed the input (form, volume, and process of the development to be conducted), the output (results expected after the input), and the calculation of the level of food-insecurity. The analysis in intervention program of food-insecurity reduction was based on the data before and after the program was implemented. The analysis identified and described the fundamental connection between the indicator variables. The PCA analysis was applied to nine indicators of food-security in general to produce a composite score. PCA analysis produced major components as many as the original variable, along with the contribution of each major component in explaining the variation among indicators. The calculation of the composite was made with the following formula:

$$Y_j = a_1X_{1j} + a_2X_{2j} + \dots + a_8X_{8j} + a_9X_{9j}$$

Information:

Y_j = composite score of the j^{th} district

$a_1, a_2, \dots a_9$ = the weight of each indicator

$X_{1j}, X_{2j}, \dots X_{9j}$ = the value of each indicator in the j^{th} sub-district

3. Results and Discussion

Food-insecurity characteristics

Kupang district's vulnerability to food-insecurity was based on the composite index shown in Table 1. The main indicators that made it categorized as priority 3 in food-insecurity were; (1) the prevalence of stunting among children under 5 years of age was very high (more than 40 percent). Based on this parameter, Kupang district was in danger. At sub-district level, 16 of them had very high prevalence (> 30%), 6 sub-districts had high prevalence (20 - <30%), and only 1 district had lower prevalence of stunting (10 - <20%); (2) About 20-25 percent of the population in Kupang district lived below the poverty line. The parameter was Indonesian rupiah value of monthly expenditure per capita to provide a minimum level of food and non-food basic consumption needed by an individual to live a decent life. (3) The percentage of households without access to clean water showed priority 5 (secure enough). However, the fact showed that 50-70 percent of the households in 7 sub-district in Kupang had no access to clean water, about 40-50 percent of households in 11 sub-districts had no access to clean water, about 30-40 percent of households in 3 sub-districts had no access to clean water, and only 1 sub-district had less than 30% of households without clean water. The access to clean water remained an indicator in handling food-insecurity issue because water is an important element related to food. The priority should be made regarding water for non-consumption uses, including for agricultural and livestock production. It would prevent the functional change from water for consumption to water for production, so the already limited clean water did not fall into scarcity.

Table 1. Status of Food-Insecurity in the Studied Area based on FSVA Atlas 2015

Kupang	Cases								
	P1	P2	P3	P4	P5	P6	P7	P8	P9
Priority Rank	1	6	3	6	5	5	4	6	4
Priority Scope	>40 %	<0.5	20 - 25%	<10%	30 - 40 %	10- 20 %	64 – 67 %	<20 %	10- 20 %
Percentage/ Ratio	54.4 %	0.35	24.71 %	9.46 %	39.86 %	19.79 %	66.94	19.69 %	19.68 %
Note	high prevalence	very high	moderately high	very low	Low	moderately high	high	moderately high	moderately low

Note:
P1: Prevalence of stunting among children under 5 years of

P5: Households without access to clean water.
P6: Percentage of households without access to electricity

age.

P2: Ratio of per capita normative consumption towards net cereal production.

P3: Population living below poverty line

P4: Villages without street

P7: Percentage of life expectancy at birth

P8: Percentage of village with access to health facilities more than 5 km

P9: Percentage of female illiteracy at age 15 and above

The strategy for the development of food-secure region in Kupang district can be designed in accordance with the resources and environmental conditions. Kupang district has varied characteristics, ranging from coastal ecosystems, estuaries and oceans, low plains, plateaus and hills. According to Syahza (2007), rural development must be done with an approach in accordance with its nature and characteristics. Rural development should follow four major interrelated efforts as well as key strategies such as: 1) Empowering the economy of rural communities; 2) Improving the quality of rural human resources in order to have an adequate basis to enhance and strengthen productivity and competitiveness; 3) Constructing the rural infrastructure; 4) Building the rural institutions both formal and nonformal. The focus of food-insecurity reduction needs to be determined along with the identification of the region’s potential resources to be developed, so a program is needed to be designed in certain location, which then is called Area Development Model. On the basis of agreement with local government, the food-secure region will be developed is Takari sub-district, particularly Tanini village.

Physiographic characteristics of the development model of food-secure region (Tanini Village)

Tanini village has higher topography and is included in the boundary area between Barisan Perbukitan Utara (Northern Range) and Cekungan Tengah (Central Basin). Tanini village, with its hilly topography (Figure 2), is situated in the area of Batulempung Bersisik Bobonaro (Bobonaro Scaly Clay), a sedimentary melange and deposits (olistostrome) and diapir formed by the contact between Viqueque formation with gray shale and cobble to boulder-size blocks. The location of the springs in Tanini is really interesting from geological perspective because most soil in the area is composed of limestone. When the location of the spring was overlaid with Kupang’s regional geological map with the scale of 1: 250,000 (Figure 3), it showed that the location of the spring had a lot of intrusion in the form of ultramafic igneous rocks. It could be concluded that the springs were the result of aquifer flows which hit an impermeable rock layer. However, because it was not major aquifer and it was only hanging aquifer, the discharges from the springs were very small. The information from the inhabitants in surrounding area confirmed the fact that in dry season, there is only one spring that emerges, so it is not advisable to build a wellbore in the location because there is no sufficient discharge. It is also reinforced by the already existing wellbore near the site of the springs (about 100 m) that has a depth of 150 meters but has no water.

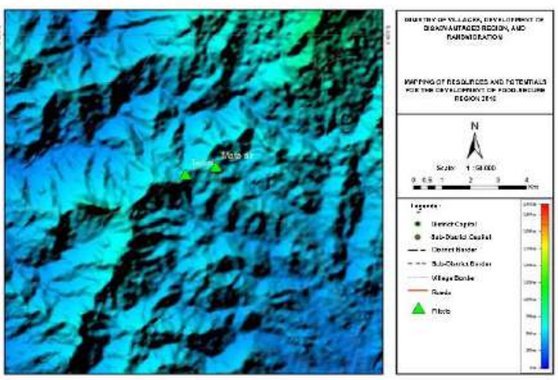

Figure 2. Morphological Condition of Tanini Village

Figure. 3 Tanini's Map of Geological Regional

The data leads to the prediction that Tanini village does require another water source for drinking and other needs, so the efforts to dig water sources or wells are necessary. Geo-electrical survey is also needed in advance to locate the groundwater before drilling a well. The first thing to do is to determine the geo-morphological and geological conditions (stratigraphy and geological structure), hydro-geological condition (well measurement, shallow groundwater depth, contour, and shallow groundwater flow). Geo-electrical survey will then generate geo-electrical interpretation in each point of observation, geological correlation and cross-section, as well as the image of water bearer layer so the location of the drilling can be found. In addition to the wellbore, the construction of water reservoir can reduce water scarcity. However, the water source should be checked first if water reservoir should be built.

The analysis of aquifer characteristics and karstic water levels should be considered as a condition of sustainable water-use (Kresic and Stevanovic, 2010). The effort to assess the characterization of karst aquifers according to Smart and Hobbs (1986) is to determine the nature of the flow, recharge area, and storage capacity that vary spatially and temporally. Spatially, the limits of karstic aquifer's catchment areas are often beyond the topographic limits. It relates to the homogeneous geological structure (carbonate rock) that receives additional groundwater from other adjacent aquifers. Temporally, the width of the catchment areas depends on the fluctuations of the water level (Juki D and Jukie, 2009; Kresic and Stevanovic, 2010). This indicates that it is not easy to make a well in the karst area.

Human resource potential of the development model of food-secure region (Tanini Village)

Tanini village has 2,326 inhabitants with 470 heads of household, and the average household size is 4 persons. The total area of the village is 120.26 km^2 with population density of 19 inhabitants / km^2. The distance between Tanini and the sub-district's capital is 37 km, and its distance to the district's capital is 74 km. It makes Tanini a remote village with little access to necessities of life. The majority of the inhabitants work as farmers, but the condition of the land is dry, and the agro-production is hampered. This is a proof why Tanini village is categorized as food-insecure region. People plant different types of fruits on their yard and grow annual crops such as corn, perennial crops such as cassava, fruit trees like banana, cashew apple, and mango, and hardwood trees such as teak and mahogany on dry land on the hills. Other than the dry land, the communities also develop rice fields on the flat river banks or flat narrow valley. The rice field is about 25 hectares in scattered area that is harvested once a year. It is due to the limited knowledge of the farmers and limited condition of the means of production. The water needed for the rice field is obtained from the river by building a simple weir system (semi-permanent irrigation canals) using wood, branches, and tree trunks to deflect the river flow. The water is conveyed by the canals made with soil and stone walls. People build distribution canals and secondary canals on non-permanent basis in the form of trenches from the area around the rice field (Figure 4).

Figure 4. Non-Permanent Dam

Tanini's staple food is rice. The villagers cultivate it themselves and purchase it from outside the village. Almost all of the self-produced rice is used for their own consumption, not for sale. When the rice harvest is not sufficient, people will consume cassava for staple food. They buy the rice at the rate of 12,000 to 15,000 rupiah per kg. If each household needs about 1 kg of rice per day, Tanini needs approximately 848,990 kg of rice per year. It means that the inhabitants and farmers in Tanini are not yet able to fulfill their basic needs related to the production of rice. The public demand for rice is very high but the production is low. The production capacity of the paddy fields is only between 1.5 to 2.5 tonnes of dry unhusked rice per hectare per planting season. It is due to: (1) the limited area of paddy fields; (2) the limited availability of subsidized fertilizer; (3) the limited capacity of paddy field that produces only once a year; (4) the low ability of farmers in terms of farming techniques; (5) the limited supply of seeds in good quality. Tanini village has a great potential in livestock farming because it has vast grazing land. The majority of the communities raise cattle by rearing them in the wild. Each head of household has 4 to 100 cows. Most of the types of the cattle are Bali cows, with higher female population than the male (the ratio is 5 females: 1 male). Cattle-raising is a side job for the villagers, so they do not give special treatment to their cattle. They release the cows to feed themselves and let them to breed naturally. Livestock ownership is a form of savings for the villagers. If their family needs money, they will sell the cattle. They do not have a specific benchmark nor perform an accurate assessment in buying and selling cattle. All cows less than one year of age are sold at the rate of one million rupiah while 2 years old cows had the rate of Rp 3,500,000. When compared to the price of Bali cows of the same age and the average weight of 200-250 kg, the price is relatively low.

Development program of resource potential for food-secure region

Most rural communities rely on agribusiness. The development of agricultural sector should be directed to the agribusiness system. This approach will be able to increase the added value of agricultural sector and the income of the agribusiness community. The economic sector in rural areas has good potential to strengthen people's economy (Syahza, 2013). Based on the mapping of existing natural resources and the needs of food, several programs are needed to develop Tanini into food-secure village. The programs can be specified as follows:

(1) **Agriculture and livestock productivity development** to improve the income of the villagers and farmers, **infrastructure development** such as the construction of dam and primary or tertiary irrigation canals. The **improvement of the means of production** is also required in addition to seeds in good quality and subsidized fertilizer. Agricultural production tools like hand tractor, power trasher, and rice milling unit are necessary to increase agricultural productivity. **Semi intensive livestock system** can be applied**:** cows are put into cowshed at night but released to graze at noon for feeding efficiency and utilization of vacant land. The **optimization of** l**and potential** can be carried with cassava or local fruit cultivation by improving the quality of seeds and cultivation techniques to optimize the production.

(2) The **needs of water for agriculture and livestock** can be fulfilled by **building water reservoirs** to collect rain water and **utilizing river water** by blocking and accumulating it, then designing its distribution system to the citizens, as well as planning further studies to **utilize the ground water basin**.

(3) The **improvement of community's capacity** is the key point in the region's development program. It can be achieved with many ways, including **farmer capacity building** to increase their productivity, or capacity building **to improve the knowledge of mothers on the daily consumption of nutritious foods** for babies and toddlers to reduce the proportion of stunted children under 5 years. **Community empowerment in improving welfare** is the basis of motivation to build a program needed in upgrading the capacity of communities, ranging from hardskill to softskill.

The intervention programs should run effectively and efficiently in accordance with the plan described by framework chart based on outputs, outcomes, baseline data, and indicators (Figure 5). The framework map is then used as the basis of developing the baseline and indicators of food-insecurity (Table 2) as well as program planning (Table 3 *on appendices*) as a form of detailed elaboration of intervention programs in Kupang district.

Table 2. Baseline Indicators of Food-Insecurity in Kupang District

Outcomes	Indicators	Baseline	Target
To lower the food-insecurity level of the district from priority 3 to priority 5	Children under five years of age with stunting issue	54.4 % (priority 1) showed very high prevalence	Decrease into 20 % or in a range between 20 – 30 % (priority 3) which showed moderate prevalence
	Percentage of people living under poverty line	24.71 % (priority 3) showed moderately high percentage of people living under the poverty line	Decrease into 10 % or in range between 10 – 20 % (priority 5) which showed low percentage of population in poverty

Source: processed data

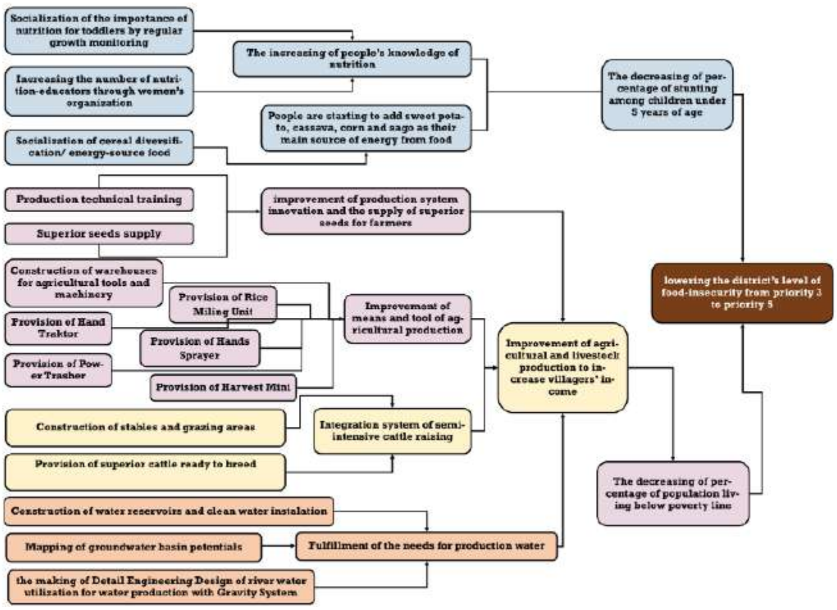

Figure. 5 Intervention Programme Framework Scheme of Baseline and Indicator Food Vulnerability

Analysis of intervention program on food-insecurity map's indicators

If done optimally, the planning program will be able to lower food-insecurity in Kupang district from level 3 to level 5. The analysis was performed by the calculation of nine indicators with a change of 2 priority indicators for intervention programs, namely the prevalence of toddler stunting and the percentage of people living below the poverty line. The calculation led to two changes of these indicators with the estimation made on the basis of planning program and the achievement of outputs and outcomes. The determination of priority based on the composite indicator of food-insecurity is shown in Table 4. On the basis of composite score in 2015, Kupang was classified at level 3 in food-insecurity. However, with the estimation of program planning, in 2021 the composite value of Kupang district will be lower, at level 5 in food-insecurity. The composite table in determining the level of food-insecurity is shown in Table 5.

Table 4. Estimation of Composite Score Before and After Interventioncx Program

No	**Indicators**	**Value**	**Indicator score**	**Composite score (2015)**	**Indicator score**	**Composite score (2021)**
1	Children under the age of five with stunting issue	0.40	54.4	21.76	20	8.00
2	Normative consumption per capita to net cereal production	0.54	0.35	0.19	0.35	0.19
3	Population living below poverty line	0.74	24.71	18.29	10	7.40
4	Villages without accessible roads or waterways	0.42	9.46	3.97	9.46	3.97
5	Households without access to clean water	0.23	39.86	9.17	39.86	9.17
6	Percentage of households without access to electricity	0.46	19.79	9.10	19.79	9.10
7	Life expectancy at birth	0.22	66.94	14.73	66.94	14.73
8	Percentage of village with access to health facilities more than 5 km	0.40	19.69	7.88	19.69	7.88
9	Percentage of female illiteracy	0.31	19.68	6.10	19.68	6.10
Total Score				**91.18**		**66.54**
Priority				**3**		**5**

Source: processed data

Tabel 5. Composite Score of Priority FSVA

Priority	**Composite Score**
Priority 1	>= 140
Priority 2	114 - < 140
Priority 3	91 - < 114
Priority 4	68 - < 91
Priority 5	47 - < 68
Priority 6	0 - < 47

Source: Food-Security and Vulnerability Atlas Indonesia 2015 by World Food Programme

4. Conclusion

Kupang district has 3 sub-districts that are most vulnerable to food-insecurity (priority 1): Semau, South Semau, and Takari sub-district. The determinant key of the food-insecurity and categorization as priority 1 are: (1) the high percentage of people living below the poverty line, (2) the high underweight rate among children under five. Viewed from the aspect of natural resources, Kupang district has great potential for business venture in agriculture and animal husbandry as the pivot of the community in improving their welfare. The programs to overcome the problem of food-insecurity are: the improvement of knowledge on the importance of nutrition, especially to reduce the prevalence of stunting infants, and the enhancement of agricultural production and livestock farms to increase people's revenue and reduce the percentage of people living in poverty. The analysis done by estimating the composite value from World Food Programme showed that after the intervention, the value of Kupang's original composite turned from 91.18 (priority 3) into 66.54 (priority 5). According to the analysis to design the effective and efficient programs, the map of food-insecurity from the World Food Programme has a big role in planning the food-insecurity reduction.

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Appendices

Table.3 Program Planing Matrix of Food Vulnerability Level Reduction in Kupang District

Indicator	Baseline	Target					Program Kegiatan	Input	Output
		2017	2018	2019	2020	2021			
Decreasing of Stunting Prevalence Among children under 5 years of age	51,4 %	45 %	38 %	31 %	26 %	20 %	Socialization of toddler nutrition importance through regular growth monitoring	Funding, Nutrition Socialization for mothers with toddle	80 % The mothers with toddle understand and apply nutrition Knowledge
							Add Nutrition Educator through woman organitation	Funding and Nutrition Educator Training	Election 3 nutrition educator agen from residents in every village
							Socialization of Serealia Diversification Energy sources Food	Socialization of Food Sources of Energy	People are starting to add yams, cassava, corn and sago as main food of Energy source
Decreasing Population living below poverty line	20,06 %	18 %	16 %	14 %	12 %	10 %	Innovations Supply System of Superior Seed for farmers	Production technical training (1package)	80 % Farmer group with intervention program understand and implements cultivation innovations system
								Add Paddy Seeds, (total 100kg/group)	Increase Farm Production and Livestock Production to Increase Villagers Income up to 50%
							Increase Means and tool of agricultural production	construction of Alsintan warehouses (1unit/group)	
								Provision of Hand Traktor (5 unit/group)	
								Provision of Power Trasher (3 unit/group)	
								Provision of Hands Sprayer (7 unit/group)	
								Provision of Rice Miling Unit (1 unit/group)	
								Provision of Harvest Mini (2 unit/group)	
							Integration System of cattle half intensive	Construction of stables and grazing areas (2 unit/group)	
								Provision Excellence breeders Cattle (20 Ekor/group)	
							fulfillment water to production	Construction small dam and clean water instalation (5 paket/Village_4mx3mx3m)	
								Potential Mapping of Groundwater Basin (1 package)	
								Make *Detail Engineering Design* of River Water Utilization For Water production with Gravity System (1 Package)	

Integration Model of Productive Enterprises for Innovation Adoption in Livestock Farming in Argorejo and Argosari Village, Sedayu Sub-District, Bantul District, Special Province of Yogyakarta

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Abstract

Adoption of innovation is a process of mental or behavioral changes in the form of knowledge (cognitive), attitudes (affective), and skills (psychomotor) since one recognizes the innovation until one decides to adopt it after receiving it. Integrated livestock development is a model of integrated resource management by integrating livestock and crop in accordance to the areas developed by community with bio-industry and eco-friendly (zero waste) orientation. The study of "innovation adoption of integrated farming" was a case study in Argorejo and Argosari village, Sedayu sub-district, Bantul District in Yogyakarta. Its aim was to explain the process of innovation adoption of integrated farming to encourage the development of productive enterprises that led to the improvement of the local economy and the development of rural areas. Using descriptive analytical method, the data obtained through interviews and focus group discussions related to the innovation adoption of integrated farming was described to define the aspects of who, what, when, and how in group activities. The results of the study formulated the concept of innovation adoption model in integrated farming to develop the rural areas effectively and efficiently by preparing a development program. The program was based on local wisdom as a reference for the empowerment program which included technological training, institutional strengthening, and mentoring program designed to produce innovation agents to conduct the adoption. The concept arose over the adoption process carried out by members of the group to create business activities that were integrated vertically and horizontally which would in turn increased the revenues of members of the business group.

Keywords: adoption, innovation, vertical integration, horizontal-integration, livestock)

1. Introduction

The availability of food and energy is a crucial and classic issue for all levels of government. The challenge of food security is food import dependency because food is the basic need to be provided adequately in quantity and quality based on the indication of population which was projected to continue to grow rapidly. The availability of energy is needed in the future. The nations of the world will face competition to earn the sources of livelihood related to food and energy which are limited. Livestock is a source of food, energy, and economics, and it encourages the potential development of other local resources. Most farmers in Indonesia had not yet made the most of various resources available in their farming businesses system (Prawiradiputra, 2004). In fact, the farm management by the community had not yet been able to contribute optimally to the provision of food sources from animal in the country. Its competitiveness in the economy was also lower than any other commodity because people had not been able to properly manage its great potential for livestock resources and the utilization of animal wastes into valuable trading products that are environmentally friendly (organic fertilizers, renewable energy sources in the biogas process, mushroom media, processed fish feed, and other valuable trading products).

Innovation is an idea, practice, or object that is considered or deemed new by individuals (Rogers, 1962), while adoption is the process of starting and expressing the ideas of one party to another, until the idea is accepted by the society as the second party and affirmed further by practicing it or not adopting the innovation as new ideas (Rogers, 1983). The development of innovation can be used as the driver of changes in all aspects of the community life for the realization of improved quality of life of each individual and all citizens concerned (Mardikanto, 2010). In essence, the adoption of innovation is a process of mental or behavioral changes in the form of knowledge (cognitive), attitudes (affective), and skills (psychomotor) since one recognizes the innovation until one decides to adopt it after receiving it. One of the most marked features of today's world is a rapidly changing technology. Therefore, the techniques and methods of livestock management and agriculture need to be increased at every stage of the process that leads to bio-industry, although the technological innovations being presented to farmers have been countless (Tatlıdil, 1997).

Livestock is an enterprise that has the potential to improve the welfare of rural communities because the resources are available locally and superbly maintained by communities. Innovation is needed in the management of an effective and profitable farm, so the farm enterprises developed by the communities are able to increase their productivity and produce high quality products that are highly competitive in the market. In this case, the farm is the main base of integration development. The development of integrated livestock farming is the management model of featured local resource’s potential in rural areas, integrated with the cultivation of productive crops that have economic value (livestock-crop integration), business-oriented, and environmentally friendly (zero waste) according to the potential of development areas held by the local community.

The implementation of integrated management model that combines the management of natural resources and human resources is more efficient so it can produce maximum benefit and contribute greatly to the development of growth centers, improve the welfare of rural communities, and support food security and national economy. The adoption and innovation of integrated livestock farming carried by the intervention program called Mandiri Bersama Mandiri (MBM) to productive groups in Argorejo and Argosari village, Sedayu sub-district, greatly helped to speed up the transfer of appropriate technology and add value to the product being developed. The research of Beckford and Barker (2002) indicated that the weakness of institutional strategies in information dissemination regarding the adoption of innovation were the key issues of the emergence of negative views among the majority of farmers. The institutions involved in the information dissemination should build a partnership with farmers, as well as take local knowledge into account in order to create a system that is beneficial to farmers (Leeuwis and Van Den Ban, 2004).

2. Methods

This research was a case study of the process of innovation adoption in integrated livestock farming in Argorejo and Argosari village, Sedayu district with qualitative approach and using descriptive analytical method to describe the phenomenon of the innovation adoption to study the aspects of who, what, when, and how of a topic (Donald & Schlinders, 1998). The data was collected through interviews and focus group discussions with the selected informants from the group members and the community of Argorejo and Argosari village. Both villages were the site of the development program Mandiri Bersama Mandiri (MBM). The data analysis described the process of innovation adoption and the livestock farm-based integrated business model, and its contribution to economic improvement. The data was analyzed using the measures of Tadjoer (2004), namely: 1) data collection; 2) data reduction; 3) display of data; 4) verification and conclusion drawing.

3. Results and Discussion

Analysis and adoption discussion on the innovation of integrated livestock farm

The productive business activities of the community groups in MBM program of Argorejo village were shown in the group's activities scheme: 1) production: organic fertilizer, feed fish, and mushroom media baglog[11]; 2) cultivation: rice, mushrooms, catfish farming, and economic commodities cultivated in the yard (Figure 1). The productive business activities of community groups in Argosari village was reflected in the group activities: 1) the production of poultry feed; 2) cultivation: rice, chicken farming, goat breeding and fattening (Figure 2). The activities showed schematically that the groups had a relationship of mutual support and they established the farm-based synergistic productive business that were integrated vertically and horizontally.

Figure 1. Sketch of Business Activity Integration in Argorejo village, Sedayu, Bantul

Figure 2. Sketch of Business Activity Integration in Argosari village, Sedayu, Bantul

Innovation adoption in the development of productive business activities

The innovation adoption of integrated livestock development in MBM program had given effect to the productive activities of community groups, and the result could create potential development opportunities for featured local resources into the real economy. The example of the innovation adoption was shown by the group of Mekar Harapan in Metes hamlet in the production of organic fertilizer. The cow manure in Argorejo village did not have high economic potential before because it was sold "in a raw state" to the vegetable growers in mountainous regions of Dieng and Temanggung, Central Java. The process of innovation adoption had helped the villagers of Argorejo to manage livestock waste that used to be left around the cattle-pen (cow), resulting in the decreased comfort and health of the environment. They made it into organic fertilizer that could help in the cultivation and production high quality and healthy rice.

Innovation adoption of integrated livestock farm in increasing the revenue

The benefits of innovation adoption in integrated farm management were to increase the productivity and added value, as well as to foster new business activities and employment that had impact on improving welfare. The development of integrated livestock farm would be conducted effectively according to the concept if the adopter developed and adopted the related productive business activities that had more value than the conventional farm activities. The integration patterns applied by the productive business groups in MBM program was using a strategy and approach to the process of vertical and horizontal integration. The pattern of vertical integration was applied by the adopter on the productivity of business activities, and it was

1 Mushrooms media planting in the final stages of the nursery process before the mushrooms in the harvest

able to gain advantage in both the fulfillment of the supply chain and the business development. The horizontal integration was an amalgamation of several business activities that had the same production process and the resulting products were also similar (Hasibuan, 1993).

Assistance in the adoption process and institutional strengthening

The main doers of the innovation adoption in integrated livestock farm were groups of people. Therefore, the increase of the capacity of human resources (HR) to create a productive culture was important and strategic for the success of economic improvement in optimizing the management of featured local resource's potential. The competency of group members needed to be improved in the mastery of knowledge and skills, and in the development of business sectors developed by the group. The emphasis for the facilitators in the improvement of human resources competence was not to let the group members adopt a knowledge and technology that were not structured. The facilitators in MBM program should prepare the innovators from the group as both pillars and parameters that would easily be a reference in adopting the other group members. The principle tasks of the facilitators in mentoring were to cultivate the values or principles of agribusiness and to bring up the strong motivation in the efforts to increase the revenue for the community to develop business together. The strengthening of productive business groups to become the expanding and independent institutions was directed to focus more on the aspects of human resource management, financial management, and business legality.

Vertical integration activities in livestock farm development

The activity of vertically integrated livestock development was a merger between companies or business activities that had a continuing production process, both in the upstream and the downstream (Hasibuan, 1993). The activities of productive business groups in MBM program in running the vertical integration were illustrated in (Figure 3).

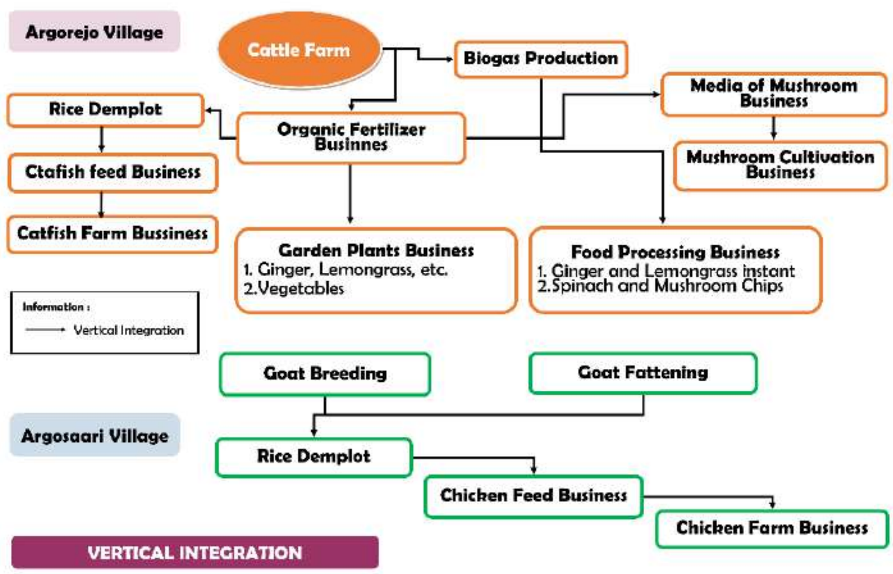

Figure 3. Scheme of Vertical Integration in Argorejo and Argosari Village

The production of organic fertilizer, the rice cultivation, and the cultivation of crops in the yard Production of organic fertilizer. The business activities in producing organic fertilizer were based on the strong desire of the community groups in Metes hamlet to independently meet their needs for fertilizer in Argorejo village, and based on the potential of livestock waste from about 90 cows in their region. Technically, by assuming that the production of manure was 20-25 kg/cow/day, there was about 1800-2200 kg of raw material for organic fertilizer per day, or about 5.40 to 6.75 tons of raw materials per month. The production of organic fertilizer by the community in Metes hamlet (Mekar Harapan group) was intended to: 1) utilize the livestock waste to produce environmentally-friendly products with economic value; 2) fulfill the needs of organic fertilizer in balanced fertilization program, to maintain the fertility of paddy fields in Argorejo village and the surrounding areas; 3) promote the integration of livestock development activities with the development of organic farming, resulting in the added value of livestock development through waste management, the increasing income, and the clean and healthy environment.

Rice cultivation. The communities of Argorejo and Argosari village had applied new technology in paddy cultivation after the adoption of innovations, such as: 1) "legowo" planting patterns (many farmers had applied it; it is planting pattern that considers the distance between plants, the optimum exposure of the sun light, and more); 2) composting; 3) production of organic pesticides; 4) support of equipment and materials for agricultural production such as tractors, paddy seed, and other crops of economic value for various community resources in productive enterprises to produce a variety of food products and to increase the revenue. The organic fertilizer products made by Mekar Harapan group in Metes hamlet, Argorejo village, could be utilized in the application of balanced fertilizer for 169 hectares of paddy fields in Argorejo village and the surrounding areas. About 37 hectares of arable land that belonged to the Argosari's farmer groups in MBM program and the potential agricultural land of the community outside the MBM group also utilized the organic fertilizer produced by Mekar Harapan group in Argorejo village.

Cultivation of crops in the yards. In Polaman hamlet, the Women Farmer Group developed a pilot project of the utilization of the yard to grow agricultural crops of economic value by applying the organic fertilizer produced by Mekar Harapan group. The most important benefits of growing the yard with crops for the communities of Polaman hamlet were: 1) the fulfillment of the needs of family kitchen, such as vegetables and spices, thereby reducing the household expenses; 2) the improvement of family income by selling the harvest from the yard and the processed products; 3) the creation of a beautiful and healthy environment by the utilization of the waste into compost that was made independently. The management of the yard for growing crops was still conducted partially with various types of plants to meet the needs of family consumption. In the future, the development of their economic prospects could be built in groups with the leading commodities focused on economical scale, such as: 1) vegetables (cabbage, eggplant, beans, chilies, tomatoes, and more): 2) medicinal plants (turmeric, ginger, lemongrass and others); 3) fruit crops and plantations crops (longan, rambutan, jackfruit, mango, guava, sapodilla, or chocolate). The result can be gathered collectively to be sold through the group, village cooperatives, or village-owned enterprises (BUMDesa).

Baglog production and mushroom cultivation. The business activity of baglog-making for mushroom media was developed by Surya Mandiri group. The Women Farmer Groups in MBM Program utilized 1,200 pieces of baglog produced by Surya Mandiri group each month for mushroom cultivation activities in Polaman hamlet; the community groups in Metes hamlet also. The horizontal integration was built in the supply chain of business developed between groups: the development of baglog business could meet the speed of supply, the guaranteed quality of the baglog could meet the needs of the community, and it was followed by mushroom cultivation by villagers of Argorejo, resulting in the creation of employment opportunities as the provider of raw materials for baglog and as processor in mushroom production. The development of mushroom cultivation by Women Farmer Groups expanded into 2 mushroom growing houses with the capacity of 3,000 baglogs that could be harvested three times a year (before, the group had mushroom business capacity of 700 baglogs in one mushroom growing house). Mushroom was also cultivated by individuals who initially only produced 200 baglogs but then grew into 500 baglogs. Mushroom cultivation as business activity had grown rapidly after the intervention program enhanced the skill and technique in making mushroom media baglog, in mushroom cultivation until post-harvest, in the development of processed mushroom products. The Women Farmer Groups had also created mushroom processed product diversification in the form of crackers and other snacks.

The Impact of biogas installation management on cultivation and postharvest. Biogas installation in Polaman hamlet was managed by Women Farmer Groups. The raw material of biogas was the existing manure from the communities. The knowledge and skills in managing the biogas installation were acquired from the facilitator's innovation adoption. The livestock manure was processed into biogas that produced energy for fuel, and the solid residue (sludge) could be used as organic fertilizer or as compost for the needs of group members. Biogas was produced to meet the needs of fuel in the families, in lieu of the LPG commonly purchased by the villagers. Horizontal integration occured in the use of solid sludge produced in biogas installation that was used as an ingredient of compost or organic fertilizer to maintain soil fertility, to grow plants in yards and land development in small scale by Women Farmer Groups, as well as material for mushrooms baglog. As the efforts to increase the added value, the Women Farmer Groups developed the diversification of processed products such as: 1) ginger powder, instant lemongrass and kaempferia galanga without chemical preservatives, made by reducing the water content for longer storage; 2) processed mushroom products such as mushroom crackers and snacks with high quality and competitiveness in the market.

Production of fish feed and catfish farming. Catfish food pellet production with local raw materials was used by Women Farmer Groups in catfish farming, which was done in two systems, namely: 1) three ponds belonged to the group as pilot project, carried out on a small scale with the capacity of 9,000 seeds; 2) catfish ponds maintained by individuals with the seeds obtained from the group and utilized the fish food pellets made by the group.

Horizontal Integration in Food Products Processing

This concept was the development of some companies or business activities that had the same production processes and the products were also similar. The activities include: 1) business activities of mushroom products, by developing a mushrooms product differentiation such as mushroom chips; 2) the ginger plant in homeyard was developed into instant processed ginger; this process made the added value and increased the selling prices compared to ginger products that were sold directly as raw materials; 3) business activities of goat breeding and fattening that had the same product, differing only in the maintenance management that affected the output of the business activities. The schematic illustration of horizontal integration in Sedayu sub-district was shown in Figure 4.

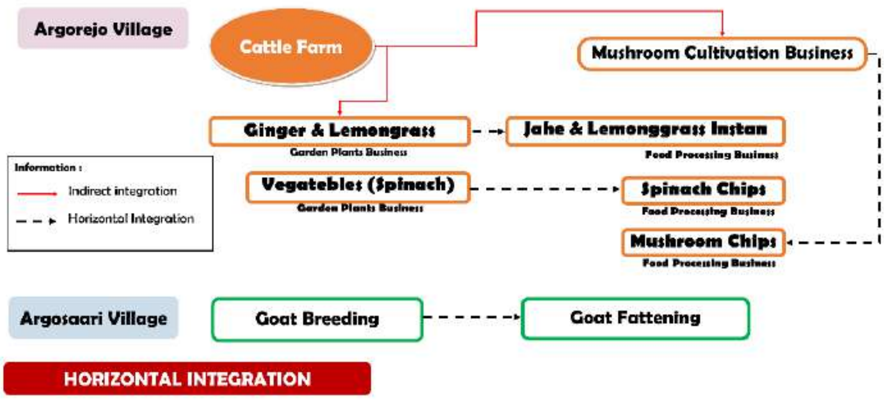

Figure 4. Scheme of Horizontal Integration in Argorejo and Argosari Village

Development of processed mushroom products. Horizontal integration had been built in the supply chain of the business developed by the group that produced baglog to meet the supply speed and provide quality-assured baglog for the mushroom cultivation by the villagers of Argorejo. The supply chain of baglog production to meet the needs effectively and efficiently was already well established, followed by mushroom processing activities as an effort to increase the added value, such as the production of mushroom crackers and other snacks as an optimal source of public revenue. The implementation of the innovation adoption developed the packed refined products for durability and attractive appearance for the consumer. It made the group's business activities more effective and efficient since the mushroom crackers products had high quality and was hygienic so it was competitive in the market. It would in turn increase the added value in mushroom business developed by the group and led mainly to the economical-scaled business activities and the increasing of quantity with the market's standard and access.

The development of instant ginger product. The innovation adoption in the development of garden plants was pushed to diversify the processed products, so as to create the increase of added value organized by community groups. The innovations adoption that was made included the packaging of processed products and the skills in processing the food products in the

Household Industry Development program, organized together with the Department of Health. One of the diversified development of processed products managed by Women Farmer Groups was the processing of instant ginger powder. It became the basis for the creation of integration activities in the group's business. The activities of garden plants development made the horizontal integration within the same group, which was Women Farmer Group, but with different activities to produce differentiated products in the form of instant ginger.

Goat breeding and fattening. Goat business development through breeding patterns in Kalijoho and Klanggan hamlet, Argosari village, was conducted with centralized maintenance pattern in communal cattle-pen (cow) with special treatment for the cattle (cow). The centralized maintenance was meant to utilize the waste or livestock manure by processing it into compost and other products that were environmentally friendly, and brought the added value in developing goats. The results of goat breeding were then continued by the goat-fattening group with a revolving system. For the feed supply to meet the needs of protein and the maintainance of cattle (cow) development, the group was taught to produce preserved processed feed so it can always be provided. The innovation adoption of integrated livestock farm that were studied by the groups were: 1) feed fermentation technology: the preservation of feed in order to increase the feed quality and it could be used as a backup supply in a sustainable manner; 2) livestock waste treatment technology with EM4 use for the production of organic fertilizers efficiently: this innovation was adopted since it was beneficial for the land management and maintain the fertility of agricultural land. The horizontal integration patterns were applied to the management of activities, upstream to downstream, from the preparation of raw materials, processing, packaging, and marketing as created through horizontal integration: 1) the diversity of productive activities; 2) various sources of income; 3) the increasing added value; 4) employment and new business opportunities.

Recommendations for the Concept Preparation of Integrated Activity Development Model

Integrated activities was a model for the innovation development of business activities based on local resources, in order to resolve the problems and difficulties associated with increased productivity and added value. The development of the integrated activities will be effective if done in accordance to the concept of "Integration Model of Productive Business Activity on the basis of Livestock" shown in Figure 5.

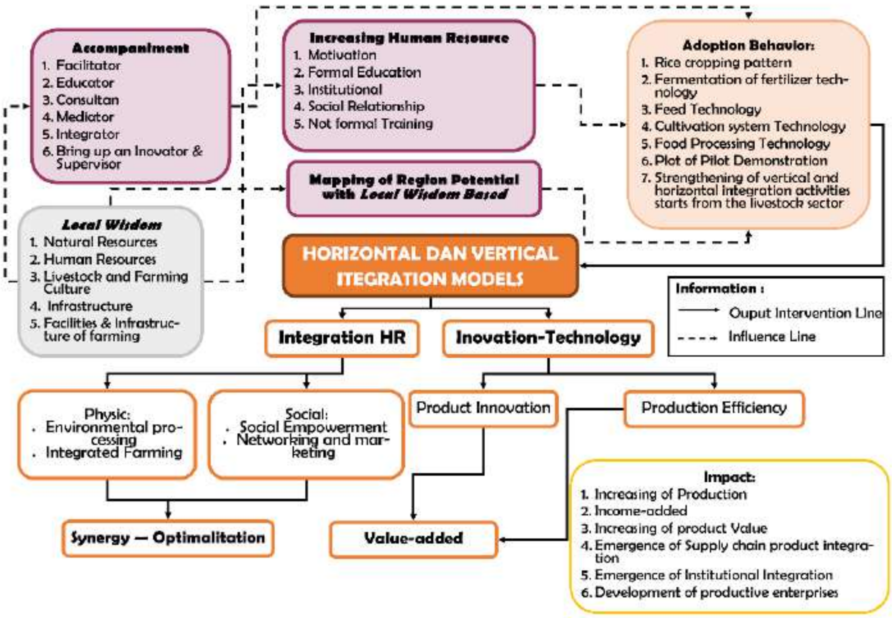

Figure 5. Scheme of the Formulation of Integrated Activity Development Model

The community empowering with a "total solution" approach that was facilitated by MBM program in Argorejo and Argosari village had shown the progress of the farm-based productive business which was synergistic and integrated with agricultural development and generated other creative economic activities that were managed by local community to increase their income. The scheme of the concept explained the integration approach (vertically and horizontally) of the activities of a productive business group. It was the basic principle or the main aspect of the independent community empowerment and competitive rural development. The community involvement as a major potential for self-development did not make the facilitator as the focal point of the empowerment, and it created the adoption behavior to achieve an impact as the main purpose of the model. The implementation of the concept in question refered to the characteristics of local wisdom or local knowledge which, according to Gobyah (2009), was the truth that has been a tradition or always exist in an area. It was all forms of knowledge, belief, understanding, insights, and customs or ethics that guided human behavior in life in an ecological community (Keraf, 2002).

The development model of business activities which were integrated horizontally and vertically is shown in Figure 5. The implementation of activities began with the stages of: 1) the mapping and preparation of action plan for the development of featured resources potential (natural and human resources), the facilities and infrastructure supporting the development of productive and creative economic ; 2) capacity building of human resources through training, mentoring and pilot project; 3) the strengthening of institutional group to support business management, production, and product marketing; 4) the facilitation of the productive enterprise development by encouraging the integrated activities vertically and horizontally; 5) the assistance in improving the competence of group members through a medium called the facilitators.

4. Conclusion

The adoption of innovations is the demanding need in optimizing the management of featured local resource’s potential to become the real economy which was managed by community groups in rural areas. To execute the sustainable innovation means to create added value in the business being developed so it becomes profitable and sustainable. The innovations in integrated farm development is the development of productive activities based on natural resources starting from the livestock farm to support the activities of other leading potential such as agriculture, plantation, fisheries and other resources. The innovation adoption in integrated farm through the facilitation of increased knowledge, skills and the support of infrastructure have been able to encourage the development of productive enterprises, increase the added value, and brings up various additional revenue source. The role of the facilitators and assistants is to transfer the applied technology as innovation by developing productive activities. They are also the integrator that integrates activities between the groups to drive the synergy and integration of activities both vertically and horizontally. The concept of innovation adoption in integrated farm in rural area development needs the mapping and preparation of local wisdom-based program that includes technological and institutional training, the enhancement of human resources, and mentoring programs that brings up innovator agents who conduct the adoption. The process led to the adoption process carried out by group members to create business activities that are integrated vertically and horizontally and resulting in the increased revenues of the members of the business group.

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Novel technological and management options for accelerating transformational changes in rice and livestock systems

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Abstract

Agricultural producers grapple with low farm yields and declining ecosystem services within their landscapes. In several instances, agricultural production systems may be considered to be largely unsustainable, in socioeconomic and ecological (resource conservation and use and impact on nature) terms. Novel technological and management options that can serve as vehicles to promote provision of multiple benefits, including improvement of smallholder livelihoods, are needed. We call for a paradigm shift to allow designing and implementing agricultural systems that are not only efficient (serving as a means to promote development based on the concept of creating more goods and services while using fewer resources and creating less waste), but can also be considered synergistic (symbiotic relationship between socio-ecological systems) by simultaneously contributing to major objectives of economic, ecological and social (equity) improvement of agro-ecosystems. These transformations require strategic approaches that are supported by participatory system-level research, experimentation and innovation. Using data from several studies conducted, we here provide evidence for technological and management options that could be optimized, promoted and adopted to enable agricultural systems to be efficient, effective and, indeed, sustainable. Specifically, we present results from a study conducted in Colombia, which demonstrated that in rice systems, improved water management practices such as Alternate Wetting and Drying (AWD) could reduce both water input and methane emissions (~70%). We also show how women can play a key role in AWD adoption. For livestock systems, we present *in vitro* evidence showing that the use of alternative feed options such as cassava leaves contribute to livestock feed supplementation and cost-effective reduction of enteric methane emissions (22-55%). We argue that to design and benefit from sustainable agricultural systems, there is a need for better targeting of interventions that are co-designed, co-evaluated and co-promoted with farmers as allies of transformational change (as done in the climate-smart villages), not as recipients of external knowledge. Moreover, for inclusive sustainability that harnesses existing knowledge and influences decision-making processes across scales, there is need for constant, efficient, effective and real trans-disciplinary communication and collaboration.

Keywords: Rice, Livestock, Cassava leaves, Forage, Greenhouse gases.

1. Introduction

To address the challenges faced by farmers in Latin America and the Caribbean (LAC), the International Center for Tropical Agriculture (CIAT) and its partners are currently working within the framework of climate smart agriculture (CSA). The CSA approach is defined as agriculture that (a) sustainably increases agricultural productivity and incomes; (b) improves adaptation and builds farmer resilience to climate change; and (c) reduces and/or removes greenhouse gas (GHG) emissions where possible (FAO, 2013). The process of scaling CSA builds on a theory presented by Lipper et al. (2014), who proposes four key types of partnerships for change which include: (a) implementing partners and local organizations, to build science-based evidence; (b) climate risk management service providers and National Agricultural Research and Extension Systems (NARES), to explore possibilities to strengthen institutions and services through better use of climate information; (c) policy partners to gain insights for improved agricultural policy and governance; and (d) large agencies and companies driving implementation, to understand opportunities and possibilities for stable and strategic investments.

Consideration of the socioeconomic and cultural aspects is important as it leads to better understanding on how social differentiation can affect or influence the adoption of CSA options and how the CSA options may impact farmer relationships. For example, in most farming communities, women have different needs, preferences, constraints and responsibilities compared to men (Huyer et al., 2015), in part, due to the gendered roles and the inequalities in accessing and controlling key agricultural resources (Bernard et al., 2016). Therefore, understanding intra-household allocation of productive resources and gender-based constraints to adoption of CSA options is crucial for scaling. Additionally, for assessment of men and women farmers' needs, researchers and development practitioners must examine how the introduction of a CSA option may increase or decrease the labor requirements of men and women farmers in different agricultural sectors (World Bank Group, 2015).

In the cattle sector, CIAT and partners are promoting the concept of LivestockPlus. The LivestockPlus concept is based on three interrelated intensification processes namely, *genetic intensification* – utilization of superior and well-managed forage grass and legume cultivars for increased livestock productivity; *ecological intensification* – adoption of improved farm and natural resource management practices; and *socio-economic intensification* - the enhancement of institutions and policies, enabling technological changes and supporting their use (Rao et al., 2015). To operationalize this concept, technological, management, policy and cultural changes are needed at several steps along the cattle value chain. Technological options that have been promoted in the past include use of tropical forage grasses such as *Brachiaria humidicola* that contribute towards increased cattle production (Lascano, 1991), carbon sequestration (Fisher et al., 1994) and a reduction in nitrogen fertilizer use and urine-based nitrous oxide (N_2O) emissions (Brynes et al., 2017; Subbarao et al., 2009). As enteric fermentation represents the largest anthropogenic source of CH_4, an indicator of feed inefficiency (Kamke et al., 2016), there is an urgent need for disruptive CSA options that improve feed utilization and, consequently, mitigate CH_4 emissions.

In the rice sector, a consortium including CIAT, the National Federation of Rice Producers (FEDEARROZ), the Latin American Fund for Irrigated Rice (FLAR), the Ministry of Agriculture and Rural Development (MADR) and the Ministry of Environment and Sustainable Development (MADS), is proposing options to reduce GHG emissions from the rice supply chain through more efficient water management practices within the Massive Adoption of Technology (AMTEC) programme. The main goal of AMTEC is to transfer all available advanced soil and crop management and technological options to increase productivity and reduce production costs within a period of five years with a minimum environmental impact (FEDEARROZ, 2016). Within the AMTEC, the rice consortium presupposes that the adoption of improved water management practices will be based on four key pillars: (a) increased farmer awareness, (b) improved water distribution systems, (c) on-farm control of water resources, and (d) identification of incentives for water savings.

Alternate Wetting and Drying (AWD), is a management strategy characterized by an intermittent irrigation schedule that alternates flooded and non-flooded conditions. This practice can reduce water inputs (and possibly irrigation costs) and lower methane (CH_4) emissions as aerobic conditions largely eliminate the activity of methanogenic bacteria (Adhya et al., 2014). Since water management practices within the AMTEC programme share similarities with AWD, promotion of the latter in Colombia can be done through merging the two practices to develop a more advanced best-fit water management practice that takes into consideration prevailing socioeconomic and biophysical conditions.

Soil types and properties vary across landscapes and thus function differently depending on their biophysical properties and applied management. Understanding soil variability is critical for improving the targeting of management and technological options that enhance crop and livestock productivity and promote the efficient use of costly inputs, such as fertilizers. Access to recent innovations has allowed soil experts to integrate current technologies (e.g. satellite images, digital elevation models) with soil data, to provide continuous soil property maps at high resolution that allow decisions at local and/or regional level (Da Silva et al., 2016). Digital soil maps (DSM) provide detailed site specific information that informs management and technological choices for improving efficiency in resource use and conservation. However, due to the large quantity of soil data required to develop high resolution maps and the associated laboratory costs, accurate soil mapping efforts are normally beyond the reach of small farmers.

With a strong emphasis on gender, we focus here on understanding the socioeconomic and cultural context within which farmers operate and explore opportunities to sustainably reduce GHG emissions within cattle and rice production systems and also co-effectively target CSA options. Specifically, for the cattle sector, we take the forage research a step further and explore the possibility of cattle diets that include a tropical forage grass (*Brachiaria humidicola*) in combination with leaves of a root crop, cassava (*Manihot esculenta*) for reducing enteric methane emissions. For rice productions systems we present the first results of field measurements comparing methane emissions from flooded and improved water management in Colombia. We also provide evidence on the utility of a Pro-Poor Digital Soil Mapping (DSM) approach that uses available information combined with less intensive field sampling, to cost-effectively generate continuous soil property maps at high resolution. Finally, we discuss how lessons learnt in the Climate-Smart Villages (CSV) initiated by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) can be harnessed to create platforms where farmers, researchers and other stakeholders can work together as allies of change (CCAFS, 2016).

2. Methodology

2.1. Rice systems

2.1.1. Gender dynamics

During March and April, 2016, a farm household survey, which included 609 households, was conducted in five rice producing departments of Colombia (Tolima, Norte de Santander, Córdoba, Cesar and Casanare). The sample size represented 10% of the total number of farmers with irrigated rice, which was determined through the National Rice Census of 2006 conducted by FEDEARROZ. A sex-disaggregated research instrument was used to collect information on decision making, labor, and access to key resources, as well as limitations and incentives for the implementation of CSA options, such as AWD.

2.1.2. Monitoring CH_4 and N_2O fluxes in rice fields under AWD and continuous flooding

A field study was conducted at the FEDEARROZ Experimental Station "Las Lagunas" in Saldaña, Tolima (3°54'47,45'' N, 74°59'8,47''W, elevation: 350 m.a.s.l) during two cropping seasons (June-September, 2015, and March-June, 2016). The study region has mean air temperature, annual precipitation and relative humidity of 28°C, 1541 mm and 70%, respectively. The soil order at the experimental station is Inceptisol and has a sandy-loam texture with a bulk density of 1.6 g cm^{-3}, a pH of about 5.3 and an organic matter (OM) content of 1.4%.

The experiment was designed under the framework of technology transfer and cooperation between the Science and Technology Research Partnership for Sustainable Development (SATREPS) and FEDEARROZ. The experiment had a randomized block design with three replicates per treatment. The GHG evaluation, was conducted on two water management treatments (continuous flooding and AWD), that differed in the number of irrigation and drain events. During 2015 cropping season, continuous flooding (CF) treatment was irrigated 24 times while the AWD treatment was irrigated 17 times. During the wetter year (2016) the CF was irrigated 11 times while the AWD treatment was irrigated 5 times. Cumulative rainfall, during the growing season was lower in 2015 (10 mm) compared to 2016 (223 mm). We used the commercial variety FEDEARROZ-60, which was planted using direct seeding, as a test crop. In addition, the plots we used were fertilized with nitrogen at a rate of 180 kg N ha^{-1} which was split in doses of: 27, 45, 45, 36 and 27 kg at 12, 25, 35, 50 and 65 days after plant emergence, respectively.

Gas measurements during the first cropping season were conducted during the period from June 5 to September 24, 2015, and during the period from March 10 to June 17, 2016 for the second cropping season. During both measurement campaigns, gas sampling was initially aligned to fertilization with measurements being conducted one day before fertilization and for two consecutive days of post-fertilization. After the fertilization period, measurements were conducted weekly until harvest. All samples were taken in the morning (8:00 – 11:00 am). The method used for gas sampling was the static-closed chamber technique. Specifically, plastic buckets (114 liters in volume and 80 cm height) were used in combination with custom-made chamber bases (40 cm height) that included a canal which made it possible to have a water seal during chamber deployment. Vents were installed in the static chambers to avoid the creation of pressure differences between the inside and outside of the chamber during chamber deployment. A fan was also installed inside the chamber to ensure mixing of air within the chamber and that, at any given time, the sample (20 ml) collected using a syringe and stored in a pre-evacuated vial, was representative of air inside the chamber.

Methane and N_2O concentrations in the collected vials were analyzed by gas chromatography (Shimadzu GC-2014). The fluxes of each gas were calculated using gas concentration rate and sampling time (45 minutes) in combination with the ideal gas equation. The cumulative fluxes for the monitoring period were calculated using linear interpolation.

2.2. Cattle systems

2.2.1. Gender dynamics

The analysis of gender relations within the livestock sector was based on two exploratory studies conducted along the cattle supply chain (Arora et al., 2017). These studies were used to gain insights on the roles played by men and women in livestock production. In addition, the studies are used to predict potential impacts of climate change and the introduction of cassava leaves in cattle diets on the workload of men and women in small-scale livestock producing households.

2.2.2. *In vitro* experiment on cattle diets with cassava supplements

An experiment organized as a completely randomized design with three batch replicates per treatment was conducted using different combinations of swards of *Brachiaria humidicola* (BH) and cassava leaves from six genotypes (ME1 to ME5 and MP6) in different proportions: 100% BH, 50% ME1 to ME5 and MP6 + 50% BH and 100% ME1 to ME5 and MP6, giving a total of thirteen treatments. The genotypes of ME were COL 22 (ME1), BRA 12 (ME2), COL 1468 (ME3), COL 2246 (ME4), PER 239 (ME5) and PSE (MP6). Nutritional quality of the different combinations was determined according to methods of the International Organization for Standardization. Neutral detergent fiber (NDF) was determined following the method described by Van Soest et al. (1991) and acid detergent fiber (ADF) according to AOAC 973.18 (2010). Ash content was determined through direct incineration in a muffle furnace according to AOAC 942.05 (2005).

The *in vitro* gas production technique was conducted according to the methodology suggested by Theodorou *et al.* (1994). Specifically, 1 g of samples including leaves of BH and mixtures of BH with cassava leaves from six genotypes were incubated in 160 ml glass flasks with 85 ml of buffer solution and 10 ml of strained rumen fluid, obtained from two donor animals, and 4 ml of a reductor solution (Theodorou et al., 1994). The bottles were hermetically sealed and maintained in a bath maintained at 39^{o}C. Over 96 hours samples were incubated and readings of volume (V) and pressure (psi) were taken using a pressure transducer (*Sper Scientific, USA)* at nine different incubation times: 3 ,6 ,9, 12, 24, 36, 48, 72, 96 hours.

2.3. Soil information for better targeting and resource use efficiency

A pilot area in the Tolima Department of Colombia was chosen for the calibration and validation of the DSM approach. The study was conducted over a rice growing area of 4,640 km^2 located between the latitudes 3°40’0’’N and 5°0’0’’N and longitudes 75°14’0’’W and 74°42’0’’W which include Norte-Meseta, Saldaña and Ortega, in Colombia. The average annual precipitation in this region is 1500 to 2000 mm and average annual temperature is 24°C. The study area has elevation varying from 219 to 1,662 m.a.s.l and the main soil orders are Alfisols, Entisols, and Inceptisols (IGAC, 2008).

Two data sets were used for mapping continuous property maps for the study area: 1) *GIS data:* digital elevation model (DEM) SRTM of 90 m, soil class polygon map at a scale of 1:500,000 from Instituto Agustín Codazzi (IGAC) and b) *field data:* 90 soil samples collected in 30 sites with 3 replicates each from 0-20 cm soil depth. Collected soil samples were characterized for pH, organic matter (OM), sand and clay content.

To develop the DSM model, landscape units were defined for the study area by combining soil classes map from IGAC with a landform map generated from the DEM. Landform classification was performed using the Geomorphons add-on in Grass-GIS which segregates the landscape into the 10 common landform elements: flat, peak, ridge, shoulder, spur, slope, pit, valley, foot slope, and hollow (Jasiewicz and Stepinski, 2013). Soil maps of pH, OM, clay and sand contents at 90 m resolution, were then generated using a fuzzy logic approach in the Soil Land Inference Model (Zhu et al., 2001). Class threshold values were determined statistically from the distribution of Wetness Index (WI), Normalized height and percent slope within each soil unit in combination with 80% of field data.

2.4. Climate-Smart Village approach in Colombia

The CSV approach is an agriculture research-for-development approach that enables dialogue between communities of farmers, scientists, extensionists and development practitioners towards learning and developing context-specific options that support short and long-term adaptation to changes in climate while reducing impacts on the environment (e.g. GHG emissions) and increasing productivity, thus addressing the three pillars of CSA (FAO, 2013). In Colombia, a CSV is located to the northwest of Popayán, the capital city of the Cauca Department. Farmers in this locality, such as others in LAC, face several challenges related to climate variability, limited resource availability, and soil degradation affecting the productivity of their crops and livestock systems and thus their quality of life (CCAFS, 2016).

3. Data Analyses

To analyze the gender data in rice systems, we conducted a descriptive analysis based on attempting to answer the following key questions: (a) Who within or outside the household made decisions over rice production? (b) Which households have access to the key resources required for the implementation of improved water management? (c) Are there economic or noneconomic incentives for improved water management? c) Which labor activities are conducted by men or by women? In order to answer questions b and c, we used Chi Square test to calculate the association between incentives for AWD and type of households. It was not possible to obtain information from women's and men's perspective in the same proportion, since only 9% of the respondents were women. Therefore, for our analyses we used the men's perspective on the gender dynamics as well. Even though we assume that the information provided by men underestimates women's actual participation, the data collected are useful since they provide information about women's and men's role along the rice production chain.

Differences in cumulative CH_4 and N_2O emissions between treatments and years were determined through analysis of variance using the R software (R core team, 2012).

Fermentation dynamics and ruminal nutrient degradation in the *in vitro* experiment on cattle with cassava supplements were assessed by the gas (pressure) transducer technique as described by Theodorou et al. (1994), where data were analyzed using the randomized complete design model for fixed effect models and significant differences were tested with Tukey mean comparison test ($P<0.05$) (Di Rienzo et al., 2012).

The validation of DSM model was performed using 20% of field data not used for model calibration in pilot area in the Tolima. The Root Mean Square Error Normalized (RMSEn) by the data total variability was used to validate and assess the model accuracy. RMSEn values are expressed in percentage and lower values indicate less residual variance and then present good accuracy indicating that the model is appropriate to develop soil property maps for the local conditions.

A discussion on the utility of the CSV approach for grounding research on appropriate and location/context-specific enabling conditions is also included.

4. Results and Discussion

The objectives of this study included (a) improving our understanding of the socioeconomic context with a strong emphasis on gender dynamics in rice and cattle production systems; (b) evaluating the potential of two CSA options to reduce CH_4 emissions along the rice and cattle supply chains; (c) exploring the utility of a pro-poor DSM tool; and (d) discussing the possibility of farmers, researchers and other stakeholders working as allies of change using the CSV approach. We discuss here our findings on the different aspects and also include a discussion on our perspective on what these results mean for improving the sustainability of agricultural systems.

4.1 Socio-economic and gender aspects

4.1.1 Rice systems

Within the rice growing households, about 38% of the respondents indicated that both women and men participate in decision-making. However, it is unambiguous that women are generally not recognized as the principal decision-makers, since only 8% of the respondents identified them as such. Whereas in the majority of cases women respondents recognized themselves as principal decision-makers, there were few cases in which men recognized women as being the main decision-makers. It is probably prudent to assume the prevalence of a gender bias that depended on the sex of the respondent (Ambler et al., 2017). Therefore, as women are not generally recognized as decision-makers from the men's perspective, it is also probable that their needs and preferences may not be adequately considered when deciding on adoption of CSA options. It is therefore possible that, without an understanding of these dynamics, adopted technological and management practices may increase the burden on women and thus increase their time poverty (Beuchelt and Badstue, 2013).

According to the given responses, rice producers in the five rice-growing departments of Colombia have control over the amount of water they receive (93%) and affirm to having leveled their plots (88%). Yet, several of the respondents (44%) indicated that they face water availability challenges. Paradoxically, it seems that, bar challenges related to water availability (particularly during the drier years), there may currently be no economic incentives to save water, as farmers do not pay for water based on the volume of water they use but based on the area of land they own. To promote water savings, there may be a need to change the pricing mechanism to reflect usage, though care must be taken to avoid increases in water prices that would be detrimental to farmer welfare. This is particularly important for the scaling of CSA options such as AWD. Surprisingly, our results show that households that have women producers had a higher propensity towards more non-economic incentives (interest in GHG mitigation and reducing water) to save water (Figure 1). However, while available information does not adequately explain why households with women participation are more likely to be motivated by GHG mitigation and water savings, Figueiredo and Perkins (2013) suggests that that historical gendered roles may have made women more passionate and caring than men.

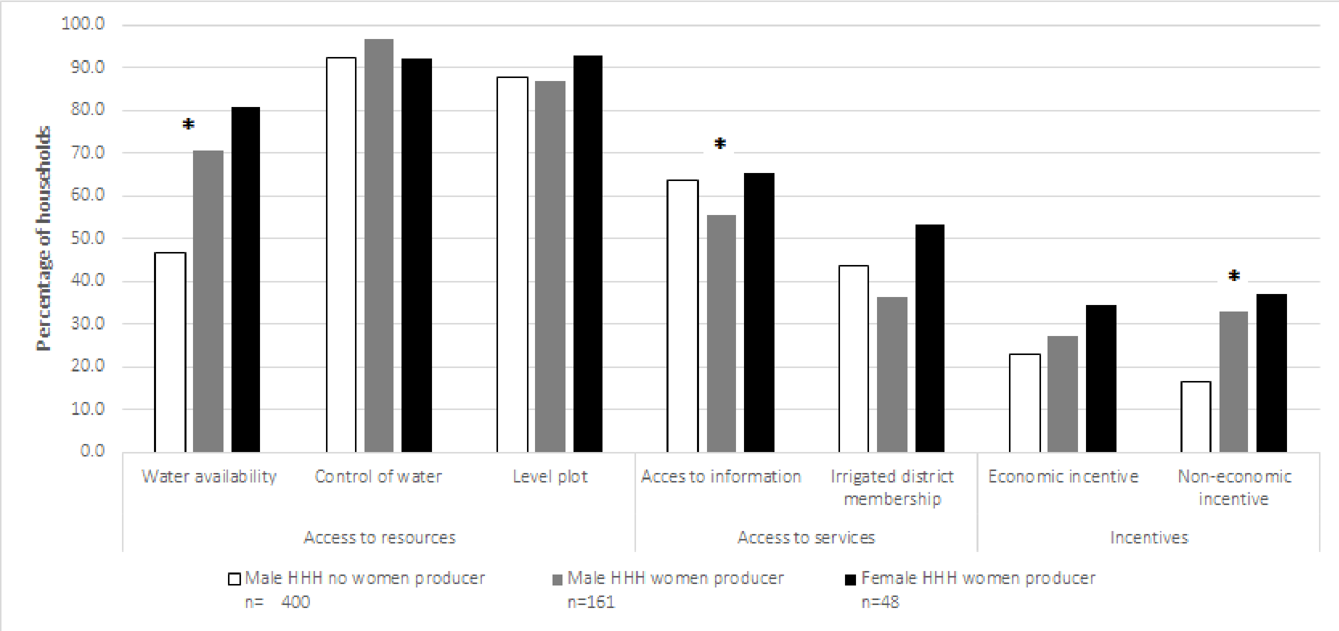

Figure 1. *Differences in access to key resources and incentives to implement AWD, among types of households (Male and Female headed households (HHH) and if there are women producers involved in decision making and ownership of land/machinery). Source: García, et al., 2016. * Statistically different at 5% level of significance.*

It is also clear from our results that women participate in the rice supply chain as hired labor for specific manual activities such as manual weed control (García, et al., 2016). If management practices such as AWD impact the time needed for performing agricultural activities, especially manual weed control, it could reduce or increase the time used by rural women workers.

4.1.2 Cattle systems

An exploratory qualitative study was conducted in the Cauca region of Colombia. The study included two focus group discussions, held separately with men and women livestock producers. The main objective of the study was to understand what the direct roles played by men and by women are in livestock production and how they support the production through indirect contributions.

Contrary to what is perceived in the literature, women play an active role in livestock production in Colombia. The women in this region perform a wide range of activities like management of pastures, caring for animals, helping in the process of curing the animals, milking, processing milk products and selling of livestock products. In addition, women perform all the household chores and care work that indirectly supports the productive efforts of the men in the livestock sector. The idea of this study is to examine the potential impacts of CSA options on the workload of men and women. For example, based on the cassava experiment there is a potential to introduce a sustainable feed, especially during the dry season. However, it is crucial that we assess who is involved in the production and processing of cassava leaves.

4.2. Potential of CSA options to reduce GHG emissions

4.2.1 Monitoring GHG emissions in irrigated rice systems

In 2015, the cumulative CH_4 emissions from flooded rice and AWD were 7.54 and 2.28 kg CH_4 ha^{-1} $season^{-1}$, respectively, representing a 69% reduction with the latter. Similarly, in 2016, cumulative CH_4 emissions from flooded rice plots were higher (19.50 kg CH_4 ha^{-1} $season^{-1}$) than those observed in the AWD (5.28 kg CH_4 ha^{-1} $season^{-1}$) plots (Figure 2a). Soil N_2O emissions observed during the drier year (2015) were significantly higher in the AWD (1.53 kg N_2O ha^{-1}) than in the continuously flooded (0.56 kg N_2O ha^{-1}) plots. However, N_2O emissions, which showed a tendency of being lower than in the wetter year (2015) were similar in both treatments (Figure 2b). Similarly inconsistent results on soil N_2O emission have been reported previously (Lagomarsino et al., 2016; Sander et al., 2014). The CH_4 emissions in the continuous flooded plots were generally significantly lower than those estimated using the global average estimated through a meta-analysis (134 kg CH_4 ha^{-1} $season^{-1}$) conducted by Linquist et al. (2012). However, the observed emissions were within the range reported in several previous studies (Cicerone et al., 1992; Mitra, 1992). The low methane emissions may be due to a combination of factors including low soil pH, coarse-textured soil (Wang et al., 1993) and low soil organic matter (Cicerone et al., 1992).

The cumulative CH_4 emissions in the continuously flooded and AWD treatments were significantly different within ($p<0.001$) and between cropping seasons ($p<0.05$), with the latter result probably due to variations in weather conditions between the two cropping seasons. The percent reductions in CH_4 emissions were similar to those observed by Thawda et al. (2015) and Katayanagi et al. (2012) who also reported high CH_4 emission reductions with AWD (65-73%). Our results show that compared to continuous flooding, water management strategies such as AWD have mitigation benefits under both El Niño and La Niña conditions. However, AWD showed a higher mitigation potential under the wetter La Niña conditions, possibly due to the fact that during the drier year first monitoring period, there were challenges in maintaining continuously flooded conditions due to limited water availability. Therefore the continuously flooded treatment was not flooded during the whole monitoring period which may explain the high variation observed with soil N_2O emissions.

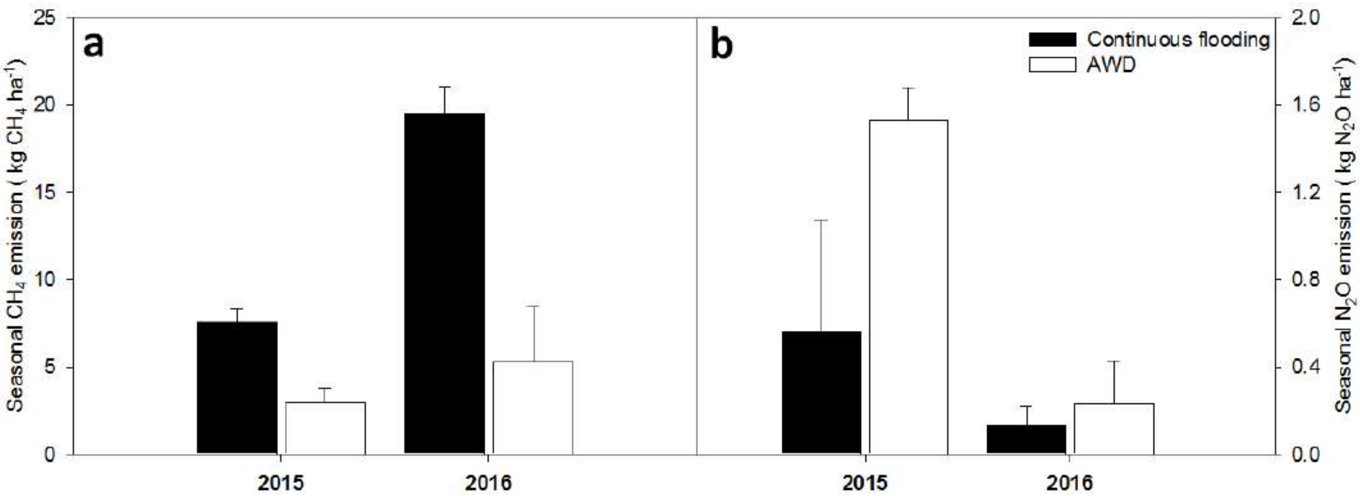

Figure 2. *Methane (a) and nitrous oxide (b) emissions from soils under continuous flooding and subjected to Alternate Wetting and Drying (AWD).*

4.2.2 *In vitro* experiment on cattle diets supplemented with cassava leaves

Results in Figure 3 indicate that CH_4 emissions from the 100% BH treatment were significantly different ($p<0.001$) from those from all the 100% cassava leaves treatments. This result is not surprising as the higher tannin content in cassava leaves than in

BH swards (Table 1) probably reduced methanogen activity as reported in previous studies (Hess et al., 2006). Secondary compounds such as tannins have been reported to either target methanogen activity or disrupt the commensal relationship between methanogens and other microbes such as protozoa populations and fungi (Beauchemin et al., 2009; Tan et al., 2011). Thus tannins reduce gas production by reducing fiber digestion (Tiemann et al., 2008). In addition, Kume (2002) reported a reduction in CH_4 production when NDF content is low, which may also explain the lower CH_4 production in treatments of 100% cassava leaves (NDF: ~47%) compared to 100% BH swards (NDF: 71.2%). Other studies (Elghandoura et al., 2017; Jayanegara et al., 2009) have also reported that high concentrations of NDF in forages cause an increase of CH_4 production, due to a shift in the proportion of short chain volatile fatty acids towards acetate, which produce more H_2. However, though showing a tendency for lower CH_4 production than in the 100% BH treatment, mixtures of cassava leaves and BH swards did not result in significantly lower CH_4 production in all but one treatment (BH +ME4).

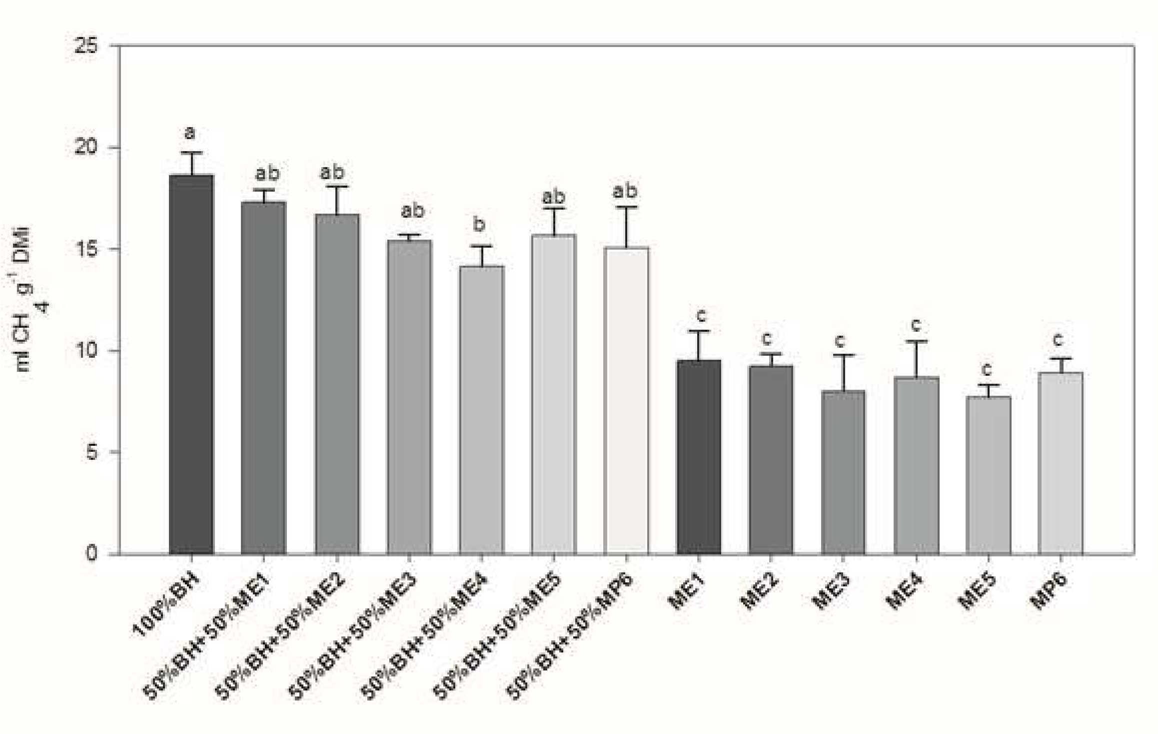

Figure 3. CH_4 emissions *(ml CH_4 g DMi $^{-1}$) from an* in vitro *assay conducted with (BH) and different cassava (ME) and Brachiaria (BH) mixtures.*

From our results, it seems that tropical grass-based diets with cassava leaf supplements (a resource accessible to resource poor farmers) have the potential to serve as an important source of cattle feed particularly during the dry season (Wanapat, 2003), with low methane production compared to those based on tropical grasses alone. Whereas, the presence of condensed tannins in cassava leaves could form indigestible complexes with protein and thus increase the amino acid requirements of cattle fed with cassava leaf supplements (Reed et al., 1982), different studies have shown that cassava leaves can safely serve as an important source of cattle feed (Henderson, 2015; Lukuyu, 2014). Yet, it is clear that further research is required to confirm mitigation benefits and inform development of protocols for safe administration to cattle in the tropics.

Table 1. Chemical compositions of the treatments utilized for *in vitro* experiment on cattle diets.

Treatment	DM	OM	A (%)	NDF	ADF	DIVDM	Total	Total

	(%)	(%)		(%)	(%)	(%)	tannins (%)	phenols (%)
100%BH	96.8	91.4	8.6	71.2	37.2	60.8	0.87	1.35
50%BH+50%ME1	96.2	89.0	11.0	57.3	30.4	63.5	-	-
50%BH+50%ME2	96.6	89.7	10.3	58.6	33.4	61.3	-	-
50%BH+50%ME3	96.3	89.8	10.2	57.7	32.1	62.7	-	-
50%BH+50%ME4	96.3	87.9	12.1	58.1	31.4	62.0	-	-
50%BH+50%ME5	95.8	89.6	10.4	60.8	32.2	61.2	-	-
50%BH+50%MP6	96,1	89.7	10.3	57.8	30.8	62.6	-	-
ME1	95.5	90.6	9.4	44.2	25.0	65.3	2.28	2.93
ME2	96.1	89.1	10.9	47.8	31.4	65.0	1.63	2.15
ME3	95.5	89.8	10.2	45.9	27.3	67.6	1.93	2.48
ME4	95.5	90.1	9.9	49.4	26.4	65.5	2.24	2.80
ME5	94.7	90.9	9.1	48.8	27.6	62.4	2.01	2.54

DM = dry matter, OM = organic matter, A = ash content, NDF = neutral detergent fiber, ADF = acid detergent fiber, DIVDM = digestibility *in vitro* of dry matter.

4.3. Soil information for better targeting and improving resource use efficiency

A total of 21 landscape units were generated for the pilot area and used to link the soil properties data to these units to generate continuous property maps of pH, organic matter (OM), clay and sand contents for the topsoil (0-20cm) at 90 m resolution for a study area including three rice growing regions in the Tolima Department, Colombia (Figure 4). All three rice growing areas showed differences in soil properties which require dissimilar management strategies to improve resource use efficiency. Although soil pH did not vary much within the rice areas, we observed that soils in the study region are generally basic (pH >7) and that soils in Norte-Meseta have higher pH than the other two study areas. In Saldaña the areas with pH greater than 7 increased by 10% from 1980 to 1997 and in Norte-Meseta this change was 15% for the same period (FEDEARROZ, 2000). The Norte-Meseta region also showed higher soil OM content than the other areas, especially when compared to those in Saldaña, which had the lowest OM content. The soils in Saldaña have lowest sand content while clay did not show much difference among the three rice growing areas.

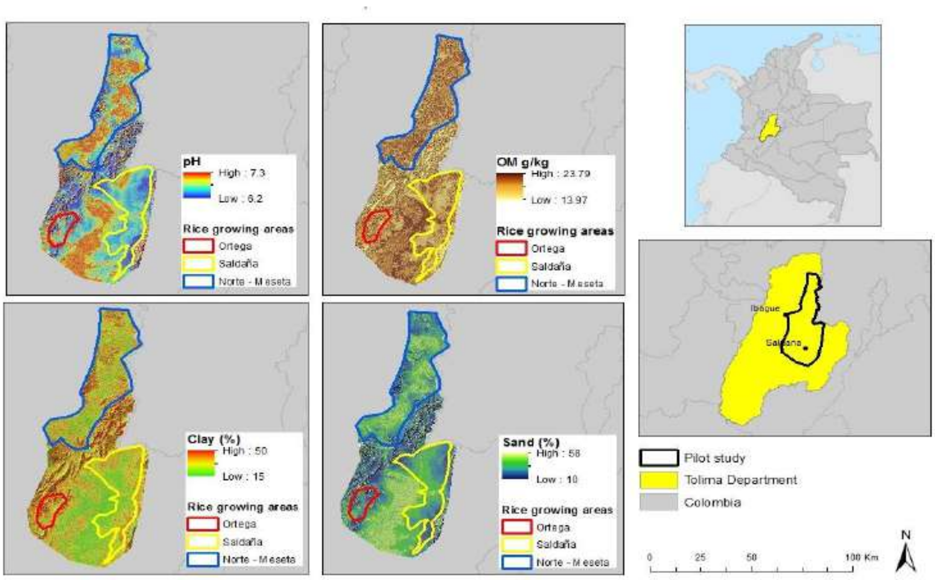

Figure 4. Continuous digital soil maps of pH, organic matter (OM), clay and sand for a pilot area in the rice growing region of the Tolima Department, Colombia.

The descriptive statistics and accuracy of the prediction at validation points are presented in Table 2. In general, all the soil properties mapped in the pilot area had prediction performance different from each other, indicating that not all soil properties vary equally in the region. The average values of the prediction were very close to the observed values for soil pH and sand, but smaller for OM and greater for clay. Comparing the maximum and minimum values of the prediction with the observed values it is noted that the approach overestimated the minimum values and underestimated the maximum values. On the other hand, when we analyze the accuracy of the prediction, we observe that the model performed very well with errors varying from 5% to 22 % (general precision > 78%) indicating that this approach works well with limited data.

Table 2. Descriptive statistics and accuracy of the prediction at validation points (RMSEn).

Property	Observed			Predicted			RMSEn %
	Average	Maximum	Minimum	Average	Maximum	Minimum	
pH (H_2O)	6.47	7.96	5.35	6.60	7.30	6.20	19
OM (g/kg)	20.9	66.6	5.1	17.4	23.8	14	5
Clay (%)	22	85	10	27	50	15	17
Sand (%)	40	68	2	40	58	10	22

OM: Organic matter; RMSEn: Root Mean Square Error normalized.

4.4. Implementing CSA practices in CSV of Cauca-Colombia

The key strategy for implementing the CSV approach is based on combining a triad involving: (i) an *interested and committed community*, (ii) *local development practitioners* including local governments and extensionists whose goals are aligned to supporting communities to address climate challenges in agriculture and food security, and (iii) the technical branch with *scientists and researchers* committed to understanding local challenges first and then proposing and co-developing CSA options that address them considering context specific conditions. The approach includes a farm-level vulnerability analysis developed together with rural families where major climate risks are identified for each farm. This analysis is used to prioritize the CSA options needed for each farm to address those risks through the formulation of a local adaptation plan.

The CSV process is grounded on having farmers as allies, who decide on what kind of research they consider useful in their territory. They are also part of the designing and implementation process of research activities. Moreover, local youth are involved to increase their knowledge and accelerate their learning towards becoming community experts on CSA practices. The CSV approach is based on the premise that farmers should be able to explain research results generated in their territory and be aware of the implications for their agricultural systems in terms of economic and environmental sustainability. This enables communities to engage in scaling up and out promising CSA options through local organizations and governments, which goes beyond traditional participatory approach. Moreover, communities are empowered to determine how to invest official resources allocated to their village and they are also able to develop project proposals that can support the implementation of their local adaptation plan and continue increasing resilience in their territory.

4.5 Perspectives

At the farm level the major drivers of management practices or new technology adoption include: (a) reduction in production costs, (b) increased productivity, and (c) increased resource use efficiencies (i.e., water). These three components are influenced by interactions between farmers, research, government and the private sector. In the case of multiple-win management practices such as AWD, which, if done properly, may be associated with a reduction in total costs of production (depending on water pricing) while maintaining rice yields and reducing GHG emissions, adoption by farmers should be a given (Yang et al., 2016). Yet, generally adoption of AWD, by farmers, is still limited (Mushtaq et al., 2009) due to several factors: (a) limited farmer awareness of the technology and its associated benefits; (b) the risk aversiveness of farmers as AWD can be inherently risky, especially if not executed properly; (c) a policy landscape that does not incentivise AWD adoption, i.e., policies related to water pricing; and (d) lack of evidence on the benefits of AWD under local conditions.

To achieve wider adoption of AWD there is a need to focus on better spatial targeting of the management practice by using a combination of soil mapping tools, rice statistics and climatic data to develop AWD suitability maps (Nelson et al., 2015). Besides promoting the efficient use of limited financial resources in promoting AWD, avoiding areas where AWD will not be beneficial is also strategic, as it allows development practitioners to focus on areas where success is more probable and, consequently, leading to farmers gaining a better appreciation of AWD. In addition, to increase the probability of successful scaling, borrowing from experiences in the Cauca-CSV, there is a need for real, open and continuous communication between farmers, researchers and development practitioners.

Adaptation of AWD to suit local socio-economic and cultural contexts is necessary to increase adoption rates. For instance, as our results suggest that weeding is an activity mostly done by women, AWD should be adapted to reduce the time dedicated to weeding by applying the drying cycles after full canopy cover has been attained, so that weeds are easily outcompeted by the rice due to lack of light within the canopy (LaHue et al., 2016). Therefore, we believe that in addition to environmental sustainability, targeting the correct actors and not burdening the farmers with excess work of implementing the technology are crucial factors. Finally, from a policy perspective, to support the adoption of AWD, water pricing mechanisms that incentivise farm-level water savings are necessary.

In the case of using cassava leaves to supplement cattle diets, a major challenge is related to increasing farmer awareness on this technological option and its benefits. CIAT and partners are currently testing the utility of this technology by conducting measurements on CH_4 emissions from cattle fed diets including cassava and BH mixtures. However, lower proportions (<20%) of leaves are being used to avoid huge negative effects on feed digestion. Moreover, to avoid misuse of the technology there is need to use data from *in vivo* measurements to design protocols with clear instructions on how to benefit from the technology. Interestingly, previous studies suggest the pruning of cassava several days or weeks prior to harvest increases root quality and shelf-life (Wenham, 1995). This implies that pruning cassava leaves to use as a cattle feed supplements is a multiple-win strategy. However, more research is needed to understand who in the household would be responsible for pruning and processing cassava leaves and to develop an in-depth understanding of the gender roles along the cattle and cassava value chains.

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Participatory innovation tools in food sovereignty

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Abstract

In this paper we present the use of participatory innovation tools in a food sovereignty project. We introduce participatory innovation as a feasible method for engaging a community of farmers in an innovation process regarding food production; and we do not intend to show it as the only way to innovate with farmers. We expose how a participatory innovation approach can be used to transform, through tools that invite to a groupal reflection, the production practices of a farming community. Our approach was a path that established that the transformation of daily practices and the introduction of new technologies is feasible when it involves the active participation of community members. We describe all the stages of a case study with a community of organic farmers in Chocontá, Cundinamarca (Colombia). As a result of the innovation process, the community recognized together their resources and limitations, and discovered ways of transforming their organization in order to achieve better production practices and transform their commercial practices.

Keywords: Tangible models, participatory innovation, organic agriculture.

1. Background

Organic production in Colombia is relatively low compared to the total agricultural land, especially when compared to other countries in the region like Ecuador, Brazil, México or the USA (Table 1); plus it has determinants that limit the commercialization of their products, e.g. "quality and periodicity requirements" (Rubio, 2006, p. 21), the level of training, lack of labor and access to markets (Caister, 2012, p. 61). Usually, organic production initiatives have a limited size, and their organizations are "professional entrepreneurship in small and medium-sized enterprises" or "small and medium-sized empirical entrepreneurships". The difference between these categories lies both in the technical aspect and in cultural knowledge; the technical training of its members and the management of solutions on an international level, as well as the importance of the family bond and traditional knowledge as a center for the development of agriculture (Rubio, 2006; Caister, 2012, p.139).

Table 1. *Shares of organically managed land (FiBL, 2015).*

Country	Shares of organically managed land. Percentage of total agricultural land.
Brazil	0.27%
Colombia	0.07%
Ecuador	0.82%
Mexico	0.55%
United States of America	0.59%

Thus, the internal structure of farmers' organizations is built as the sowing and harvesting process increases along with its intention to expand production. Rubio (2006) emphasizes the structures of planning and disposition of resources that arise among peasant organizations. Here it should be noted that in many cases the motivation to develop the organization lies in meeting the requirements for organic certification, resulting on a raise between 30% and 40% of the commercial price, compared to common products (Rubio, 2006, p. 20).

By increasing the level of internal organization, there are roles "that determine decision-making" (Caister 2012). Those who occupy them are able to influence this process because others accept them and "feel comfortable with it" (Caister 2012). Other tasks that can arise, either as a complement or as an independent role, are those of internal and external communication of the association (Rubio 2006), of great importance in small-scale organizations, because they are the logistics center that allows the coordination of production and association with the outside world.

Likewise, the recognition of the territory and the artifacts that identify its cultural tradition is key to the discussion on enterprises of organic agriculture. The territorialisation of the areas of cultivation in organic production is given "as a function of the crossing of two variables: ecosystem and culture" (Delgado & Escobar, 2009, p. 57) Furthermore "in this definition of territoriality, forms of social organization existing in each region have to be respected" (Delgado & Escobar, 2009, p. 57) and this implies working together with participatory methods with these organizations and not, as some entities consider, to seek their adaptation to forms of organization related to medium-large enterprises.

2. The participatory method

The use of a participatory method seems appropriate when working with farmers, because they are the ones with a practical knowledge built by their experience working in the field and by the interaction with other family members who are also involved on the productive activity (Caister, 2012). Nonetheless, Cruz (2004) considers that farmers should be at the center of the formulation of politics and hypothesis about food production. When doing research, the farmers' knowledge is the raw material for the research team when developing tools that bring to discussion and consensus between the farmer community members and other stakeholders (Delgado & Escobar 2009). Taking into account that the potential farmers participating on these sessions have the clearest notion of the use of resources and of their own abilities (Caister, 2012), their knowledge can be used to refute the assumptions we might have about the treated topic (Caister, 2012; Haggar, 2001).

However, when we compare this approach with agricultural knowledge systems proposed by Moschitz (2014) a contradiction arises, because the principles of these knowledge systems contradict the principles of participation. According to Dosi (1988 quoted by Moschitz 2014), the paradigm of agricultural knowledge systems relies on the idea that "science is the only legitimate source of knowledge and the engine of innovation; and the point of view, needs and knowledge of the final users of the innovation do not have to be taken into account" (Dosi 1988 quoted by Moschitz 2014).

In spite of this contradiction, the knowledge systems perspective considers that these “'systems' do not have a purpose, they are given one” (Engel, 1995). This suggests a versatile comprehension of the system in terms of its meaning for the community and not an imposition of it to the target system. Additionally, Engel (1995) considers that the application of this perspective requires the conjunction of the abilities and skills of the participants, over their individual contributions, thus the integration of the community. In regards to the development of tools and frameworks for analysing, designing and managing the target system Roling (1992 quoted by Engel, 1995) suggests that the potential of a knowledge systems perspective in agricultural contexts is the support it generates for this task.

Correspondingly, our approach in this paper is to show the use of the proposed tools to alter the existing knowledge system by creating "‘knowledge interfaces’ as a spaces where different knowledges can meet, communicate, share knowledge, and collectively create new knowledge." (Moschitz 2014)

In like manner, we build scenarios on which the participation of farmers is required as a raw material, and a reflective process arises from the experience of the participants (Caister 2012). The benefit of this scenario lies on the principle that there are the participants who clarify the path and define solutions that are born from real worries about the existing conflicts on their context. Additionally, the participants appropriate individual situations and perceive them as something close to their surroundings, understanding those situations as facts of communal solution though cooperation (Caister 2012).

The fact that participation takes into account the perspective of different stakeholders implies that the reflective process has to identify, develop and maximize the capacities of the participants that are not evident and that could also be keys for the autonomous development of the proposed solutions (Ponzio et al. 2013). The resulting dialog of participation determines the collaboration in which the farmers and the researchers are open to learn and respect the perspective and knowledge generated by the counterpart (Ponzio et al. 2013). An essential element for an effective implementation of a participatory method, and specially of the resulting co-learning, is the change of perspective according to which the only acceptable source of knowledge is located in a place far from the effective location of the application of such knowledge, something that has to change in the cultural imaginary of all the participants, including the farmers and the research team (McNie 2006 cited by Caister 2012).

To reach these objectives, the research team needs to become more a facilitator of the dialogue and an ability developer for the farmers (Caister, 2012). This can be done applying tools that allow reflection and development of solutions from the community itself. Besides, for Caister (2012) to motivate participation it is key to have “the attitude, the environment” to generate the appropriate dialogue. In it the participants must be able to expose their worries and interact in such a way that allows them to understand their circumstances and the reasons why of the analysed situation.

When applying the participatory approach the relationships between the participants are not hierarchical (Moschitz, 2014) and the participants find their own place as the knowledge development process is interactive and dynamic. Collective learning as a sample of participation shows the "non-hierarchical, collaboration, trust and joint exploration" (Moschitz, 2014) way of relationships in the approach. These characteristics are key for involving the participants with the process and guiding the research to topics that are important for them. The consequence of using this approach for this system will be the easier adoption of the solutions by the farmers, in terms of relevance and physical pertinence for their context (Lockeretz 1987, Bachinger et al. 2000 cited by Ponzio et al. 2013).

The critique to the tools as artifacts that drive participation in research is clear. In our process and from our point of view as designers-researchers, the tools show the ability of the designer to make concepts and intangible ideas, tangible. For example, when a designer creates a game, it creates a tangible artifact of an analog reality, alongside with fictional elements which are as well analog to an existing reality (NAVARRO-SANINT, M.(2015). MINEROS: A COLLABORATIVE GAME FOR MINERS' REFLECTION. In 4TH PARTICIPATORY INNOVATION CONFERENCE 2015 (p. 344). It is questionable if the tools themselves can achieve participation as they depend on who and how they are applied. The participation capacity depends upon the affordances included by the designer in the tool while the use varies according to the objective of the one who applies it. In this case, the tools need to be a driver for the dialogue: making visible invisible elements, generating a tangible remembrance, building shared meaning and allowing the participation of every stakeholder.

For us participation has five main goals:

Expose the real situation of the community. Approach the actors, understand the structure of their organization, their interests, the emerging roles of their agricultural and organizational practices, understand the link between the context and its influence on the community. Comprehend the territory, interpreting it as the tangible and/or intangible elements where the set of practices that define the community take place; defining practices as knowledge in action, i.e. how does the community acts in order to fulfill their interests.

Integrate the stakeholders, creating a common language between the participants (researchers and non-researchers).

Build spaces for discussion where community members can expose their differences between their individual interests and their shared ones.

Generate conscious and acknowledgment on the participating actors towards their own reality through the exposure of their real situation.

Communicate and discuss alternate scenarios (present and future ones) to the current situation.

Participation intends to benefit all the stakeholders and achieve agreements through the positive management of conflicts that emerge during the intervention of the practices of the community. According to McIntyre et al. (2009 citado por Ponzio et al. 2013) it is through the tools used to encourage the participation that the dialog between traditional knowledge, formal agricultural knowledge and scientists and technologists can be mediated. This is essential on the field of organic agriculture, because this dialog constitutes a vital mechanism for the construction of identity (Carvajal, 2009); provided that this type of agriculture is not only about the development of the productive process, but also about the social and cultural manifestation that underlies it. For organic farmers, their process makes sense in four dimensions that affect them in different ways, according to their roles and their commitment with the practices: “vital, environmental, productive and economical”.

3. The case: Orgánica

In the middle of the cundiboyacense highlands, in the municipality of Chocontá -Muisca word for "labor of the good ally"- a community of farmers tries to strengthen a shared life project, on the quest for health and wellbeing. Surrounded by industrial producers of potatoes, strawberries and green peas, they commit to find an alternate and sustainable way of growing vegetables to improve their feeding conditions. Motivated by the knowledge they have about industrial farming and their desire of eating and providing healthier food, they associated under the name "Orgánica". We entered the project as facilitators of this process convinced that the longevity of the project lies on networking between stakeholders and participation of diverse institutions; anyway, the association already existed and the farmers already had clear motivations for dedicating themselves to the project: intrinsic motivations triggered by their will of eating healthier food and extrinsic motivations triggered by the need of creating a sustainable productive activity to make the project feasible.

By no means this underestimates the purpose of the research of knowledge creation and enrichment of the academic world to which we belong as researchers. It rather highlights a key characteristic of academic research: to bond personal interests and research interests, granting empathy between the participants and the research team. We joined Orgánica as facilitators for their project, to create decision making spaces in place of deciding for them. We created tools and facilitated the participatory sessions, while trying not to bias the discussion and maintain the objectivity. Nevertheless the tools will always hold a subjective meaning as they propel the dialogue in a certain path.

Somehow we reasoned that the best way to support the network of farmers was to support the commercialization of their products, in order for them to arrive to us, the consumers who want to have access to organic products. Our intuition was supported on the fact that even though participants belong to Orgánica due to their motivation for a better health, they also needed to achieve economic sustainability. The time they spend in growing self-consumption products it taken from other productive activities. It is thus coherent to think that the commercialization of organic products benefits the producers as they hold self-consumption while creating their own economic support. And they enable the consumers’ access to products perceived as healthy.

Initially the project involved the implementation of a software that withstanded the production and commercialization of organic products, but then transformed into a research process to understand the diverse practices of this community. We joined the project by facilitating the participatory sessions in which we promoted the dialogue around key issues regarding the commercialization of the products of these network of farmers. Our approach answers to our thought that the transformation of practices and the introduction of new technologies is more feasible when the stakeholders are actively participating.

We do not intend to introduce the participatory approach as the only way to work along with farmers, but to expose that this kind is valid when wanting to achieve results when working with this type of communities.

4. Observation and analysis

To approach these objectives, we divided our facilitation process into three sessions, done within the period of around eight months. These visits correspond to three phases through which the research was developed, although not consecutive: (i) analysis of the present condition of the network, (ii) assess the actual practices and (iii) explore and evaluate the possible future practice.

The first step prior to meeting with the community, was to define the meeting point. As we were working with farmers we had to face factors like the long distances between their households and their time availability. Following these factors, we chose one farmer's house as meeting point. Her house is already known to be a gathering point for the network's activities and it is a commonplace for decision making as well as a place to stock supplies and products.

The first session we held with the farmers was through a social cartography (Navarro-Sanint 2014). This tool enables the understanding of relationships between participants and their surroundings, based on the point of view of the participants. The social cartography shows three properties that support the dialogue: memory, discussion and dynamic access:

a. Memory: By leaving the trail of previous conversations, participants can build on the discussion, identify where do things happen and identify other actor while referring to him. Cartography can become a visible memory of what has been said.

b. Discussion: Cartography supports the discussion because it permits to debate around certain elements that otherwise would show up in a research process. For example, a social cartography can show the lack of knowledge of a specific actor, without anyone pointing it out. It is simply the absence of it which makes it visible. It is through discussion that these key issues emerge, and actors can share and discuss their ideas within the community.

c. Dynamic access: The intangible properties of the cartography enable the actors to participate in it indiscriminately; each participant should have the same access to the discussion.

For the cartography of the farmers' network we met with six participants who belonged to Orgánica, five producers and the sixth, Mauricio, a trader (Figure 1).

In spite of the fact that most of them knew each other, we began with a brief presentation from every participant including the research team. When presenting, the participants expressed their reasons for participating in the process. Olga emphasizes on the hard work they have done for nearly four years. César, Olga's husband, talks about their cows, which are their financial support and then defines organic products as “clean food”. Matilde expresses that she expects to be more qualified after the research process while Cristina highlights that the difficulties they have had to overcome “have not been easy at all”. She adds that people leave organic production because of the money rush and the fact that the production process proposed by Orgánica does not generate short-term profit.

Then we gathered around a piece of paper and using markers we drew the actors, the geographical area and the relationships between the actors and the territory. The objective was to understand the current practices of Orgánica: How did they begin? Who are the members? How do they grow? How do they commercialize their products? What do they do when they have questions about growing their products?What do they do when they need help in their production? The discussion held as follows: the research team asked triggering questions according to what was shown in the common piece of paper. That was how the answers to the questions were written on the paper creating a memory of the discussion and a reference for further use.

Along the process we used game chips -as ludos- to ease the representation of the relationships and make the actors tangible. We also used colored wool to join the game chips according to the type of relationship held between the actors: information and knowledge, seedling flow, compost and products and social relationships. This gave as a result a network of connections that represented the social, economic, physical and knowledge relationships.

The process of building the cartography allows to understand the relationship between the community and the access roads, quite precarious, and with water. The roads and the water became two reference point to locate the different actors within the territory. It is to highlight that do not hint the location of Chocontá as often as the location of Bogotá, where they have their market.
The participants also place in the cartography the different actors both present and absent. For example they reference Victor as the ‘one who did not come’ and placing him in the piece of paper. Something interesting is the lack of detail about the crops in their smallholdings, leaving them as something implicit with no detail on their drawings and aside of the analyzed issue.

Although initially the actors of the network picked Cristina as its core and drew it in the cartography, Mauricio begins to emerge as the heart of every process: the transport of the seedlings and compost to the smallholdings, as well as the transport of the production towards the market. He gathers and manages the information of the products needed, the timing and he is the contact point with the agronomists who are the primary sources of information in case of any difficulties with the crop e.g. plague or fungi. The dependence of the organization towards Mauricio becomes evident for every actor in the session.

The resulting cartography allows us to see the complexity of the connections that join the community, just as the fragility and dependence of this community when they identified the actor responsible for the commercialization as a critical point not only in his role as reseller, but in terms of the access to knowledge and supplies needed for the production.

5. Current practices

The evaluation of the current practices was done with a session following the social cartography, starting from the results of this previous tool, and facilitating a discussion on which the parts could reflect and be critique about the exposed practices. In this discussion, different topics came up: (i) the importance of information technologies, (ii) the limitations in the integration of new stakeholders, (iii) access to new knowledge and (iv) the challenges of building trust with their clients.

(i) The importance of information technologies.

It is important to highlight the amount of interactions that take place between the stakeholders supported on ICTs. One of the cases is Sebastián, Mauricio's brother. He is in charge of contacting the buyers and of compiling the database of all the buy and sale operations. He receives a request from the buyers through email. In addition, Mauricio uses this information to contact the farmers through cellphone to let them know about the products that he will pick up to bring to the buyers. When reflecting about this situation, the participants discuss about the use of SMS to manage orders, quantities and shipment. Matilde exposes her lack of technological literacy, as she does not know how to send SMS, but expresses her will to learn with the support of the other members of Orgánica.

(ii) The limitations in the integration of new stakeholders

The members of Orgánica perceive a difficulty when integrating new people to the group. According to Matilde "integrating people is to start all over again", because they have to share all their knowledge with them from the start, feeling this as a waste of time. Furthermore, Olga highlights the complexity of the situation, because many of the new members quit during the first year and new members keep coming, making this process of induction a constant task for the old members, always with a high risk of desertion.

(iii) Access to new knowledge

The farmers are aware of the importance that new knowledge has on their agricultural practices. In particular, Cristina considers that a proper guidance is "what is needed to continue supporting organic products." Currently, when farmers have a problem with their crops, they contact José, an agronomist, being him their main reference source. Usually, they get to him through Mauricio, who sometimes solves some of the doubts. Mauricio emphasizes on the qualities of José by saying that "he is one of the few agronomists that if you say that we have to plough with the hoe, he does it and he knows how to do it", adding that he knows how to explain things to people because he is 'a country folk', just like them. In addition to this, sometimes the farmers consult their personal library, being these of free access to other members of the community.

The discussion around the previously exposed situation lies in the fact that they no longer gather to learn from each other because, as Cristina expresses "as they already learnt from the others they can do everything on their own". This behaviour results on the stagnation of knowledge together with the deceleration of the evolution of the agricultural practices. In other words, if one of the farmers finds the solution to a problem, he does not communicate it to the other members unless another member expresses the same problem.

(iv) The challenges of building trust with their clients

As a consequence of the absence of a certification on their products, the community of Orgánica has to build trust with its potential buyers on their production methods and their products. In several cases, buyers doubt about the organicity of the products, consequently, pictures of the farms are used to build when selling the products. According to Mauricio, buyers get excited when they see the pictures. It is important for the buyers to have access to a trustable market where they can know that the products are really organic; on the other side, producers feel the responsibility of providing healthy organic products to the customers. During the discussion, the community expresses the importance of building that trust, because, otherwise, the consumers of the products will not be willing to pay the extra cost of the organic product and they will go for something cheaper at the supermarket.

During the discussion about Orgánica community's current practices, we identified that the farmers perceive their knowledge and their practice as something static as long as they think that they have already learnt enough. Sometimes, they also perceive the passing of knowledge as a waste of time, justifying with this the complexity of integrating new people into their community.

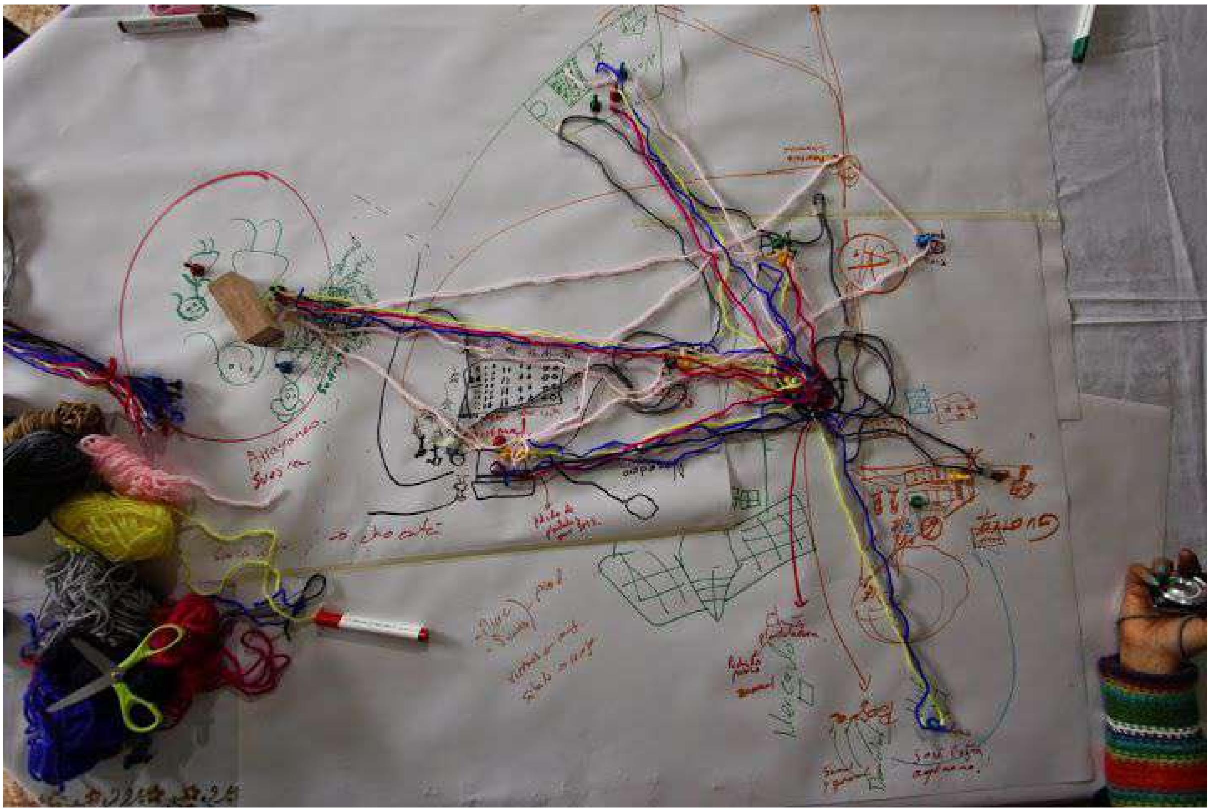

Figure 1. *Social cartography created by the community.*

6. Proposing future practices

Inspired on the results of the previous participatory sessions, we filtered the information to answer to the common interest of commercializing the products as a mean to achieve economic sustainability. Correspondingly, we built a tangible model of the commercialization of the products. We emphasized on the possibility of the farmers to interact with the model to allow them to set the initial condition of the model and visualize the possible consequences of their decisions. The model was not intended to replicate the exact behaviour of the actual commercialization process; but it intended to trigger a reflection about the different events that could take place during the process.

The commercialization process was understood and represented as a flow of products from the producers to the buyers, representing the products as spheres that run on an inclined plane from the producers toward the market (Figure 2). The participants could intervene the model by selecting the products that they wanted to commercialize, putting them on the top part of the plane. On the base of the plane, the market, the participants could set different partitions marked with the names of the possible buyers. The spheres corresponding to the products were liberated simultaneously, implying commercialization days. This is the ideal context, when all products run from the top to the bottom and achieve a buyer without no resistance. However, the model also has two movable bars over the inclined plane that allow the producers to aim for a specific buyer. This triggers a group discussion about where do they want to put all their efforts. In addition to that, there are movable pieces that allow the participants to represent difficulties and strengths or actions to overcome those difficulties (Figure 3). When placed on the plane, these pieces condition the process of commercialization and force the participants to discuss about ways of intervening it.

Figure 2. *Tangible model of the commercialization process.*

The participants perceived the following difficulties during the session:

1) Obtaining a workforce: Farmers perceive difficulties in obtaining workers that support farm tasks, given that they have to compete with conditions imposed by the biggest producers. According to them, there are no workers willing to work on a daily wage for a low scale production with no guarantees regarding stability. In contrast, according to the community, it is hard competing against farmers who handle bigger volumes of production. Then, Orgánica must compete with quality.

2) Lack of economic resources: The perception of lack of economic resources it always surrounding the current situation of the community who has not achieved the economic sustainability for its organic crop.

3) Lack of communication: In many cases the producers do not exchange their information between them. According to Cristina, in some cases they do not know what are producing their neighbors and end up cultivating the same product, resulting on bad selling because of oversupply. Before, they rotated from farm to farm to learn from others and everyone knew what everyone was producing. Now that they do not feel the need to learn, they do not know anymore what others are producing.

4) Crop management: The farmers do not have clarity on the calendar of the products to be spread. They are used to spreading the product by intuition rather than according to the market.

5) Transportation difficulties: The location of the farms makes it difficult for the farmers to get to the market as most of it is located in Bogotá, a couple of hours away. Therefore, they depend on someone transporting their product and serving as an intermediary.

6) Water: Access to water has always been regarded as a difficulty, especially since they have little or no

control over it -- sometimes it rains and sometimes there are droughts.

7) Planning: Planning is one of the most important issues in food production. At the time, the farmers had to manage the uncertainty regarding the demand of their products. According to Mauricio, sometimes they carry overproduction and certain products expire after they have not been sold. This corresponds to the lack of information about what to grow and when to do it.

8) Limited organic fertilizers: In many cases, farmers do not have access to the necessary fertilizers for their production. In other cases, such as that of Mrs. Cristina, farmers realize very late that manure replaces fertilizers. However, they throw it away when milking is being done.

9) Unpredictable weather: the weather from the region is unpredictable and crops are sometimes affected impacting on production times and on the amount of production. On top of that, all the farms of Orgánica are located nearby, thus, they are all affected simultaneously by the weather.

Although, they also identified six main strengths and possible solution:

1) Will: The farmers highlight the willingness to work that every participant has, for the production of organic food as an important asset for the organization's subsistence.

2) Networks: Networks created by 'Orgánica' are a support for getting over the difficulties that arise. During the time they have been working, they have managed to build strong connections with Mercado restaurant as well as other stakeholders. This connection makes it easier to generate trust amongst buyers and ensure the market for their product. According to Ingrid, Orgánica's coordinator, Mercado gives them recognition and visibility.

3) History: History -- as in everything they have done so far -- is considered as a support because it is what drives them forward.

4) Diversified Production: Farmers recognize the risk of single-crop farming. This is why Diversified production is perceived as a strength.

5) Drainage Systems: In order to compensate for the effects of weather and water, they consider it is necessary to create drainage systems to sustain production in a variety of climates.

6) Market Opening: It is apparent to Orgánica's members that they must access other markets so that their production becomes sustainable. Ingrid considers that it would be ideal "to have diversity, but [...] with specialized products and markets". In other words, to open markets but keeping in mind they are stable.

***Figure 3.** Difficulties and strengths identified with the tangible model.*

6. Results

(i) Thoughts about the practice

The use of the tangible model and the results of the activities performed with it made the participants reflect about the way they commercialize their products and possible changes they in the practices the use in their crops. When conscious about the possibility of including new markets and realizing that certain markets could be receiving more products, than those favorable, Ingrid considers that for she "would think that is better a big market that guarantees the acquisition of the entire production." Specially because if they send too many products to unstable markets like the Hub, sometimes when people go on holiday, the products may not be sold and expire. Nevertheless, Olga defends the existence of the "little market" because sometimes they pay better and they award recognition. This discussion awakens the fear of going back to single-crop farming because of the risk it holds and the intention of having organic food for self-consumption can be harmed; this drives them to think they could lose more than they can win.

Still, some farmers affirm that they became motivated a second time when the market opened again; some consider that the sessions: "make you think about what are we failing in, what should we fix" (Criollo, 2015). For some, the tangible model was a reflection point about the process of production and commercialization that the organization had at the time. Cristina states that this activity made them reflect about the work and the organization; it moved them to work harder.

(ii) The Role of Women in Organic Production

It is key to contemplate women as an active actor in the rural production process (Cruz 2004). Even though the community is not made up of women only, the participatory sessions had few male participants. Most of the active actors of ‘Orgánica’ are women who consider convenient the appropriation of these alternatives. Not only they provide financial support for financial independence, but also they nurture their family with the work of their hands.

Women participation on organic production comes through the support of organic crops; it is also the reason for dropping out. On one hand, women, in their role of nurturers, are the ones who make the decision of feeding their family with healthier products, in other words organic products for self-consumption. But just as Mauricio says, men arrive home after their work and hope to find food and if “the lady has to work on her crop, the food can take a while longer”. Women start having conflicts at home -- this is another reason for them to drop out -- as household chores and lack of support by their children and husbands start building up

Ingrid also recognizes the central role women play in the strengthening of organic production. Actually, she bets on women doing this arguing that “women have less possibilities of leaving home because of the work required in raising children” and, therefore, they could dedicate to farming the garden.

Jointly, all of the factors above make relevant the participation of women in the production of organic products. These are summed up eloquently in the following sentence:

“No dough. No Money. It is health we need! We need health.” says Cristina, one of the producers, by making emphasis on her interest in improving her family’s health. Then she adds: “those who want to support us, we’ll gladly sell them our products”. Here she recognizes, first, the importance of commercialising their products as a form of life support, and then, her interest to share the advantages of her products. Both these phrases condense the interest of women, of producers and even us, the consumers and investigators.

7. Conclusions

By analysing information gathered, it became evident that participatory design methodologies are useful for facilitating mediation between an actor such as Universidad de los Andes and a community. This due to the fact that it sets a shared language between the interaction participants. The dynamics (cartography and tangible model) done allowed the participants to become aware of the status of ‘Orgánica’, as the community itself depicted the geographic, economical and emotional conditions of their environment. Understanding the context enabled each of the farmers to clearly understand which was the process of their organization and how it was relating to the outside.

Furthermore, the tangible model eased the identification of resources and limitations for the commercialisation of the product inside the competitive market. This was useful at the time when a commercial agreement with a renowned restaurant came to fruition. At that moment, 'Orgánica' already knew what they should work in and who could support their value generation process.

The networks are recognized by the farmers as their key asset to grow. Being aware of their knowledge sources, logistics and financial support made them gain a wider perspective of their business.

Months after having implemented both tools, we performed a follow-up session in which the objective was to update the findings of the first stage. The change of perspective of the community became evident thanks to the parallel processes held with different areas of the University, such as Law and Design.

In this case, it became clear how the community knew what they had and where they needed to go with these resources. Also, a better communication amongst some participants and the enthusiasm that comes with attending to the participatory sessions summoned arose. It is important to stress the fact that these sessions work as a space of dialogue, in which the producers catch up and see how other participants can actually see their point of view. This heightens the effectiveness of applying participatory design methodologies.

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ISDRS Bogota, 2017: Track 3a – Climate change predictions:

Predicting climate change impacts on vulnerable small farmers in South Africa's Eastern Cape.

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Abstract

South Africa's Eastern Cape province has extremely high levels of poverty, partly due to the highly variable rainfall; rainfed farming systems are notoriously risky due to poor rainfall distribution, and this results in wide-spread food insecurity. Two magisterial districts (Sarah Baartman near Port Elizabeth and Amathole near East London) were selected, and large variability of rainfall distribution was noted. Factors implicated in food insecurity were analysed including resilience, biodiversity and productivity, and five climate prediction models were examined to assess their relevance in supporting small scale farmers. Sensitivity of the models to variable data input was assessed. Given that rainfed crop production requires 500 mm of rain during the growing season, that all of the models examined were highly sensitive to variations in rainfall and that rainfall in the sub-districts varies from year to year between 200 and 900 mm per annum, it was concluded that none of the climate change models available would be useful in the Eastern Cape. It was rather decided to use existing rainfall data as an initial predictor of likely drought patterns, as these are already a severe constraint on rainfed crop production. Strategies to assist vulnerable farmers should therefore focus on small livestock production, home gardens with rainwater harvesting and soil management systems which improve soil water holding capacity, such as organic farming and conservation agriculture.

Keywords: climate change; drought prediction; plant available water; food insecurity, water use efficiency.

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Introduction and objectives

"No continent will be struck as severely by the impacts of climate change as Africa. Given its geographical position, the continent will be particularly vulnerable due to the considerably limited adaptive capacity, exacerbated by widespread poverty and the existing low levels of development" (AMCEN, 2015). This is true for much of Africa, and certainly true for most of South Africa's Eastern Cape Province, where rainfall is already highly variable and erratic.

This paper presents an analytical overview of predicted climate change impacts and approaches to helping vulnerable small scale farmers to adapt, seeking to improve the resilience of African farmers. It defines climate change, climate change resilience and biodiversity, summarises research findings with emphasis on African research reports, examines site-specific variability and summarises results of some efforts to build climate change resilience among Africa's small scale farmers. Various models give varying predictions for the global impacts of climate change, and some of these will be examined (Challinor *et al.*, 2015; Morton, 2007; Ayers & Forsyth, 2009; Elbehri, 2015). Before we look in detail at climate change modelling, let us examine the concepts of climate change, resilience, biodiversity and productivity, and their application to sustainable food and fibre production.

Definitions and conceptual framework

There is little point in giving extensive definitions of climate change, even though there are still many who deny that anthropogenic climate change is an urgent reality in the twenty-first century. The realities are now so stark and the data so compelling, that a real effort of burying one's head in the sand is required in order to "not see" shrinking water bodies, melting ice, rising world temperatures, unprecedented greenhouse gas levels in the atmosphere, ocean acidification and pollution. This has led to the creation of millions of climate change refugees, who are currently prepared to risk their lives in precarious boats headed for Europe. A recent National Geographic documentary shows the compelling links between drought, desertification, food insecurity and migration (Years of living dangerously, available at http://channel.nationalgeographic.com/years-of-living-dangerously/). The Intergovernmental Panel on Climate Change (IPCC) has assembled scientifically robust, compelling evidence of man-made climate change (IPCC 2014).

Their definition: "Climate change inIPCC usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer" (IPCC 2007a).

The links between climate change and food systems, especially in Africa, are fairly obvious, given that most small scale African food production occurs under rainfed conditions, and as temperatures rise and rainfall becomes more erratic, the already difficult crop and animal production conditions will become ever more precarious. The Food and Agricultural Organization of the United Nations (FAO) brought out a 330-page report on "Climate change and food systems" in 2015 (Elbehri, 2015), the eleven chapters of which cover most of the topics of this paper in great detail, but from a global, rather than a specifically African, perspective. Not a single contributing author is based in Africa. This work points out the importance of matching evidence of climate impacts to the needs of policy makers: "When used effectively, evidence can … guide decisions on policy, highlight options for policy action and also identify areas where insufficient interventions lie along a continuum, from those that overlap almost completely with development practices that build general resilience to those that are focused more specifically on climate change impacts" (p.15). They advocate a process, citing an example from Bangladesh, following a linear sequence of stages:

- Raising awareness;
- Scientific capacity building;
- Generating evidence;
- Conducting pilot studies;
- Informing and engaging decision makers on policy planning.

They point out that there is often a mis-match between the approach of those generating data on climate impacts on food and the needs of policy makers; the scientific data is often too detailed, and too careful. Scientists are understandably cautious about making sweeping generalisations, as they have to be honest about the limitations of the particular context of their research, and the many variables which make precision impossible and accuracy difficult. One of my arguments in this paper will be that precision is relatively un-important as the changes we are examining are large, and they are (especially in the Eastern Cape) likely to occur in a context which is already highly variable, as existing rainfall data confirm. Precision, however, is very different scientifically to accuracy. We cannot be sure about precisely how much temperatures will increase over the next twenty years, nor exactly how rainfall patterns will change. This need not stop us from analysing the implications of historical data, understanding the trends it illustrates, and preparing for the likely scenarios which common sense tells us we will have to deal with in the two districts where our pilot activities are located (see Map 1).

In the Eastern Cape, where rainfall already varies from 200 mm to 800 mm per year, we do not need precise prediction to within one percent of what is likely to happen to prepare us for what we should expect over the next fifty years. Rainfed crop production requires 500 mm of rain in the growing season for most crops; we can confidently predict that the current situation, where rainfed crops fail in one year out of three in many areas, will deteriorate to crop failure every second year. We need to identify the most vulnerable sub-districts in each of the two magisterial districts involved in this study (Sarah Baartman and Amathole), and distinguish between four major agricultural potential classifications, which will each require different support:

- Areas where irrigation is available,
- Areas where rainwater harvesting is feasible,
- Areas where rainfed crop production is currently not risky, and
- Areas where there are already regular crop failures.

The historic record shows that the sub-districts are highly variable, and two other IFAD-funded papers will focus on identifying these details and recommending how farmers can be helped with crop production; animal production will be examined by other researchers. In order to identify these sub-districts, at least eight typical areas should be selected (if it is not possible to get data for all sub-districts), and the two districts should be divided into the four proposed climate vulnerability sub-districts, each with a strategy to be developed (see Map 2).

This should allow us one focus area in each of the four categories in each of the two municipal districts (Sarah Baartman and Amathole). In looking at support for small scale farmers in particular, we should take care to learn from local best practice, and develop strategies which make use of readily available, cost-effective resources. The discussion of existing initiatives in Africa (Auerbach, 2013) will illustrate the dangers of using expensive inputs to produce the wrong crop! Climate change resilience requires strategies which help local people to use locally available resources to produce products which are in demand and can be consumed or sold (not necessarily locally, but if they are to be sold elsewhere, the infrastructure required is a pre-requisite for such systems to function, often forgotten by planners).

Resilience

Climate change science has much to offer policy makers, but it needs to be translated into terms which are general enough and robust enough to be useful to policy makers, and it also should build on decades of developmental work in Africa. There are lessons to learn from history, where millions of dollars have been spent on projects, many of which have not resulted in long-term improvements in African food security, because they often do not improve the resilience of local farmers and farming systems. The lense of resilience is a useful concept through which to examine climate change in terms of likely impacts and possible helpful strategies.

Buzz Holling and Lance Gunderson and their colleagues have worked on ecosystem resilience for many years (Gunderson, Holling & Light, 1995; Gunderson & Holling, 2002; Folke *et al.*, 2004). In my doctoral thesis (Auerbach, 1999, pp.25-26) I quoted Holling as follows: “Holling and [colleagues] examine the tendency of inflexible managers to lose sight of the complexity of the systems they manage once a simple and apparently effective management policy has been developed. Holling (1995) points out that two critical points emerge: firstly, the reduction of ecosystem variability inevitably seems to lead to reduced resilience and increased vulnerability. Secondly, there seems no other way for agencies to manage and to benefit from resource development. He then searches for examples of narrowly controlled systems which are successfully managed in nature. The example of warm-blooded creatures proves interesting. Tightly regulated endotherms are indeed less resilient and more vulnerable in the sense that if their body temperature varies outside a very narrow range, they die. Terrestrial ectotherms (‘cold-blooded’ animals) can survive a much wider range of temperature variation. However, two interesting aspects appear after careful examination. Endothermy does persist, and is thus a ‘revealing metaphor for sustainable development... First, the kind of regulation is different. Five different mechanisms, from evaporative cooling to metabolic heat generation, control the temperature of endotherms. Each mechanism is not notably efficient by itself. Each operates over a somewhat different range of conditions and with different efficiencies of response. This overlapping of ‘soft’ redundancy seems to characterise biological regulation of all kinds. It is not notably efficient or elegant in the engineering sense. But it is robust and continually sensitive to changes in internal body temperature. This is quite unlike the examples of rigid regulation by management where goals of operational efficiency gradually isolated the regulating agency from what it was regulating' (Holling, 1995)". Some lessons here for resource managers and climate change planners, I suspect!

Earlier in my thesis, I quoted Holling (1995) and commented as follows:

> "Managing complex processes such as these means that one has to operate at a variety of scales, from the individual land user's level, to the local level where collective action can lead to effective resource management. At local, provincial and national level, the three spheres of government have a host of regulatory and planning obligations. The interaction between 'bottom-up' processes originating with land users at individual and local level and 'top-down' processes from government at local, provincial and national levels can be conflictual, neutral or synergic. Participatory design processes, through creating platforms for negotiating about resource use, can help to address conflicts and develop a joint vision for a catchment, thus maximising the chance of building synergy among the various stakeholders - this involves designing 'soft systems'. The process of bringing people together, however, is greatly assisted if it is preceded by practical problem-solving work at individual and local level.
>
> "With increasingly complex systems, a different approach becomes necessary. Even farm, forestry and nature design processes (especially the latter) deal with complex systems. When one moves to education and communication design, the shift to 'soft' systems requires an iterative planning process, if it is to avoid over-simplification. Holling (1995) shows in a comprehensive review of large-scale ecological research, policy, design and management efforts, that very often a complex problem is defined too narrowly. This leads to a technical solution, which succeeds in its narrow aim of holding variability at a certain desired level.
>
> "Thus the design appears effective: uncertainty is reduced, and initially the management intervention seems to have solved the problem. However, Holling points out that it appears to be a characteristic of complex systems that their variability, their very complexity, allows them to absorb a wide range of disturbances. Simplistic interventions often reduce the resilience of ecosystems, because they increase homogeneity. This is often compounded by the switch of the attention of managers from monitoring to managing the 'successful intervention'. He concludes 'The very success in managing a target variable for sustained production of food or fibre apparently leads inevitably to an ultimate pathology of less resilient and more vulnerable ecosystems, more rigid and unresponsive management agencies, and more dependent societies'" (Auerbach, 1999, p.25).

This conclusion of Holling is deeply insightful, and highly relevant to useful planning for climate change: How can we understand communities in the context of climate variation? How can we help food and fibre producers to adapt to changes in climate, using robust mechanisms within complex systems? How can we avoid what Holling calls 'an ultimate pathology of less resilient and more vulnerable ecosystems'? How can we modify the responses of management agencies to be more robust and less rigid? Can we help societies to become less dependent?

Ecosystem Resilience is defined by Folke *et al.* (2004, p.558), citing co-author Holling (1973) as “the magnitude of disturbance that a system can experience before it shifts into a different state (stability domain) with different controls on structure and function”, and he distinguished ecosystem resilience from engineering resilience. They also cite co-author Gunderson (2000) stating that the self-repairing capacity of eco-systems can no longer be taken for granted once resilience has been eroded. Folke *et al.* (2004) then define resilience as “the capacity of a system to absorb disturbance and reorganize while undergoing change”, still maintaining essentially the same function. They go on to speak of “regime shifts and irreversibility” (*op. cit., p.567*). Clearly, resilience of ecosystems is closely linked to biodiversity.

Biodiversity

In discussing biodiversity and resilience dynamics, Folke *et al.* (2004) state that “The diversity of functional groups in a dynamic ecosystem undergoing change, the diversity within species and populations, and the diversity of species in functional groups appear to be critical for resilience and the generation of ecosystem services” (*op. cit., p.569*). Once functional group diversity is lost, the addition of just one species may have a major effect on the functioning of the ecosystem. More diverse systems are less sensitive to invasion, and thus more resilient. “Recovery after disturbance has often been measured as return time to the equilibrium state” (*op. cit., p.571*). There are clues here for sustainable agriculture: the difference between a mono-cropping system, and a two-crop system is massive; almost equally important is the introduction of a different type of third crop, which is why our long-term research trials use three crops (cabbage [heavy feeder leaf crop], followed by sweet potato [light feeder root crop], followed by cowpea [nitrogen-fixing legume], see Auerbach, Mashele and Eckert, forthcoming). Preliminary results of these trials are given in Mashele & Auerbach, 2016 and changes in soil fertility (and their impact on water use efficiency) are given in Auerbach, forthcoming.

When working with the concept “resilience” in an agro-ecological context, it is important to recognise that anthropogenic (human-induced) changes may give rise to regime shifts in the sense that fertile, productive agricultural land becomes infertile and unproductive (Auerbach, 2013). This is often due to mono-cropping, industrial farming, over-use of chemical fertilisers and poisons and/or poor tillage techniques (Morton, 2007). The loss of biodiversity in the soil and the low agro-biodiversity in many industrial farming systems reduces the resilience of these systems (Auerbach, 1995); improving productivity requires support which eases the constraints identified.

Productivity

Productivity in times of climate change can only be defined locally, in terms of the resources which are scarce in a given area. In the case of the Eastern Cape, water, energy and tractors are scarce in most areas, and motivated skilled labour is also not as available as many might assume. To understand this, we will examine changes in population, labour migration and changes in South African agricultural productivity. According to WWF (2008, p.3), South African food consumption since the 1970s has diversified due to the growth of the middle class between 2001 and 2004. “This has allowed a shift from staple grain crops to a more diverse diet. South Africans have shown a decrease in the consumption of the staples maize and bread, and have massively increased their annual consumption of chicken from 6 kg to 27 kg per person. Per capita egg consumption has also doubled. Interestingly, the per capita consumption of fruit and vegetables has remained constant, while beef, mutton, pork and milk consumption has declined" (citing Agricultural Statistics, 2008).

WWF continues: "Within the region, South Africa stands out as one of the most water-scarce countries. The country is also characterised by extremely variable rainfall, both geographically and over time. In the 12% of the country that is suitable for the production of rain-fed crops, productivity tracks rainfall, making farming a challenging business. Climate change predictions are that rainfall will be more infrequent but more intense. This will shrink the country's arable land and increase agricultural unpredictability. Farmers will find it increasingly difficult to increase productivity to meet the growing demand for food. This highlights the need for sound cropping and rangeland production practices to retain soil integrity despite these predicted intense rainfall events" (WWF, 2008, p.10).

I reported on research into assisting small-scale maize producers in southern KwaZulu-Natal to improve their own resilience by building up soil organic matter, and strategically allocating inputs only as the season unfolded (Auerbach, 1995). I pointed out that while the population of South Africa (SA) had increased by 2.4 % *per annum* in the decade of the 1980s, food production had only increased by 0.6 % *per annum* over the same period (1995). In the twenty five years since then, the situation has deteriorated further, although at a somewhat slower rate until 2014. From 2007 to 2013, population increased by 1.3 % *per annum*, but then the rate of growth increased again in 2014 and 2015. Population grew from less than 48 million to almost 55 million people from 2007 to 2015 (Table 1).

Table 1: Increases in South African population and food production, 2007 to 2015

Year	Population (million)	Percentage Increase	Food Production Increase Percent
2007	48.91		
2008	49.56	1.3%	1.4%
2009	50.22	1.3%	1.4%
2010	50.89	1.3%	1.4%
2011	51.58	1.3%	1.4%
2012	52.27	1.3%	1.5%
2013	52.98	1.3%	1.5%
2014	54.00	1.9%	1.4%
2015	54.96	1.7%	1.4%
Average		1.5%	1.4%

(Adapted from StatsSA 2015 and http://www.tradingeconomics.com/south-africa/population, accessed 25/1/2017).

South African food productivity (defined as production per unit of land) varied widely, growing at less than 1% per year from 1900 to 1960, but then seeing a massive increase to 2 % and then 4% per year in the 1980s and 1990s; over the past fifteen years, productivity has hovered around 1.4% per year increase, after a stagnant period in the year 2000 (see Ramaila *et al.*, 2011, p.7 and Figure 2). More recently, food production is only increasing at about 1.4% (see Table 1), while population is now increasing at about 1.7% *per annum.* We have moved from net food producers to net food consumers, importing 12% of our food. The percentage of our GDP derived from agriculture has fallen from 7.1% in 1970, to 1.9% in 2011 (DAFF, 2013).

Ramaila and colleagues tell us (2011, p.7) "Before 1965 growth of the agricultural productivity was estimated at 0.65% per annum. In 1965, there was no growth of productivity ... This was due to input prices which were rising faster than the output prices farmers received throughout the period to 1965. However, it recovered to 2.15% in 1980's due to a quick adjustment of farmers to the effects of deregulation. Productivity grew rapidly at 3.98% between 1981 to 1989 due to mechanization and use of fertilizer, herbicides, pesticides, etc. Farmers at this stage were no longer severely constrained by state intervention but had the ability to change the mix of inputs that were less costly after the deregulation phase. From 1989-1994 growth of productivity declined to 0.28% due to inflation rates that had reached a peak and negative net farm income" (see Figure 1).

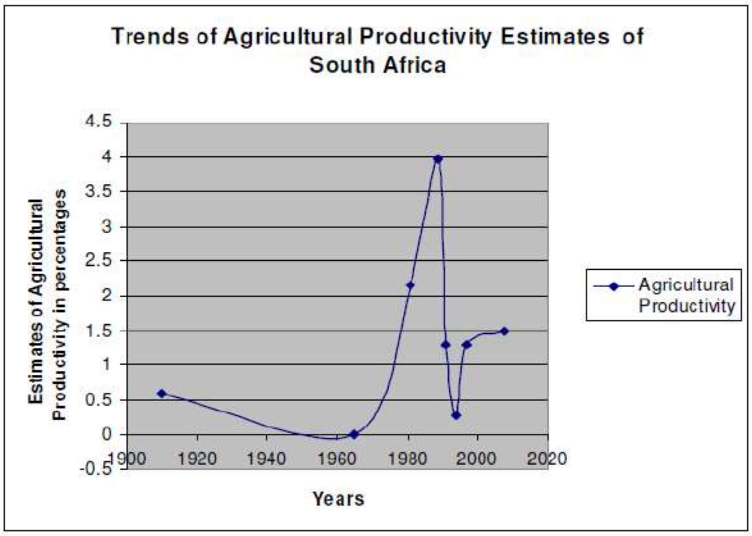

Figure 1: Agricultural Productivity Estimates from 1910-2008
Source: Ramaila *et al.*, 2011, p. 7.

They continue “After 1994 the growth was positive due to a positive net farm income and then stagnated due to declining output growth and increasing use of inputs around 2008” (Ramaila *et al.*, 2011, p.7).

At present, agriculture has increased the production of high-value crops, and exports have again increased. The sharp decline in commercial farming since the mid-1990s is confirmed by the abstract of agricultural statistics for South Africa, which reported 60,938 commercial farming units in 1996, 45,818 in 2002, and only 39,966 in 2007 (DAFF, 2012). This is a dramatic change.

> “South Africa has a dual agricultural economy, with both well-developed commercial farming and smaller-scale communal farming (located in the former homeland areas). Agriculture contributes a relatively small share of the total GDP, but is important in providing employment and earning foreign exchange. The commercial agricultural sector has grown by approximately 14% per year since 1970, while the total economy has grown by 14,5% over the same period, resulting in a decline of agriculture’s share of the GDP to 2,5% in 2008. However, there are strong backward and forward linkages into the economy, so that the sector is estimated to actually contribute about 14% of the GDP” (WWF 2008, p.18).

> “As South Africa moves towards larger and more intensive farms, the real costs of agricultural production are not being fully calculated in the cost of production. The negative impacts of intensive farming methods on the environment are not being reflected in the input costs. These impacts include pollution of ground- and surface water, loss of biodiversity, spread of genetically modified organisms, loss of soil fertility, erosion, transport costs and climate change, to name a few. It is the individual taxpayer and tomorrow’s generations that will pay the real price of these inputs through reduced options” (WWF 2008, p.18).

The situation on large intensive farms is very different to small scale production, where infrastructure is poor and access to markets is difficult. Both sectors in this dual economy are under severe pressure, but the nature of the pressure is very different. Both sectors are dependent on access to plant available water, and agriculture is a major user of the available water. Irrigation uses more water than any other sector of the South African economy, and even animal production, traditionally an activity which took place on our veld (rangelands) and pastures (which make up more than 80% of our agricultural land), now uses a great deal of water:

> “Originally cows grazed on grasslands that were not suitable for crops, converting inedible grass into high-value protein. Today this simple truth has been forgotten and 75% of South Africa’s cattle spend a third of their lives in feedlots, fed by grains grown on the country’s scarce arable land. Not only does this practice produce meat with an unhealthy fatty acid profile, it is also a major water issue. Compared to naturally fed beef, it takes about 65 times the quantity of surface water to produce feedlot-finished beef in South Africa if the feed crops are irrigated – 860 litres for every 500 g grain-fed steak (see data in Appendix). A sustainable solution is to reduce our daily consumption of red meat and to source natural, range-fed meat” (WWF 2008, p.12).

What are the implications of this concentration in agriculture, this rapid growth in population, accompanied by slower growth in food production and productivity, and this extravagant use of our water resources? In concluding our conceptual framework, let us revisit the idea of agricultural productivity.

Conway (1994), in discussing resilience, distinguishes between production, productivity, stability and equitability; there will have to be trade-offs between these four aspects, he suggests. While agricultural production may increase, productivity only increases if production per unit goes up. The selection of the unit is again a perspective, a lense for examining production efficiencies. Economists will look at return on investment: is my investment productive in terms of return per rand invested? Fertiliser companies will define improved productivity as “production per unit area”, while advocates of mechanisation will argue for “production per person-hour”. Water scientists will select “crop per drop”, using water use efficiency as their lense, while renewable energy analysts will look at “non-solar energy produced as food against non-solar energy used”.

Professor David Pimentel has worked at Cornell University for fifty years, and has shown that organic farming systems are more energy efficient than high-input chemical systems, and he summarises the situation (Pimentel, 2006, p.1):

> “The total fossil energy used in U.S. conventional crop production is approximately 1,000 liters per hectare. Of this, about one-third is for fertilizers, another third is for mechanization to reduce labor, and about a third covers all other activities and inputs, including pesticides. Past studies on energy use in alternative and sustainable corn and soybean production systems have pointed to nitrogen fertilizer and pesticides as the inputs leading to the biggest differences in energy use and efficiency, compared to conventional production systems.”

However, mechanised, irrigated high input systems are very efficient per unit of land and per person-hour – modern agronomic research has trebled yields per hectare. Mechanisation has allowed a single person to manage 300 ha of land with a big tractor, while in many non-mechanised systems a single hectare is a full-time job, and irrigation is usually a highly effective investment in stability and improved yield, especially in Africa with its erratic rainfall distribution (Auerbach, 1995).

Pimentel again spells it out (2006, p.3): “Yields of most U.S. crops have increased approximately four-fold since the 1940s .... Steady yield gains have been the result of technological changes rooted in the breeding of higher-yielding plant varieties, increases in the number of seeds planted per acre, more intensive use of fertilizers and pesticides, and more extensive irrigation of cropland. All of these new production technologies depend on the use of significant amounts of fossil energy. The availability of ample quantities of fossil energy and new farm technologies has reduced the human labor required to grow and harvest a hectare of row crops like corn and soybeans from approximately 1,200 hours per hectare prior to the introduction of farm machinery, to about 11 hours now.” He concludes that for maize, organic agriculture uses about 31% less fossil fuel (p.9) and most animal systems use about 28-30% less fuel per unit of product (p.30).

Bringing together the concepts around climate change, resilience, biodiversity and productivity presented above, sustainable rural development demands that all four of these perspectives should be incorporated into systems which help local people to develop their capacity to use local resources for the production of desired and usable food and fibre.

In 1994 (as part of a study for the new democratic government), I led a process of consultation with farmers, labour unions, farmer trainers, academics and policy-makers. I summarised some of the conclusions about the need to build on local capacity, of both commercial and small-scale farmers (Auerbach, 1994). I quoted this work in my doctoral thesis (Auerbach 1999), and some of the concepts developed may be useful in this discussion.

Figure 2 summarises the four common perspectives on rural development which I identified. Agricultural scientists are most comfortable with a production-oriented approach, which is often rather short-term and technology-centred. This is not to say that National Food Self-sufficiency is unimportant – it is essential.

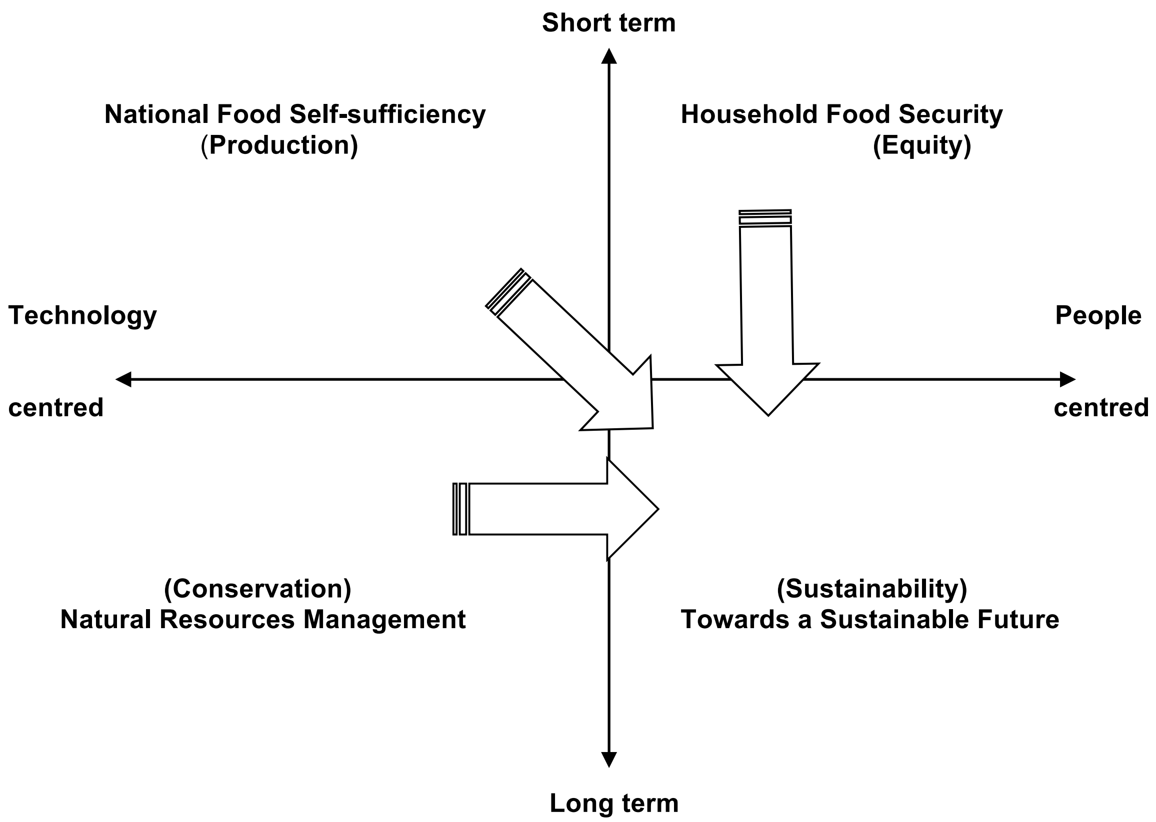

Figure 2: Production, Equity, Conservation and Sustainable Development (Source: Auerbach 1994, cited in Auerbach 1999)

However, politicians and social scientists are concerned that the poorer households may not be able to access food if they have to purchase it, and therefore Household Food Security is important if there is to be reasonable equity. Conservationists on the other hand, have long been critical of the damage being done to the resource base by industrial agriculture. While their philosophy has always been long-term, they were rather technical in their approach. Over the past twenty years, however, the World Wide Fund for Nature (WWF) has increasingly emphasized the importance of working with communities, if conservation is to become socially sustainable.

> “While most conservationists have learned about people, and social scientists are learning about sustainability, those who research technical aspects of agricultural production have to learn about both: their research techniques need to take account ways of working with people, and of long-term sustainability. This is what is required for “triple-bottom-line accounting”: economics, environment and equity are all important – we cannot sacrifice any of them. We need to find ways to balance this triple equation. We also need to balance short-term individual interests (so important to wealth creation and the provision of efficient services) with long-term measures to increase both productivity and equity of access to resources, without damaging our resource base” (Auerbach 1999, pp.6-7).

In his much-publicised book “The end of poverty: How we can make it happen in our lifetime”, Professor Jeffrey Sachs (2005) postulates that if modern agricultural technology (fertiliser, hybrid seeds, pesticides and mechanisation) are combined with interventions on education and health, and are made available to African villages, small scale African farmers will be able to produce a surplus, and by selling this will enter the market economy and improve their livelihoods. This pre-supposes that there are roads, trucks, demand for the crops and a market able to pay for the crops produced. Several critiques of the approach adopted by Sachs claim that it has not worked (Munk 2016; Friends of the Earth Africa 2017), as the contextual conditions do not simply require technological solutions, but rather human and institutional capacity building. I will examine the evidence later in this paper, but thus far will summarise the conceptual framework adopted for this study by concluding that sustainable development requires a long-term approach to building community participation in agriculture and other aspects of rural development. Resilience, biodiversity, improved productivity and strategies which address soil fertility and water use efficiency need to be adapted to local conditions and to robust predictions of the major climate change constraints likely to affect small scale farming.

Conceptually, I believe that the implications of climate change, resilience and productivity for food security in Africa are that systems using renewable natural resources and based on local culture and local resources are required for Africa.

Let us now examine what the IPCC tells us about the likely nature of climate change:

The IPCC and regional predictions for Africa (IPCC, 2007b)

Extract from Chapter 11.2 of IPCC 2007: Working Group I: The Physical Science Basis

11.2 Assessment of projected climate changes for Africa:

“All of Africa is very likely to warm during this century. The warming is very likely to be larger than the global, annual mean warming throughout the continent and in all seasons, with drier subtropical regions warming more than the moister tropics.

“Annual rainfall is likely to decrease in much of Mediterranean Africa and northern Sahara, with the likelihood of a decrease in rainfall increasing as the Mediterranean coast is approached. Rainfall in southern Africa is likely to decrease in much of the winter rainfall region and on western margins. There is likely to be an increase in annual mean rainfall in East Africa. It is uncertain how rainfall in the Sahel, the Guinean Coast and the southern Sahara will evolve in this century.

“The MMD (multi-model data set) models have significant systematic errors in and around Africa (excessive rainfall in the south, southward displacement of the Atlantic Inter-Tropical Convergence Zone (ITCZ), insufficient upwelling off the West Coast) making it difficult to assess the consequences for climate projections. The absence of realistic variability in the Sahel in most 20th-century simulations casts some doubt on the reliability of coupled models in this region. Vegetation feedbacks and feedbacks from dust aerosol production are not included in the global models. Possible future land surface modification is also not taken into account in the projections. The extent to which current regional models can successfully downscale precipitation over Africa is unclear, and limitations of empirical downscaling results for Africa are not fully understood. There is insufficient information on which to assess possible changes in the spatial distribution and frequency of tropical cyclones affecting Africa”.

Later in this chapter (11.2.1), the authors go on to say: “The factors that determine the southern boundary of the Sahara and rainfall in the Sahel have attracted special interest because of the extended drought experienced by this region in the 1970s and 1980s. The field has moved steadily away from explanations for rainfall variations in this region as primarily due to land use changes and towards explanations based on changes in sea surface temperatures”.

One is thus forced to conclude that the contributions of climate science to prediction of climate change in southern Africa, and to steps which we might take to ameliorate this, are rather limited! However, there is a great deal known about climate variability, the effects of periodic drought on crop yields, and adaptations which can be made to farming systems to manage drought conditions, and anticipate changes resulting from flooding.

Global assessment and implications for food security (Elbehri, 2015).

The above concepts (the potential of agro-ecological approaches to increase biodiversity and resilience in small farming systems; the importance of soil organic matter in achieving this; the deficiencies of conventional industrial agriculture in terms of agro-biodiversity, resilience and efficient use of non-solar energy) imply that, especially in Africa where access to external, fossil-fuel-based agricultural inputs is at best problematic, systems which use agro-ecology to reduce the use of expensive externally supplied synthetic fertilisers and agro-chemicals are more likely to provide lasting improvements to rural livelihoods than intensive industrial farming systems; these systems will also reduce the production of greenhouse gases and help small farmers to adapt to climate change. What can the modellers tell us about the likely impacts of climate change?

An overview of models shows that there is tremendous variability in output:

Summary of impact modelling and implications for resilience under climate change:

Morton (2007): Impacts on smallholders will be greatest because of their limited capacity to adapt to change. The impacts will be difficult to model or predict, given that these systems are complex, diverse and risk-prone. More than 70% of arable land in Africa and the Pacific is managed by smallholder farmers, and the International Fund for Agricultural Development (IFAD) says that 75% of the 1.2 billion people making up the world's poor live in rural areas. Morton calls for a conceptual framework that can understand the impacts of climate change on smallholders. This should recognise complexity of systems, incorporate non-climate stressors (such as market access), and study biological and environmental processes, as well as impacts on human health and non-agricultural livelihoods.

Challinor *et al.* (2007): vulnerability and the range of models available.

In southern and eastern Africa, IPCC studies predict rainfall changes between 35% decrease and 5% increase (IPCC, 2001); together with temperature increase, this will add stress to crop production. The likely availability of water *per capita* in Africa is likely to decrease, also with further population growth and urbanisation. However, Challinor *et al.* (2007) comment that the models available are so variable that predictions are difficult. However, they point out that the magnitude of African rainfall changes projected by IPCC is relatively small, though extremes of rainfall and temperature may happen more often. Arnell *et al.* (2003) predict both positive and negative changes in average annual rainfall and runoff for southern Africa. Rises in CO2 levels can increase crop growth, especially under warm conditions (a doubling of CO2 levels can increase production by a third; Challinor *et al.*, 2007). However, increased CO2 levels have substantial negative implications on food quality (Elbehri *et al.* in Elbehri, 2015),with reductions in zinc, iron and protein content of crops.

Crop simulation models evaluate genotype, environment and farm management changes; these include SUCROS, IBSNAT and APSIM. Climate models usually operate on a broader area than crop models. Some researchers carry out integrated assessments using multiple models; market prices show a systematic bias according to climate model. Fischer *et al.* (2002) report that the NCAR model simulated a 10% fall in prices, while HadCM3 predicted an increase in prices.

The recently-released FAO publication “Climate Change and Food Systems” edited by Aziz Elbheri (2015) has a great deal of useful information, some of which is summarised below.

Elbehri *et al.* in Elbehri, 2015, comment that models may be primarily mechanistic or primarily empirical; they generally model the crucial exchange processes between land and atmosphere, including carbon, water and energy balances. They point out that maize yields in the US and China have grown consistently over the past sixty years, and in the US the average is now over 10 t/ha, while in Africa maize production has varied between 1 and 1.5 t/ha average over the same period, showing little or no growth trend. The same is true of wheat yields in Europe and China, though these have flattened. In comparison, Russian production has been flat around 2 t/ha for the same period. Rice yields have grown more steadily but growth has also slowed in recent years. There is more potential for growth in maize and wheat yields than in rice. These substantial yield gaps (between actual and potential yields) represent an opportunity for increased food production.

Elbehri *et al.* in Elbehri (2015) point out that increase in sub-Saharan fertiliser use could raise crop yields, but they say that availability of fertiliser is unlikely to improve dramatically enough to bring this about. AgMIP, ISI-MIP and MACSUR models are discussed, and all are found to have such major variations due to different ways of inputting data, that results often differ substantially.

The global gridded crop model (GGCM): Elbehri *et al.* in Elbehri (2015) document response using harmonised data to try to move beyond these problems. They involve planting date, growing season length, fertiliser application rates and atmospheric CO_2 concentration pathways. Conservation tillage is another important emerging practice with major implications for climate and crop models.

It will also be important to acknowledge impacts on food availability, food quality and fresh water availability, which have been linked in Kenya to increases in stunting of exposed young children.

On p.16 they do point out that robust predictions for Africa project the following declines in crop production: wheat (-17%); maize (-5%); sorghum (-15%); and for millet (-10%), with no change forecast for rice production in Africa.

Biophysical models and productivity: Muller & Elliott in Elbehri, 2015:

C4 plants (e.g. maize, sugar cane, millet & sorghum) are not dependent on CO_2 levels for photosynthesis, while C3 plants depend for stimulation on CO_2 levels. As these levels rise, C3 plants (e.g. wheat, rice & soyabean) will therefore increase photosynthesis and production, if water is adequate. Crop growth models combine data on photosynthesis, root growth, leaf formation, flowering, organic matter mineralisation, plant diseases and frost damage.

Biophysical models may be empirical or process-based. Gridded versions of site-based process models are run for each location, after inputting large amounts of data to calibrate them.

Dynamic global vegetation models simulate energy, water, carbon and nitrogen exchanges between the terrestrial biosphere and the atmosphere.

Large-area crop models or empirical/process model hybrids simulate agricultural production at continental or global scales.

With global-scale modelling, there are many unresolved issues, such as effects of changes in fertiliser use, planting date, crop mix, rotation cycles and variety used. The interactions with market-prediction models give rise to many more imponderables. Global predictions for a high-emission scenario are for a decline in maize production of 20-45%; wheat 5-50%; rice 20-30%; and soybean 30-60% (Rosenzweig *et al.*, 2014). Recent combinations of various crop models, though they have some major differences, all agree that crop yields will decline in tropical regions, with decreasing precipitation and increasing temperatures and CO2 levels.

“Therefore, the extent to which climate impact models can reproduce the effects of large-scale drought and heat events is likely to be one of the most important measures of model effectiveness” (Muller & Elliott in Elbehri, 2015, p.45).

Economic modelling and adaptation Elbehri & Burfisher in Elbehri, 2015, p.61:
“Integrated assessment models of climate impact report mostly negative… outcomes of climate change on agriculture; but suggest substantial capacity to offset negative climate change through adaptive supply-and-demand responses, productivity-enhancing investments and trade. …. Improving policy-relevant economic analysis of climate impacts and adaptation requires better integration of biophysical processes with socio-economic analyses and stronger use of inter-disciplinary approaches. … As adaptation decisions are inherently local, economic models at the farm/household level require better integration with biophysical and spatial techniques, improve[d] accounting of climate risk and expand[ed] food security analysis…”.

Ahammad *et al.* in Elbehri, 2015, p.293, International trade:
“The likely impacts of future climate change and socio-economic drivers on international trade in agrifood commodities would vary depending on assumptions regarding how the future will evolve as encapsulated by ‘scenarios’. …. Impacts differ across models under specific ‘scenarios’ [and models] … The analysis presented in this chapter suggests an increasing role for trade under future climate change but the extent of the change varies substantially between models.”

Wheeler in Elbehri, 2015, p.315: Impacts on food systems and policy implications, concludes that “Climate change risks to agricultural output, to food systems and for food security will increase over time and so should not be ignored by those making medium- and long-term planning decisions about food security”.

Impacts in Europe Rotter & Hohn in Elbehri, 2015, p.107:
“Projections….indicate gains especially for northern Europe, and little change for southern Europe; while many impact projections agree on this, differences in the magnitude of change are huge.”

Impacts in Africa Thomas & Rosegrant in Elbehri, 2015, p.147:
"Because there is reasonable uncertainty as to the impact of climate change on temperature and rainfall in any specific location, policies will need to be flexible and adaptable, so as not to over-commit to any one solution. … For successful agricultural adaptation to climate change, researchers will need to work together with farmers to develop new crop varieties and livestock breeds – along with supporting agronomic and husbandry methods, extension services and mechanisms for scaling up."

Impact modelling, critical issues: Elbehri *et al.* in Elbehri, 2015:
Rainwater harvesting, fallowing, mulching, cover crops are critical issues for research. A key ingredient in helping farmers cope is access to knowledge. Farmer innovation can be supported by responsive research and advisory agencies (Reij & Waters-Bayer, 2001).

Impact modelling, policy messages: Elbehri *et al.* in Elbehri, 2015:

Critical actions to enhance resilience in the face of climate change in South Africa are spelled out in Chapter 5 of the National Development Plan (NDP, 2012). Issues around coping & adaptation are dealt with in detail by Morton (2007).

Community based adaptation (Ayers & Forsyth, 2009): Developing adaptation strategies must go hand-in-hand with development, helping vulnerable communities to stabilise their livelihoods. Many of these involve rainwater harvesting. In Bangladesh, a coping strategy for floods is the setting up of "floating gardens" to produce food when the lands are inundated. Given the great need for resources in many African communities, community based adaptation may find that extra resources from outside are needed, and while the community can adapt to some degree, extreme events will require outside assistance.

A review of selected African initiatives

In reviewing two responses (both aimed at increasing agricultural production), I showed (Auerbach 2013, pp.24-32) how the Alliance for a Green Revolution in Africa (AGRA) developed a "Millennium Villages Project" (AGRA-MVP) based on conventional high external input maize cropping (Nziguheba *et al.* 2010), while the Export Programme for Organic Production in Africa (EPOPA) took an approach aimed at broadening agro-biodiversity, stimulating soil biology and thus developing resilience as an emerging property of organic farming systems (EPOPA 2008).

I compared (Auerbach 2013, p.30) the cost-effectiveness of the two approaches over an initial five-year period (see Figure 3), and found that while AGRA-MVP was spending US$120 per farm per year, EPOPA had spent US$2 per farm per year. Could there be such a great difference between the two approaches, and if so, what were the reasons for this, and is organic therefore a more viable intervention for improving food security in Africa? The AGRA approach was more ambitious, broader in the range of issues it tackled, accurate in identifying the need for infrastructure and honest in trying to address that need. However, the AGRA-MVP project did impose maize as the crop that they would help with, which did not take local variations into account, and therefore had great difficulties with the marketing of crops produced, which were sometimes not locally preferred (Munk 2016).

On the contrary, the EPOPA project built on local capacity, concentrated on market linkages and developed local training capacity based on locally available resources (Auerbach 2013). Aside from the lower cost and larger number of farmers reached, there were claims that while assisting the farmers, EPOPA had significantly benefited the environment in terms of improved resilience, increased agro-biodiversity and reduced dependence on external aid and external agricultural production inputs; if this is so, these factors will likely be important to improving resilience in South Africa's Eastern Cape Province.

The project will NOT be helpful if it over-simplifies the local economy, ignores local preferences and resources, or attempts to impose interventions on farmers as many past Eastern Cape interventions have done. The comparison of the EPOPA and AGRA-MVP projects should provide several lessons in what to do and how to do it, and also how not to do it.

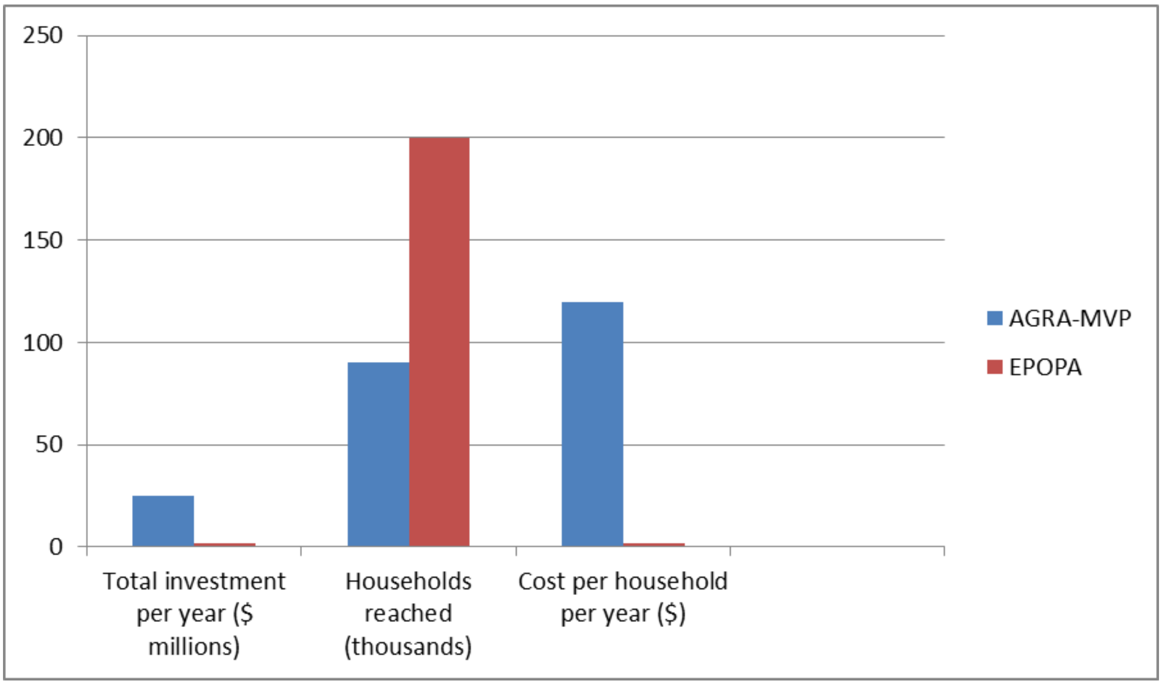

Figure 3: A comparison between the first five years: Alliance for a Green Revolution in Africa (AGRA) "Millennium Villages Project" (AGRA-MVP) based on conventional high external input maize cropping, with the Export Programme for Organic Production in Africa (EPOPA) interventions in Africa (adapted from Auerbach 2013, p.30).

The major differences in the two approaches relate to how local resources are valued and how they are managed. The conventional paradigm analyses the situation as follows:

> These soils are acidic and highly leached, therefore low in available P and soil organic matter. Therefore, to increase production quickly, they will require lime and chemical fertiliser.

The organic paradigm takes a different approach:

> These soils are acidic and highly leached, therefore low in available P and soil organic matter. This is a product of climatic and human characteristics which will not disappear. Therefore, if they are to be sustainably managed, systems will have to be developed to counteract the leaching and acidification processes; they will need some lime and then crop rotation, mulching, compost and possibly some rock phosphate. The systems will have to develop local human and institutional capacity, and will need to produce products which are useful to the local people, and to develop networks which will facilitate the sale of produce.

This is much more difficult, but not more expensive, and an approach that can get around the problems of interventions which over-simplify both the problem analysis and the (imposed) solutions, and build real production capacity on the ground!

The food massification progamme in the Eastern Cape

It is not my intention to criticise past strategies of the Eastern Cape Department of Agriculture, so I will limit myself to three comments about Food Massification:

- Several consultants were brought in at an early stage; I was one of them;
- The late Richard Fowler (Champion of Conservation Agriculture from the Agricultural Research Council) and I both emphasised the need for local capacity development and use of local resources – this was ignored in project design;
- The emphasis of the project was on farm input subsidy programmes, and these are often driven by those selling the inputs (Friends of the Earth Africa, 2017); this is not always in the interests of small scale farmers, and is often not sustainable after project funding is withdrawn.

The agricultural context of the Eastern Cape in South Africa

Details of local variability and recommendations are described in other papers in the IFAD ISASAR series, but as mentioned in the introduction, Map 2 shows that there is adequate data available about existing climate variation.

This indicates that most rainfed cropping areas in the Eastern Cape receive more than 500 mm in the growing season for two out of three years (enough to grow rainfed crops), but some already only have adequate rain for one in three seasons. These already vulnerable areas should be discouraged from rainfed crop production, and a risk assessment should be carried out for each sub-district based on historic records and a prediction of average temperature increase of 2°C, and a decrease in rainfall of about 10% on average, with poorer rainfall distribution (more flooding and more prolonged dry periods).

Unless the approaches adopted build local human and institutional capacity, they will not prove sustainable, and they are likely to join the ranks of high budget technology-driven bright ideas which have been implemented throughout Africa, and which show little long-term contribution to food security or food sovereignty in Africa.

Conclusions on actions likely to increase small scale farmer resilience

While impact modelling globally warns policy makers and agricultural managers about the likely scenarios that farmers and consumers will have to deal with in the next fifty years, it is less useful in telling us what to do about this. Here, practical experience on the ground tells us how we can increase production in the short term where we have easy access to technical expertise and external inputs. Where we wish to develop sustainable systems, improve resilience, and where there is limited access to external inputs, we have shown that agro-ecological approaches make more sense economically, environmentally and socially. They should be linked to institution building processes which develop the capacity of local farmers to make informed decisions and take joint action.

Technically, Climate Change adaptation must therefore include strategies to increase soil organic matter, use mulches wherever possible, set up small-scale rainwater harvesting systems, especially using the run-off from roads and practise crop rotation. Where feasible, compost production should be encouraged. In areas of greatest risk, rainfed crop production should be discouraged, and low-risk strategies for small stock production should be developed.

Socially, little will change in the long-term unless infrastructure, institutions and participatory planning processes are put in place.

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Assessing the impact of a wind farm in the Colombian Power System

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Abstract

The wind energy potential in La Guajira region and its complementarity with the hydrological regimes justify the current interest in Colombia on this source and technology. The power production potential is estimated up to 18 GW, enough to satisfy in excess the current peak demand of the system. The market spot price could be reduced due to the low variable costs of these generation technologies. Also wind energy could help to preserve water reservoirs in a system with a large participation of hydro plants during extended droughts, like the ones caused by El Niño phenomenon. Lastly, the inclusion of renewable generation in the Colombian mix can be viewed as a climate change mitigation option since it could replace energy generated using thermal plants, and therefore reduce greenhouse gas emissions. In this study, the impact of a hypothetical 376.2 MW wind park located in La Guajira region on the Colombian electrical system is evaluated. A retrospective analysis is performed to evaluate hypothetical changes due to the operation of this park during the period 2006 – 2016 in: i) market clearing prices and energy marginal costs, ii) levels of the aggregated reservoir through time and iii) carbon emissions due to electrical generation. Two different methodologies are used to assess those impacts: a reconstruction of the spot market supply curve by using historic economic dispatches and including the new plant, and a full long-run simulations of the marginal cost curves of the 'new' power system by using SDDP (hydrothermal dispatch model, based on stochastic dual dynamic programming). Wind park generation is calculated by using data from weather stations located in the selected region and a park model that includes wake effect for a given layout. The demand to be attended is represented in different scenarios. Results showed reductions of the spot price and energy marginal cost, increases in the level of the aggregated reservoir and reductions in emissions due to the operation of the wind park.

Keywords: Wind energy, Renewable impact, Merit Order Effect, Colombia, La Guajira.

1. Introduction

Currently there exists an important interest in wind energy technologies in Colombia. On one hand, the wind energy potential available in the country is high, particularly in La Guajira region (Amin, Biechl, & González, 2008) estimated up to 18 GW, enough to satisfy in excess the current peak demand of the system (Pérez & Osorio, 2002) and the expected complementarity between wind speed and hydrological resources is also high (Ealo, 2011) and valuable taking into account the penetration of hydro plants in Colombian generation matrix that accounts for 66% of the installed capacity in 2017 (XM, 2017). On the other hand, impacts of including wind energy in the matrix can be valuable from multiple perspectives: operatively (both in the short and long run), economically and environmentally.

Among others, the Merit-order Effect (MOE) is one of the most important consequences expected, consisting in a displacement of the supply curve that lowers electricity wholesale prices due to the low operative cost of wind energy. Because a cleaner source of energy enters the dispatch, carbon emission reductions can also be found. Finally, Colombia could find useful the wind farm even if it replaces hydro plants, as this resource could be used later, specially during scarcity events like the ones caused by El Niño events.

At the moment, there is no significant penetration of wind power in Colombia, except for a 19.5 MW wind park located in La Guajira. Among other reasons, this is due to the generation expansion mechanism used in Colombia (a reliability charge

(CREG, 2006) intended to promote capacity installment in order to overcome extremely dry seasons (Cadena, Vizcaíno, & Alzate, 2011)) whose characteristics are not favorable to variable renewables. For that reason, CREG (Energy and Gas Regulatory Commission) is proposing auctions resulting in long-run power purchase agreements as renewable integration mechanisms (CREG, 2016). In order to justify the benefits implied by those contracts, a quantification of the mentioned benefits could be useful.

The purpose of this study is to evaluate the impact of a hypothetical 376.2 MW wind park located in La Guajira region on the Colombian electrical system, during the 2006-2016 period, regarding changes in energy marginal costs and spot prices, levels of the aggregated reservoir through time and carbon emissions due to electrical generation. Two methodologies are proposed to analyze that impact: a spot market supply curve reconstruction by introducing a new bid corresponding to the estimated wind park generation, and full long-run simulations of system operation based on the SDDP (Stochastic Dual Dynamic Programming) model. In both cases historical data provided by the market operator are used to simulate the market behavior during the period 2006 – 2016 in presence of this wind energy. Wind park generation is calculated by using data from weather stations located in the selected region and a park model that includes wake effect for a given layout. Different scenarios are proposed to treat the demand in order to avoid a possible excess capacity effect created by this additional power capacity introduced in the system. A comparison between the results obtained from the two methodologies is also presented. Analyses showed reductions of the spot price and electricity marginal cost, increases in the level of the aggregated reservoir and reductions in emissions due to the operation of the wind park in both approaches. The installation of wind energy would help having a most diversified generation portfolio with competitive prices, a less vulnerable production on critical periods and a cleaner power system.

This article is organized as follows: in the next section a short literature review is presented. A detailed explanation of the two methodologies used in this study is accomplished in section 3. Section 4 resumes the results for every scenario and the next section discusses them in comparison. Finally, in view of the results some final implications and considerations for Colombia are proposed.

2. Literature review

In (Pöyry for the European Wind Energy Association, 2010) Merit Order Effect (MOE) is defined as the reduction in price of energy due to the wind power entering near the bottom of the supply curve, thanks to its low marginal cost associated with its no fuel costs. When the supply curve is shifted to the right, depending on the price elasticity of the demand, price is reduced. This reduction is expected to be higher in high wind speed periods than in periods with low wind speed. Existence of MOE is widely accepted but its quantification is still under discussion. Several methodologies have been used to quantify MOE, including ex ante and ex post analyses, being the last ones affected by all the significant assumptions regarding generation portfolios and demand (Dillig, Jung, & Karl, 2015). Ex-ante analyses try to show the implications to the systems if renewables had been part of it in the past, or if they had not been present in the generation mix in the cases where renewable plants are already installed.

A stochastic unit-commitment model is presented in (Barth, Brand, Meibom, & Weber, 2006), and it is used to compute the total change of the operation cost, value of saved water and avoided costs per additional MWh of wind power when increasing wind power capacity in Finland, Norway and Sweden until it covers 10% and 20% of the annual electricity demand, using forecasted capacities for Denmark and Germany.

Using a different approach, a model that simulates reserve and spot markets in Germany is used in (Sensfuß, Ragwitz, & Genoese, 2007) to find price increases due to hypothetical renewable technologies absence in several scenarios in the years 2001 and 2004-2006, trying to take into account the possible changes in the power plant portfolio associated with the elimination of the renewable plants. Sensitivity analysis are also performed on variables influencing the MOE such as fuel prices, scarcity mark-ups, and CO_2 emissions pricing. Findings show estimated MOE in the 3-5 billion Euro range in 2006, suggesting that the cost for the renewable support may not be as high as expected. An optimization model in which every firm tries to maximize its profit is proposed also for the German case in (Traber & Kemfert, 2011), with its costs divided in two parts, one independent of the demand profile, and other only regarding gradients in demand, to take into account ramping constraints. Wind speed scenarios to study the effect of changing the mean or the variance of the wind speeds are also presented.

In (Cludius, Hermann, Matthes, & Graichen, 2014) the MOE in Germany for 2008-2014 using a time-series regression analysis is estimated. The market prices are found to reduce considerably: 12€/MWh and 14-16€/MWh for 2012 and 2016 respectively. The cost of the renewable integration, given by the German Renewable Energy Sources Act (EEG), is again considered to compare the benefits obtained earlier. Authors suggest energy-intensive industries profit from the price reduction in the wholesale market, while being exempted from contributing to EEG. Recommendations are made to integrate the MOE and other distributional assessments into the EEG.

Linear regressions are a common approach too. For example, in (Clò, Cataldi, & Zoppoli, 2014) linear regressions are performed, finding negative statistically significant coefficients for the effect of non-dispatchable renewable generation in Italy, meaning that an increase in renewable generation reduces prices. Furthermore, this study quantifies also the increase in variability of prices due to renewables, finding increases near to 1% of the variance of price for a 10% increase in wind generation (with a small base energy: 0.6 GWh/day).

Again in Germany, the construction of a representative supply curve for the non-renewable part of the generation mix is proposed in (Dillig, Jung, & Karl, 2015), in order to evaluate the increase in prices due to the hypothetical absence of their renewable plants. A summary of several studies trying to quantify MOE of renewable energy is also presented, performed in European countries mainly and with different time horizons, finding MOE for wind energy ranging from 0.4 ct.€/kWh and up to 2.3 ct. €/kWh, showing an important variability in the expected price reductions. Results vary significantly because the renewable capacity installed, time horizons and market conditions including base prices and generation mix composition are not uniform.

Finally, it is worth to take into account the analysis presented in (Acemoglu, Kakhbod, & Ozdaglar, 2015), in which considering an oligopolistic market with agents with diversified portfolios, so they can offer renewable and conventional energy, it is concluded that MOE can be partially or totally absorbed by the supply side of the market because agents can strategically reduce their conventional offer when the renewable production is high.

3. Methodology

To evaluate the MOE of the La Guajira's wind farm, three main results are obtained. The first one, and most explored in the literature, is to calculate the change in the cost of electricity as a new renewable plant enters the market. With this modification produced in the system, it is also possible to estimate the reduction of GHG emissions because a cleaner energy source is now used to supply the demand. Finally, due to the high penetration of hydro plants in Colombia, the changes in the MOE during hydrological scarcity periods are considered, taking into account the savings in the total water reservoir throughout these events and in the whole analysis period. In the rest of this section, the common ground among the approaches is discussed first while the specific requirements for the spot market reconstruction and the SDDP simulations are presented later.

The most valuable source of information used is XM, the Colombian market operator, which provides the updated physical characteristics of every generator operating in the system and historical economic dispatch data. On the other hand, the Colombian Mining and Energy Planning Unit (UPME) publishes the CO2 emission factor by plant type. Both methodologies need information about demand, supply, carbon emission factors, ONI (Oceanic Niño Index), and wind farm expected generation.

First of all, wind farm expected generation was calculated using a wind farm model and wind historical data provided by ISAGEN. Data correspond to 1 hour wind speed average data, at 61m, for the whole analysis period, measured by two weather stations located at La Guajira, near to the hypothetical location of the wind farm. Nevertheless, data had several periods with important amounts of missing values, so a full reconstruction performed in (Chitiva, Duarte, González, Pedraza, & Pérez, 2017) was used to calculate the wind farm generation in every hour in the time horizon for the analysis.

The wind farm model was constructed using the characteristics of 3 possible wind turbines to be used in the farm, a possible layout proposed by (Barlovento Recursos Naturales, 2014.), and a simple wake effect model described in (Manwell, 2002). Generation was calculated hourly and then aggregated for its use in SDDP. The calculated capacity factors ranged from 4.19 % in the worst month to 91.73% in the best one, with a mean value of 53.02 % for the 11 studied years, higher than the maximum international mean found in (IRENA, 2016), in Brazil (45%).

Demand is also a critical input for both models because it determines which plants enters or leaves the dispatch that results in spot prices and marginal cost reductions. Hourly national aggregate demand information provided by XM was directly used for the SMR analysis, and transformed into monthly resolution in order to be used in SDDP.

Three scenarios based on demand modifications are proposed in order to neutralize the effect of additional capacity in the system. In (Dillig, Jung, & Karl, 2015), instead of proposing scenarios with demand changes, the authors modeled how the installation of generators in the system would have behaved once all renewables in Germany were removed from the mix. The proposed demand scenarios are simpler and could help to illustrate consequences of including renewables in the generation matrix, like the need of some excess capacity to covered variable plants during their low output periods.

In the first scenario, Base Demand (BD), demand information for the dispatch is unmodified resulting in the maximum excess capacity possible in the system. In the second one, Capacity Factor Demand scenario (CFD), the demand is increased constantly in all periods by the average wind farm expected generation (equal to the farm´s installed capacity multiplied by its capacity factor). In the long run, no theoretical excess capacity would occur in this scenario because the periods with a low wind farm output would exactly balance those with high ones. An intermediate scenario, Reduced Capacity Factor demand (RCFD), takes into account the inherent excess capacity required by electrical systems with a high penetration of renewables, like Germany and Italy. For this reason, demand is increased constantly by an amount equivalent to a 38% of the plant capacity factor.[1]

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[1] *In the 7th and 8th expansion scenarios shown in (UPME, 2015) 1624 MW of wind replace 670 MW of coal, resulting in a relationship of 2.423 between the sources. Using historical data an approximate capacity factor for TASAJERO, one of the newest coal plants in Colombia, is obtained being equal to 53% for 2013-2015. With this information, the resulting demand covered by the new wind generation in the UPME's scenario is equal to, resulting in a reduce capacity factor of 20.3%, finally used in the RCFD scenario.*

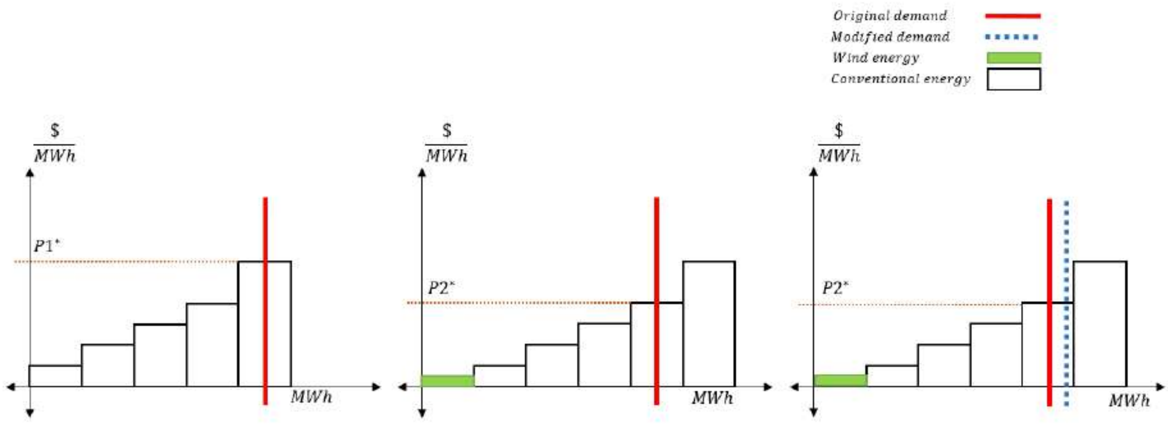

Figure 1. Merit Order Effect with demand modification

Figure 1 illustrate the concept explained before for a given period. In the left column, the dispatch is shown without wind energy, in which the market clears at a price $P1^*$. The middle diagram shows the BD scenario, the one in which the wind farm is included with no demand modification. The MOE is at its maximum and the spot price is equal to $P2^*$. In the right diagram the scenarios with demand modifications are represented. The wind farm is included, but because the demand has at the same time increased, the MOE changes. In this example, the spot price remains the same while more energy from the marginal plant is used. If the demand is increased not by a constant amount, but for example by the farm output at every time period, the only result that can be found is a change in the technologies used in the dispatch because the price effect would be nullified.

Information about supply was provided again by UPME and XM, and consisted in all offers by generators to the SMR analysis and the technical data about all generators for the SDDP analysis. Carbon emission factors for every generator were also provided by UPME. ONI index information was taken from (National Weather Services - Climate Prediction Center) and each month was catalogued using the three-month average centered in each one[2], and using the interpretation criterion described in (Golden Gate Weather Services, 2017) evaluating only moderate, strong and very strong episodes.

3.1 Spot market supply curve reconstruction (SMR)[3]

In Colombia, centrally dispatched generators (those with an installed capacity greater than 20MW) submit a two-part offer for the day-ahead market: energy availability for every hour and a unique price day by day. XM (the ISO and market operator) constructs the supply curve and finds the ideal spot price to fully cover the electricity demand (CREG, Resolución 51 de 2009, 2009). After three months, this information is accessible to the public. Following the same XM procedure, it is possible to reconstruct the supply curve and find a spot price. The average difference between the real annual spot prices and those reconstructed is below 10%, except for 2006, as shown the Appendix. A supplementary benefit is included, taking in to account the energy bought in the spot market in every period, approximately a 30% of the total demand, weighting the price reduction effect by consumption.

[2] *The index for Dec-Jan-Feb was assumed to be for January, for example.*

[3] *This methodology assumes that the behaviour of agents in the market would not change with the addition of a new plant. Although the analysis could provide insights in to possible benefits for the system during a certain period, the management of the hydro reservoirs and other important variables in the Colombian system get distorted as the duration of the reconstruction increases. SDDP performs dynamical simulations that solve this problem, but without considering the authentic way in which agents play in the market.*

Once the wind farm is added to the system, it changes hourly the marginal plant in the market depending on its own generation and the demand scenarios. Accounting for all cases, the ones in which the plant displaces generation required in the original dispatch and those when the low output of the park means new generation is needed, allows to recalculate the energy produce by each technology in the system. With the accumulated result for every type of fuel the GHG reduction per MWh is calculated. To simplify the analysis, non-conventional sources like biomass cogeneration are ignored.

3.2 SDDP simulations

SDDP is a hydrothermal dispatch model used to calculate the least-cost stochastic operating policy of systems with high penetrations of hydro and thermal generation plants (PSR). Taking the information described at the beginning of this section as inputs, as well as the fuel costs discriminated by plant (that were obtained finding correlations between the projections provided by UPME and historical producer incomes available to the public also through UPME), SDDP calculates the dispatch for every month in the time horizon of the study, the marginal cost of the energy, the level of the reservoirs, among others.

After calculating the wind farm generation, a methodology designed for representing renewable energy sources in SDDP was used to include it in the model (UPME, 2015). Equivalent hydrological flows were calculated to be the input of a run-of-the-river hydro plant whose energy is the same as the one obtained with the wind farm model.

The hourly demand information was transformed into monthly resolution, using 5 demand blocks to represent the demand in every month. Those blocks are a not-chronological division of the demand with variable duration for each block, but an approximation of a load duration curve, so the peak times in the month are all aggregated in the first block, while all demand valleys are grouped in the fifth block.

The first performed simulation tried to replicate the actual behavior of the system during the 2006-2016 period, and it is taken as the base case. Taking into account that the difference between costs and prices does not allow to compare the costs produced by SDDP with the real spot prices of the system, in order to validate the methodology, Figure 8 presents the comparison between real and simulated generations (aggregating all thermal generation plants to facilitate the comparison), finding similar shapes in both graphs, and showing that SDDP dispatches more hydro and less thermal than the real ones (approximately 8% more and 23% less, respectively), mainly because of the neglected transmission constraints. Then, several simulations including the wind farm generation and with the demand increases previously described were performed, and its results compared to the ones obtained in the base case.

SDDP obtains a “water use policy” consisting in the criterion used to define the amount of water in the storage used in each month. This decision depends on the opportunity cost of the stored water: if the stored water is used in the present, thermal generation is reduced and therefore a low marginal cost is obtained; nevertheless, that implies less stored water in the future, and a higher marginal cost in later stages (and vice versa: not using the water in the present lowers future marginal cost but increases the present one). The water use policy of the base case was kept constant in all the simulations including the wind farm, to maintain the decisions involving the reservoir, and thus keeping constant the optimal solution, so the wind farm implies a sensibility analysis, taking into account that the wind farm capacity is too small compared to the full system capacity (2.26%).

4. Results

To facilitate results interpretation, it is necessary to highlight that every result presented consist of a difference between each scenario and the base case, with no wind farm included. These differences were taken subtracting the value obtained with the Base Case from the one resulting after including the park, so they are negative when the Base Case has a greater value. In this way, positive differences in marginal cost or price represent a positive impact, while positive difference in reservoirs imply a disadvantage to the system. The differences are presented showing weighted averages and percentages over the base mean. Additionally, all results shown in Tables are separated between the complete studied periods and only those months that presented Niño events[4]. Finally, carbon emissions reductions are presented both in percentage, over the total emissions in the respective period, and in monthly average reductions, facilitating the comparison among normal and Niño periods.

4.1 Spot market reconstruction

The new spot dispatch is calculated after including the wind farm for 2006-2016. All results have an hourly resolution, but to compare them more easily to the SDDP methodology a monthly resolution is selected. In Figure 2 the energy price difference between the base case and every other is shown. Results are almost always positive for the two scenarios with low increased demand, BD and RCFD. On the other hand, the CFD scenario shows considerable negative impacts during the months with the lowest average winds speeds. Because the Colombian currency depreciated approximately a 50% during 2015, Figure 2 gets distorted. In Figure 7 the same results are shown in Colombian pesos, highlighting greater benefits during the 2015-2016 El Niño event. Figure 3 complements these results, providing a measurement of actual annual savings in the spot market.

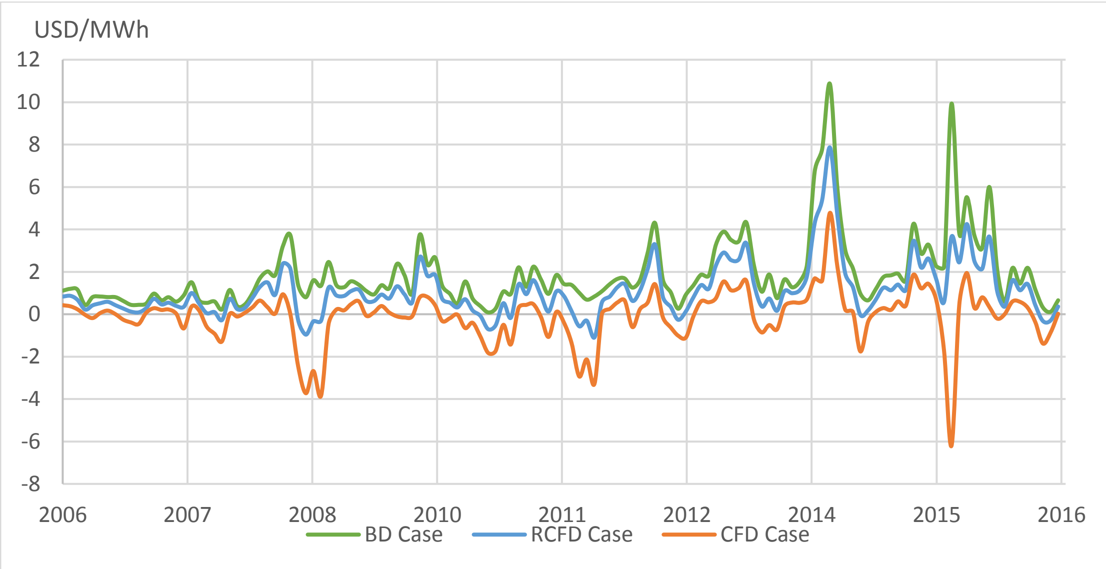

Figure 2. Price difference between base case and the three scenarios during 2006-2016 obtained with SMR

[4] *With the ONI criteria selected, in the 2006-2016 there are two periods with El Niño events: from November 2009 to February 2010 and June 2015 to April 2016.*

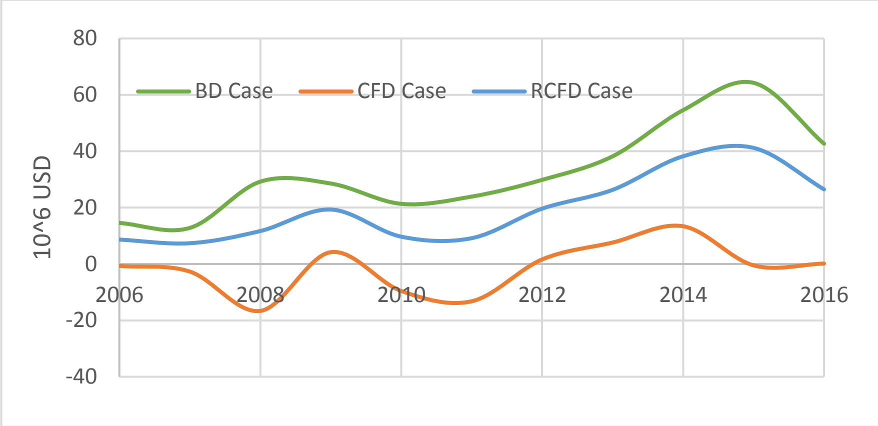

Figure 3. Savings in the spot market due to the MOE in the three scenarios during 2006-2016 obtained with SMR

An additional relevant aspect of the SMR is that a price difference only exists in hours where the wind farm changes the marginal plant. In some situations, because the output of the farm is low or the marginal plant is big enough, the price does not change but energy from another resource is taken out from the dispatch and replace by wind, resembling the behaviour of a stepwise curve[5]. This could be relevant for Colombia because large hydro plants, in the range of 500 to 1200MW, are dominant in the generation mix. Although this phenomenon does not produce price reductions, it is in fact accounted for in the calculation of emissions reduction. Table 1 summarizes the price reduction information.

Table 1. Summary of differences in marginal price obtained with SMR.

Time Horizon	BD [USD/MWh]	BD (%)	RCFD [USD/MWh]	RCFD (%)	CFD [USD/MWh]	CFD (%)
Whole analysis	1.874	2.715 %	1.0954	1.587 %	-0.07853	-0.114 %
El Niño events	3.636	2.563 %	2.24	1.582 %	0.062	0.044 %

Table 2 presents the carbon emissions reductions in each scenario due to the addition of the wind farm to the system. For the whole analysis, the ideal dispatch accumulated total emissions equal to 83.12 Million tons of CO2, while the Niño events, lasting only eleven months, accounted for 14.611 Million tons of CO2, 17.57% of all emissions throughout 2006-2016.

Table 2. Summary of differences in carbon emissions obtained with SMR

Time horizon	BD (avg.) [MtonCO2]	BD (%)	RCFD (avg.) [MtonCO2]	RCFD (%)	CFD (avg.) [MtonCO2]	CFD (%)
Whole analysis	0.03971	6.3059 %	0.02609	4.143 %	0.00546	0.867 %
El Niño events	0.04551	4.672 %	0.03081	3.163 %	0.00845	0.8678 %

As was explained earlier, it is not possible to obtain the total water stored in the reservoirs because the SMR considers an extended period of time. The 2015-2016 Niño event, lasting only eleven months, can represent this savings in a more realistic

[5] *This phenomenon is highly recurrent in the SMR analysis. For example, in the BD case during 2015 a 56.71% of all hours had a price difference equal to 0. This number varies between cases and years, but stays close to that magnitude throughout the study.*

way. In Figure 4 the hydro energy replaced by wind in the dispatch is shown. The total amount is equivalent to a 7.75%, 7.43% and 5.55% of the total system´s water reservoir[6] for the BD, RCFD and CFD scenarios respectively.

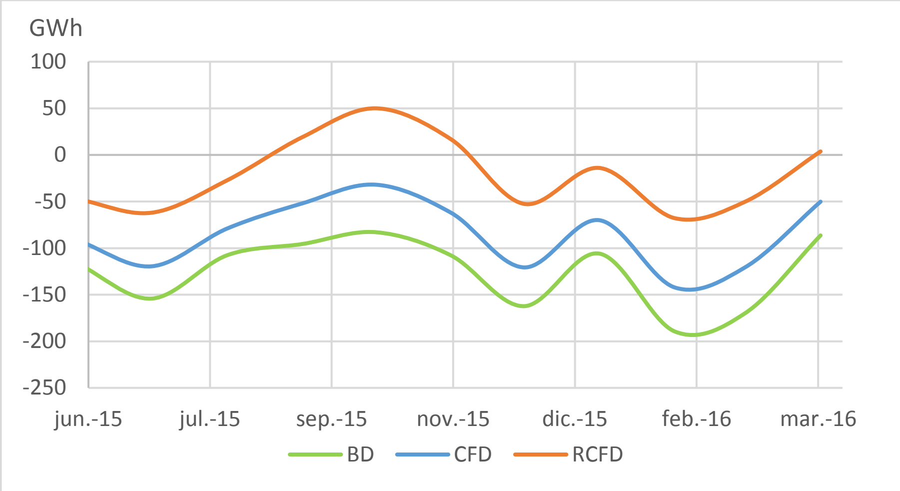

Figure 4. Differences in energy used from hydro sources between Base Case and the 3 scenarios during El Niño event 2015-2016, obtained with SMR

4.2 SDDP simulations

Figure 5 shows the almost always positive difference between marginal costs in the cases where demand was not increased or increased using a reduced capacity factor for the wind park. That means that in those cases marginal cost is reduced in most months. Equivalently, Figure 6 makes even more evident that the negative differences in energy storage (that means more water available in the reservoir in the cases including the wind farm) are greater when the wind farm represents excess capacity. In both figures the CFD case have positive and negative differences depending on several factors including wind speed and supply and demand conditions.

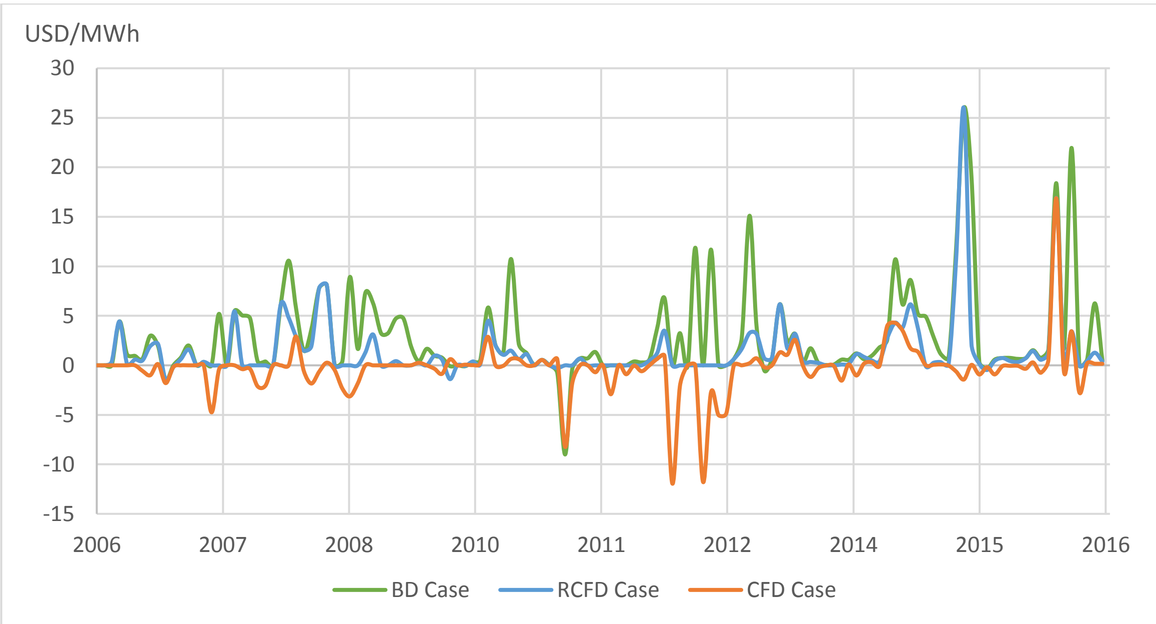

Figure 5. Differences in marginal cost between Base Case and the 3 cases including the wind farm, obtained with SDDP.

[6] 17210.06 GWh of useful capacity in the Colombian hydro reservoirs reported by (XM, 2017).

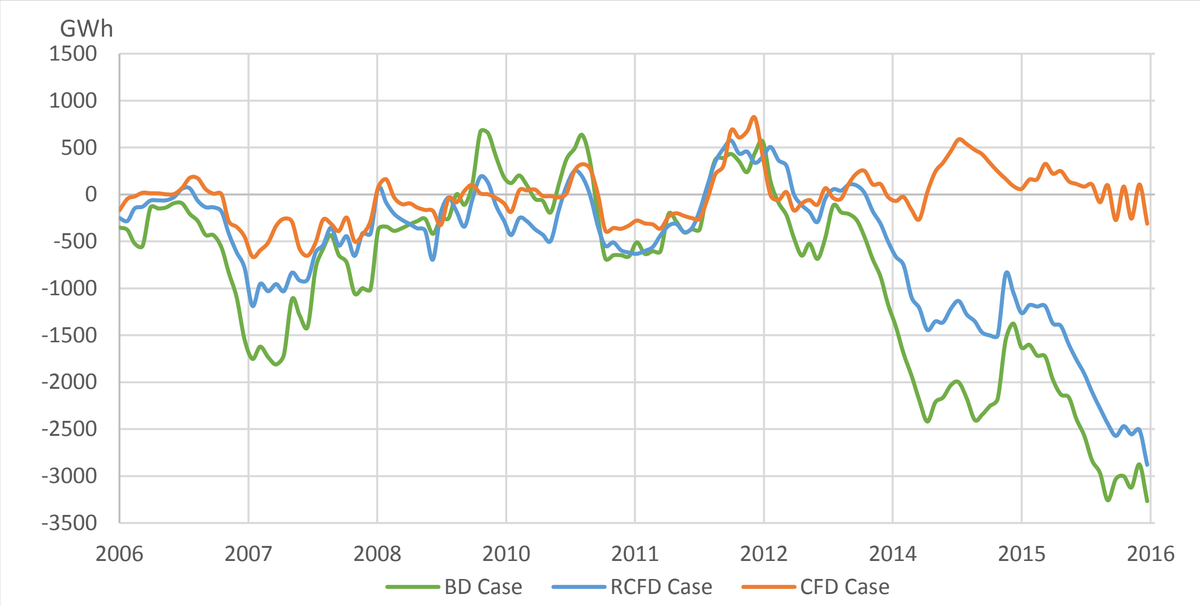

Figure 6. Differences in stored energy in the aggregate reservoir between Base Case and the 3 cases including the wind farm, obtained with SDDP.

Benefits related with marginal cost are numerically summarized in Table 3.

Table 3. Summary of differences in marginal cost obtained using SDDP.

Time Horizon	BD [USD/MWh]	BD (%)	RCFD [USD/MWh]	RCFD (%)	CFD [USD/MWh]	CFD (%)
Whole analysis	2.95	5.38%	1.45	2.65%	-0.24	-0.43 %
El Niño periods	3.48	5.52%	2.13	3.38%	-0.25	-0.40%

On the other hand, benefits related with stored energy are summarized in Table 4. All percentage results are calculated over the total useful capacity of the aggregated reservoir and as in the past results, averaged difference is also presented. Again, bigger benefits are found during El Niño Periods, showing the wind farm as a relief for the system especially in critical operation conditions.

Table 4. Summary of differences in stored energy obtained using SDDP.

Time Horizon	BD [GWh]	BD (%)	RCFD [GWh]	RCFD (%)	CFD [GWh]	CFD (%)
Whole analysis	-843	-4.89 %	-571.00	-3.32 %	-24	-0.14 %
El Niño periods	-1261	-7.32 %	-989.00	-5.75 %	110	0.64 %

These results show a positive impact of the wind farm operation on the Colombian electrical system. Besides, the wind farm reduces carbon emissions by displacing thermal generation in the dispatch. The reductions are presented in Table 5, showing average monthly reductions and total reductions as percentage of the emissions in the base case (51 MtonCO2).

Table 5. Summary of reductions in carbon emissions obtained using SDDP.

Time Horizon	BD (avg.) [MtonCO2]	BD (%)	RCFD (avg.) [MtonCO2]	RCFD (%)	CFD (avg.) [MtonCO2]	CFD (%)
Whole analysis	0.08538	22.17%	0.04897	12.00%	0.00257	0.66%
El Niño periods	0.09867	15.04%	0.05690	8.66%	-0.00978	1.48%

Again, the biggest reduction is found in the case in which demand was not increased. Even in the case of maximum demand increase, carbon emissions are reduced due to the wind farm operation, although the reduction is almost negligible.

5. Discussion

The first important debate is to assess the relationship between prices and costs of electricity. In the SDDP simulations, a variable cost is assigned to every generator, depending on fuel (for thermal ones) and variable operation and maintenance costs. Marginal cost of energy is simply the variable cost of the marginal generator in the dispatch. Nevertheless, it is important to consider that the dispatch is done accordingly to the water use policy calculated (described in the Methodology section) using full information about the system and the future hydrological resources.

In real life, agents do not have all available information and cannot make totally accurate predictions. Because of this, even in a perfectly competitive market the decisions taken could differ to those obtained from the SDDP simulations. Variations in the Colombian system could also modify the agents' behavior, like the necessity to fulfill the reliability mechanism obligations or transmissions constrains that change the ideal dispatch. Additionally, payments for frequency services and remuneration to generators needed outside the ideal dispatch could represent incentives to increase price offerings to the spot market (McRae & Wolak, 2016). For these reasons, and others that are beyond the scope of this article, prices and cost are different, with the first being usually higher[7].

Table 1 and Table 3 presented marginal prices and costs results. SMR reported price reductions in the range from 0 to 1.874 USD/MWh in normal periods and up to 3.63 USD/MWh in El Niño events depending in the scenario being evaluated. On the other hand, SDDP accounted for a maximum of 2.95 USD/MWh in normal periods and 3.48 USD/MWh in El Niño events. Although the nominal values found in both methodologies are close to each other, the relative effect is different in both cases. This could be partially explained because under the SMR method, the wind farm is not producing a MOE almost a 50% of hours due to the size of marginal plants in the dispatch. Instead, SDDP reports approximately a 25% of periods in which the wind is not able to change marginal cost.

For the scenarios BD and RCFD the SDDP reductions almost double the ones found in the SMR. The tendency to reduce benefits as the demand is increased holds for both methodologies. In addition, the wind farm is producing a slight negative impact in the CFD scenario, ratifying the necessity to accept excess capacity in a system that installs variable renewables. Colombia already has this problem due to the large penetration of hydro plants, rising extra concerns to incentivize other technologies with similar variable characteristics.

The system behavior in Niño event is similar in both methodologies. Due to water scarcity resulting in a steeper supply curve, more thermal generation enters the dispatch, increasing carbon emissions. Price and cost also increase as more expensive

[7] *The mean spot price during 2006-2016 was 67.17 USD/MWh, meanwhile the mean cost for the same period was 54.85 USD/MWh, obtained with SDDP.*

plants are used to satisfy demand. Benefits are greater in all aspects analyzed, although percentages are lower in both prices and carbon reduction. These results are explained with the extreme conditions suffered in El Niño events: prices go up and thermal generation is pushed to its maximum during months. Wind generation could be critical on these periods, reducing the impact on demand that is forced to buy expensive energy in the spot market.

Although the price reduction is considerable and could represent an advantage to the demand, revenues to all generators would fall by the same amount. If no demand elasticity is considered, the price reduction cannot be translated to an increase in social welfare directly. Furthermore, in (Acemoglu, Kakhbod, & Ozdaglar, 2015) it is argued that in the existence of limited competition these benefits would be absorbed by the supply side of the market. Even in the ideal situation where the demand pay less for electricity in the spot market, renewable sources are usually supported by long term contracts, a cost not accounted for in the SMR and SDDP methodologies. The MOE is substantial, but good care must be taken to fully get this plus of renewable energy.

Increases in stored energy in the aggregated reservoir are only fully studied using the SDDP methodology, finding savings ranging from 24 to 843 GWh in the whole analysis and up to 1261 during El Niño periods. These energy amounts can represent significant percentages over the total useful capacity of the aggregated reservoir, being therefore an important result: a wind farm with a relatively small capacity can be an important operational relief for the system under critical operation conditions because it could save water in the reservoirs, thus possibly preventing energy shortages or at least diminishing its probability. In SMR, water savings of almost 900 GWh were found in the 2015-2016 El Niño event, even in CFD scenario. Due to the marginal condition of hydro plants, the wind farm is saving more of this valuable resource during hydrological scarcity.

With respect to the GHG analyses, the first important result is the significant difference between the theoretical results, the ones obtained with SDDP, and the emissions calculated from the dispatch. Almost a 66% increase is found in the 2006-2016 period for the real system, even though the ideal dispatch does not account for transmission constraints and other physical restrictions. The comparison with the real dispatch[8] is even more troublesome, the 132.4 Million tons of CO2 reported by (XM, 2017) more than double the SDDP calculations. This information allows to affirm that there exists a hydro potential being wasted, which can be explained mainly by two reasons: the network constraints in the system are pushing thermal generation in to the dispatch and hydro generators are saving their resource due to the fear of not being able to meet their reliability mechanism obligations during a prolonged Niño event. It also implies dual plants, capable of operating both with gas and liquid fuels, are recurring more frequently to the latter in real life, while in SDDP the cheaper fuel is always selected.

The calculated reductions range from 0 to 6.3% of the total emissions in the base case for SMR analysis, and up to 22.17% using SDDP. Again, these results are significant considering the small capacity of the wind farm compared to the full system capacity. Nevertheless, it is worth to mention that Colombia has already a clean generation mix because of the large hydro penetration, so carbon emissions reductions should not the be the most important driver promoting renewable capacity in the country.

Carbon emission reductions in SDDP double the results found in SMR. Due to the difference between total carbon emissions between both methodologies, the SDDP percentage outcome is even greater. This is explained by the fact that the result of the dynamical optimization is to use more effectively the system waters resources, resulting in the thermal plants being marginal in the dispatch more frequently. In contrast, it was found that in the spot market hydro plants are usually the ones setting the

[8] *The real dispatch considers all restrictions in the system: transmission, start-up costs and loading curves for thermal generators, among others (XM, 2017).*

price[9]. Since the size of the wind farm is relatively small, compared with the total installed capacity, it will only affect plants close to the marginal point. Removing thermal generation from the dispatch, SDDP case, increase carbon emissions reduction meanwhile if hydro technologies are replaced, SMR case, carbon reduction diminishes and water is saved for critical periods.

6. Conclusions

Wind farm expected generation was calculated and found to be higher than the mean reported in the literature, summarized in a 53% capacity factor over the 2005-2016 period. This corroborates again the quality of the La Guajira region regarding wind power, and justifies the interest in taking advantage of the resources available in the country. Moreover, renewable development in this area could help to improve social and economic conditions in this department.

Evidence was found to support the three results expected in this paper. Due to the inclusion of the wind farm in the generation mix, electricity prices and carbon emissions decreased, meanwhile less stored water was used and therefore could be saved for critical periods. During El Niño periods the new plant is especially relevant: benefits are amplified because the system is using more fossil fuels and thus emitting more, and because of the poor availability of hydro power, costs go extremely high, as the 2015-2016 crisis showed. Demand would have access to a cheaper and cleaner source of electricity, reinforcing the system reliability during critical hydro scarcity periods.

The environmental benefits described, even considering the already clean Colombian generation mix, can have immense importance trying to accomplish the Colombian INDC, and considering the growing interest of the entire population on protecting the abundant natural resources and biodiversity existing in the country.

All results from the CFD scenario showed a wind farm with almost no advantages to the system. This result implies that excess capacity in a system with a given penetration of renewable generation is not avoidable, and that benefits magnitude will be highly dependent of the demand that the renewable plants are expected to satisfy.

The benefits found in this article are desired, and even necessary, to justify the inclusion of these technologies in the generation mix. Nevertheless, Colombia has a challenge to overcome as the system at the moment has extra installed generators required in Niño events: if the demand continues growing at the current reduced rates, and having generation projects already on their way, renewable technologies would have a tough time finding a place in the sector. Therefore, clear and conclusive political decisions and policy signals are needed in order to facilitate that inclusion and to allow the country to take advantage of its benefits.

As future work, analyses including cost-benefit evaluations accounting for the required investments for renewable generation, the possible complementarity found between hydro and wind resources, the increase of market competitiveness and system resilience induced by these new generators can be performed to continue promoting renewable energy in Colombia.

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[9] In the BD case for the SMR methodology, the wind farm replaces 0.75% Fuel oil, 0.597% Diesel, 12.63% Natural Gas, 15.59% Coal, 0.085% Jet Fuel and 70.35% Hydro energy. In El Niño periods the percentages are distributed as follows: 3.797% Fuel oil, 4.102% Diesel, 16.914% Natural Gas, 8.99% Coal, 0.654% Jet Fuel and 65.54% Hydro energy

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Appendices

Table 6. Average difference between real spot price and reconstructed 2006-2016 obtained with SMR

Year	Real spot price (USD/MWh)	Calculated spot price (USD/MWh)	Percentage difference
2006	35.805	31.287	12.620%
2007	39.603	40.319	1.806%
2008	43.603	44.717	2.556%
2009	61.885	64.553	4.311%
2010	64.479	67.785	5.127%
2011	40.122	40.591	1.171%
2012	61.926	64.518	4.185%
2013	92.253	94.896	2.866%
2014	107.662	112.430	4.428%
2015	127.75	137.92	7.96%
2016	91.096	98.128	7.719%

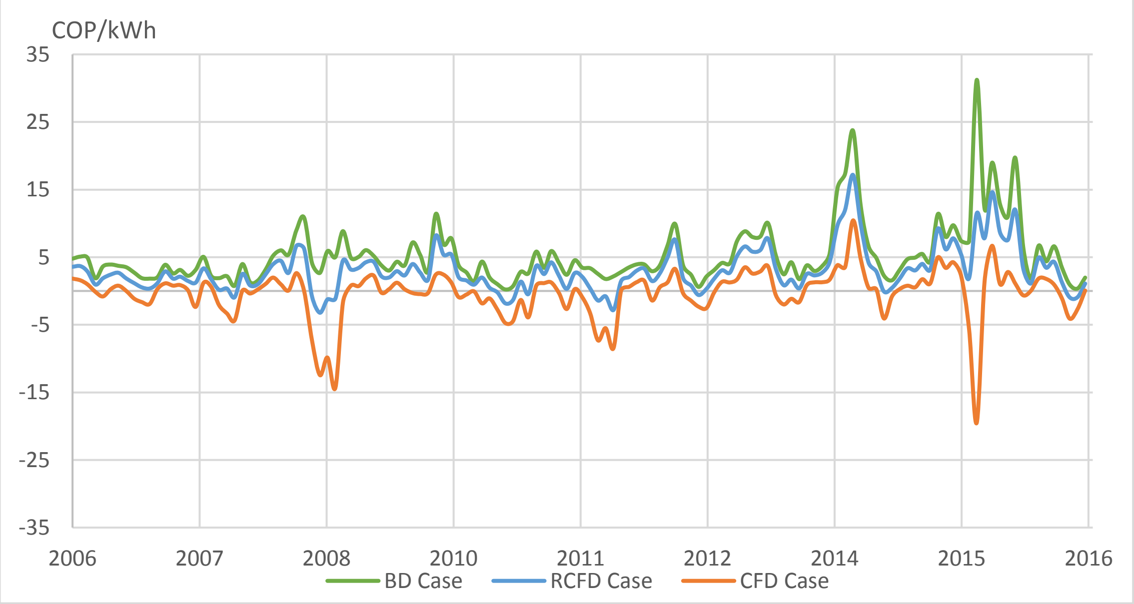

Figure 7 . Price difference between base case and the three scenarios during 2006-2016 obtained with SMR (COP/kWh)

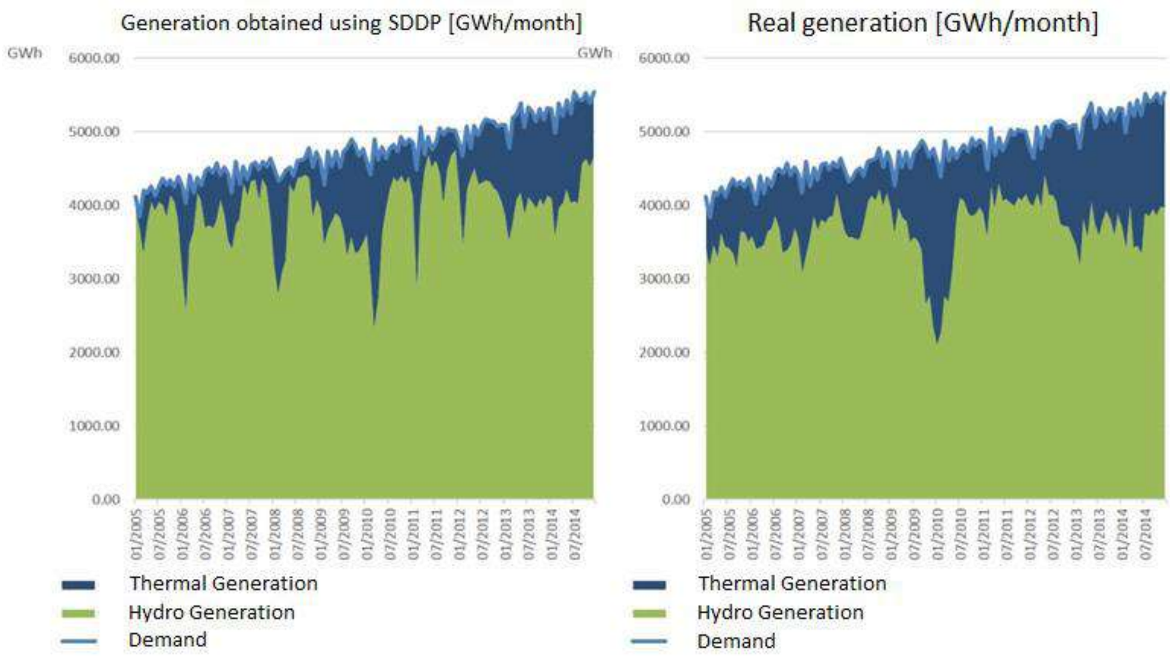

Figure 8. Comparison between Base Case in SDDP and real generation

Methodological considerations for the Life Cycle Assessment of clay masonry

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Abstract

This paper presents the progress of an investigation developed in 2016, whose general objective was to set a methodology for the life cycle assessment of clay masonry in Cundinamarca State, based on the evaluation of energy resources consumption. Recently, progress in the study of energy efficiency in the production of the brick industry in Cundinamarca State have been developed, taking into account the equipment of combustion and / or fuel injection, as well as the combustion process and its proper functioning. On the other hand, regardless of the development of eco-labels methodologies type I, the LCA in this industry does not constitute an element that leads to an eco-label type III regulated by ISO 14040: 2006. This data could be an input for national and local sustainable construction policies, energy efficiency, low-carbon growth, environmental product declaration, and also, makes it as easy to deploy of standards under the Colombian Environmental Seal of the Ministry of Environment, and whose main goal is to minimize greenhouse gas emissions and improve energy efficiency from the construction industry and the brick industry.

Keywords: materials, energy efficiency, masonry, life cycle assessment

1. Methodological introduction

Developing a LCA process is complex because of the large number of variables and requirements at the moment of data entry and the compilation of inventory data, therefore, a protocol is required that will determine the study in line of needs of a specific product, goal, need or performing a specific function. International standards and literature are iterative in terms that this kind of study is not useful to compare products with different conditions and purposes, but rather services and / or quantities of a product that perform the same function. For that, is necessary to identify clearly the system limits, after the proposed application, the hypotheses, the exclusion criteria, data, the economic constraints and the intended recipient (Antón, 2004).

As part of the established LCA methodology, the development is divided into structure and application, which feed each other. In turn, the structure consists of a series of already defined methodological steps that relate each other: objectives definition and scope, quantification through inventory analysis, results interpretation and impacts evaluation, according to the drawn objectives (according to Fig. 1), which account of a standard structuring of sequential activities necessary to reach the objective of analysis and its possible applications.

As set in the standards, it is necessary to clearly define the objectives specifying in detail the subject's areas and the final goal, because the study will be developed in different ways according to what is expected of it. Questions such as the reasons for carrying out the study are resolved, who is addressed to, intentions and decisions derived from the results, the type of information required, if it will be submitted to an eco-label, whether comparisons will be made, if the results will be published or whether an environmental improvement will be made.

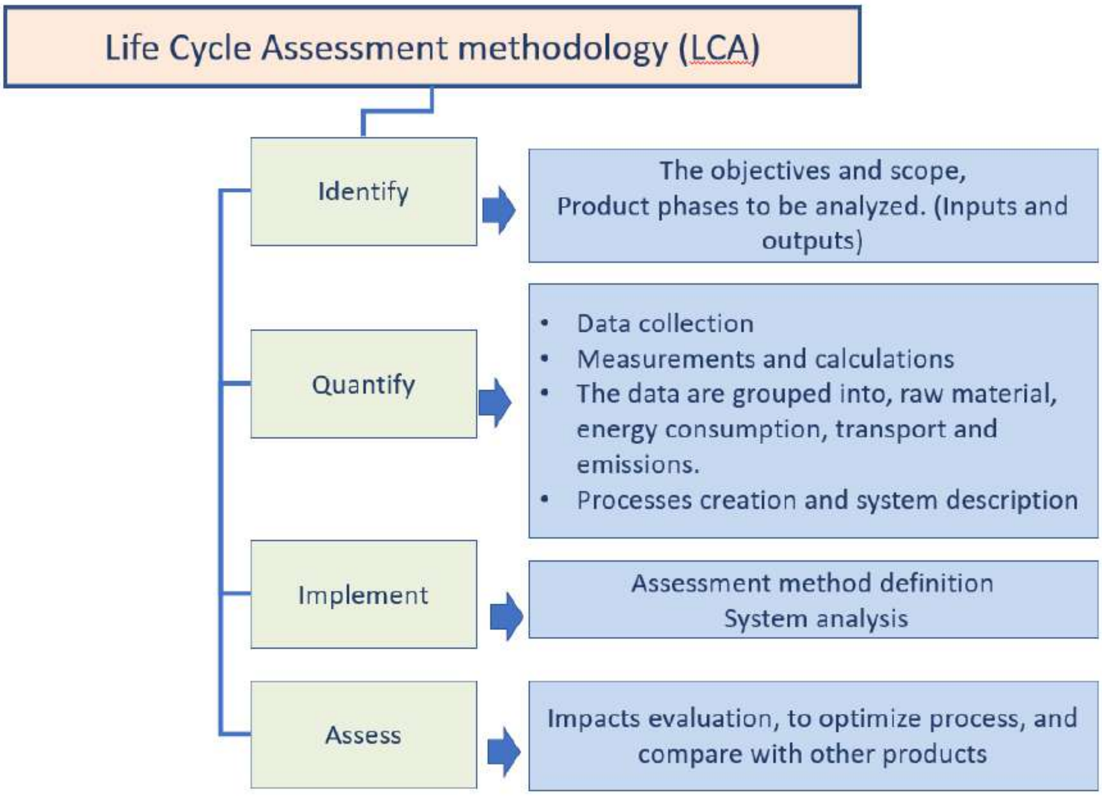

Figure 1. *Stages of Life Cycle Assessment. Source: self-made.*

To delimit the system in products such as masonry, the most practical is to develop a study that cover from obtaining the raw material to its use as a constructive element in a building, that is, from the cradle to the door, as the study developed by Cosude (n.d.) in Peru. This includes the analysis of the extraction of raw material for the mortar jont used in the construction of a particular area of the wall, depending on whether it has confinement columns and the cement - sand ratio.

The scope, the geographical and temporal sphere and the budget should be delimited according to the objectives, and also showing the systems to be studied, the hypothesis, the level of detail and the research data. This will give way to define the functional unit of the system[1], which identifies more accurately what to be analyzed and how to express the inventory analysis, making it a key point of this stage.

[1] ISO 14040: 2006 defines a system as a "set of material and energetically connected unit processes that perform one or more defined functions".

According to ISO 14040: 2006, the functional unit is a "quantification of the function of a system of a product, service or activity, which is used as a reference unit in the LCA study". In other words, it is a reference for the mathematical recording of inputs and outputs, and describes the function of the system, which makes it easier to compare them with those of another system when required. This means that the functional unit is determinant for success when it comes to comparative studies because an equivalence it needs.

Another aspect to keep in mind is that there must be some reliable and valid method to measure the selected functional unit. As in the first approximations to these studies was taken as unit a product that is a unit of physical type, this was used to mention all inputs and outputs of the system, therefore, a compound that composes the sample should be taken as a base of measure.

"*For example, in the case of an industry dedicated to produce polymers for use as packaging, if quantitation environmental impact of one of its products is raised, the object of study can be defined as '1 g of polymer' or '100 kg of polymer'. However, if we wanted to compare the function of two different polymers, it would be relevant to define the function that both products share, for example, "bottling mineral water", so that the functional unit to be studied would be, for example, grams of each polymer used for packaging 1.5 liters of water*" (Feijoo et al, 2007b, cited in Rivela, 2012. 113, Translation by authors).

In the case of agricultural systems, the main function is food production, so that one kilogram of fresh product could be considered as a functional unit. In the case of clay masonry, the usual functional unit corresponds to 1 square meter of non-bearing wall (Cosude, n.d.).

According to ISO 14040: 2006, it is necessary to define the limits of the system, which are the stages and their units that are part of the life cycle of the product or service studied. If within the delimitation, it is concluded that one or more stages must be omitted, it must be sufficiently argued, and provided that it does not significantly alter the overall results (Rivela, 2012: 113).

In the Life Cycle Inventory (LCI), environmental loads comprise data manifested in recorded inputs and outputs of matter and energy of a product, process or service throughout its life cycle and which in turn produce negative impacts in the environment as they are the different pollutant emissions, effluents, solid residues, consumptions of resources, noises, radiations, odors, etc. (Cause-effect relationship). In this way, the inventory includes the collection and technical quantification of these data to be evaluated and the calculation procedures to quantify those environmental loads related to the system, the functional unit and declared objective, including the impact category to be studied (e.g. contained energy, carbon footprint, water footprint, etc.).

In general, the inventory begins with the registration of raw materials and energy from nature, and ends with the management of product residues that are discharged equally in nature; In case they do not come or are not discharged into the environment, their origin or destination must be specified. In her work about LCA methodology for buildings evaluation, Beatriz Rivela (2012) cites James Fava to state the stages that comprising the LCI (Translation by authors):

1. "*Construction of the flowsheet according to the system limits established at the stage of objectives and scope definition.*
2. *Data collection of all activities in the production system. It is necessary to establish the origin of these data: bibliographic and / or in situ measurements; in this latter case, the methodology employed should indicated.*
3. *Calculation of environmental burdens relating to the functional unit.*
4. *Normalization or data related to the used units.*
5. *Balances of matter that allow to interrelate the entrances and exits between the different subsystems.*
6. *In and out flows quantification of the system and from nature and from and to the technosphere.*
7. *Global inventory.*
8. *Calculations documentation*"

In this way, inventory data collection is one of the longest, expensive, variable and complex phases of the LCA, as it requires measurement of consumption and waste in the field and primary information that is not always easily accessible, since without it, the results may not be reliable. The data recorded can be classified into four groups: direct measures, published documents, electronic sources and personal communications (von Bahr, 2001, cited in Rivela, 2012).

The inputs and outputs should be assigned to different byproducts with well documented procedures. For this same reason, when there are alternative allocation procedures, a sensitivity analysis should be carried out to explain their implications and to assess the effects of the chosen methods and data on the obtained results, as established in ISO 14044: 2006. Because the quality and reproducibility of the data recorded may determine the success of a study, adding to the complexity in collecting the data inventory, the databases has a big importance to find or to edit such records and performing a LCA, the reason why different specialized software incorporated one or more databases as inventory. There are different databases in the market, developed by specialized institutes in different countries, standing out the Swiss.

Among the most used databases around the world are Ecoinvent (Switzerland), Eth-esu (Switzerland), Buwal (Switzerland), Idemat (Netherlands), Ivam (Holland), Elcd (European), U.S. LCI (USA) LCA Food DK (Denmark), Danish Io (Denmark), Bousted Model (United Kingdom), Us Lci Database (Canada), Gemis (Germany) and Gabi Database (Various); Of these, the most used to perform building materials assesmenet is Ecoinvent, which was developed by the Swiss Center for Life Cycle Inventories, by the number of incorporated processes in this industry. However, one of the major difficulties in incorporating some of the databases is that there is no traceability in obtaining such data, so they can not be checked for reliability and it makes harder to edit if attached to a different geographical and temporal delimitation is needed, diferenet of the original country of the study[2], which is the case of the Latin American context and especially in Cundinamarca State, Colombia.

In the development of a LCA, the databases are useful for assigning environmental loads to each of the stages and processes of the study objects, that includes several products or cycles, because in very few cases linear processes of a single process of inputs and outputs are presented; on the contrary, most processes produce more than one product (by-products) with several input lines of raw materials and also recycle the intermediate products and their waste, which need to be registered.

[2] These data are based on information related to the energy matrix, the technology used and the transport systems of each country or region.

Inputs and outputs should be assigned to the different by-products with well-documented procedures. For the same reason, when there are alternative allocation procedures, a sensitivity analysis should be performed to explain their implications. This assignment procedure is standardized by ISO 14044: 2006 and is described in three steps by Rivela (2012).

The first step is to avoid allocating by choosing to subdivide the process so that the input and output data can be independently assigned, or to expand the system including additional functions. In the second step the inputs and outputs can be divided between the products or functions, reflecting the quantitative changes in the system. Finally, in the third step, the allocation of inputs and outputs can be proportionally based on other types of relations between co-products (economics, etc.), provided that a physical cause-effect relationship can not be established as a basis (Rivela, 2012: 123).

Software for developing LCA usually also includes one or more methodologies for performing calculations from inventory data regarding resource consumption, emissions, and the resulting damage to human health and the environment. These methodologies are grouped into two types according to the cause-effect relationship to get the calculation of the environmental impact, which are called "final effect impacts" and "intermediate effect impacts". There is a wide range of methodologies developed by different international organizations[3], of which the most widely methodologies used in different fields of research are Ecoindicador 99, CML 2000 and ReCIPe, where the first is classified as “final effect" type, The second as an "intermediate effect", and the last one as a newly created methodology that integrates both types and their use is growing because of the simplicity in the results communication (Rivela, 2012). The IPCC2007 methodology (with intermediate effect) has been applied in a similar masonry study by Cosude (s.f.) and created by the Intergovernmental Panel on Climate Change, specializing in the effects of climate change and impacts from gas emissions of greenhouse effect.

The Life Cycle Impact Assessment (LCIA) is a technical process of analysis and interpretation of the environmental loads recorded in the inventory and is determined by ISO 14040: 2006, indicating the impacts obtained due to the selected impact category. The most common impact categories are climate change, stratospheric ozone depletion, soil and water acidification, eutrophication, tropospheric ozone formation, and indicators of primary energy use; however, according to the eco-labeling needs of certain products, some industries have developed particular categories.

This phase is composed of six sub-stages or elements, the first three considered mandatory by the standard are: selection, classification and characterization, which include the selection of categories, indicators, their classification and a characterization under a model whose units are equivalents for all categories; after that, it defines areas of protection from human health, natural environment, sociocultural environment, and renewable resources. The last three elements are considered optional, which are normalization, grouping and weighting.

In the mandatory selection and classification element, one or more environmental categories should be selected for their analysis based on the inventory and, in turn, the indicators that represent them, whose calculation is given in the characterization. In the optional element of normalization, the obtained results are divided in factors that represent real or estimated values to let be compared between different categories and against certain characteristics of the environment. On

[3] Some of more known methodologies are CML2, CML92, EPS2000, IPCC2007, Ecoindicador95, Ecoindicador99, Impact2000+, TRACI2002, Ecopuntos97, EDIP97, LIME, ReCIPe, MEEUP, and others.

the other hand, the weighting is able to measure between the different categories to establish global results (or a "Environmental index") indicating which could be more harmful than the others; This type of result is very debatable and there is no scientific consensus about it, which is why little is applied and can lead to subjective judgments, as mentioned by Rivela (2012: 126).

According to María Asunción Antón (2004: 52), the allocation of environmental loads to a process and their characterization is performed through the use of a ν column vector associated where the environmental loads are grouped into types of environmental impact and which contains all Information about all possible impacts throughout the life cycle, where each element corresponds to a particular polluting. Each flow of mass and energy in a process (kg·s-1) is associated with this vector whose elements are expressed in mass (kg of pollutant per kg of product) or energy (kJ·kg-1) according to the functional unit, to be accumulated and make balances.

Thus, the process is divided into units or subsystems with a system of equations that calculate the vectors of output or intermediate currents, making the inventory to be made in a similar way to the balance of matter. "The whole system solution allows a detailed knowledge of the origin of the pollution that is awarded to each product" (Ibidem).

In the case of clay masonry, the selection of impact category is based on those that the industry prefers to show publicly, and identifies as inefficient processes and requires improvement; Thus, it has been identified as potential categories to be developed later and communicated in the current context of climate change (quantified in Kg CO2eq) and the primary energy use (quantified in MJ) that leads to establish the energy embedded in a unit of masonry. The rigour with regard an inventory analysis can be carried out will be reflected in a correct classification, characterization and later graphing by the software. This takes into account the consumption of energy used in the manufacturing process of masonry through machines, equipment, metering plant, mixers and transport of raw materials.

It is worth mentioning a study with similar characteristics carried out by the Swiss Agency for Development and Cooperation (Cosude, n.d.) in Cusco, Peru, which develops a LCA and compares the results obtained from analyzing artisanal, mechanized and concrete masonry, Concluding that the mechanized brick has a 36% greater environmental impact by emissions of CO2eq related to the artisanal brick, due to the consumption of energy and transport and the production inputs. Likewise, when concrete masonry is obtained there is an increase of impacts of 175% and 102% related to the brickwork and mechanized brick respectively, due to the consumption and impacts of the cement and transport of the raw material, and inputs of the production plant. This study becomes a point of reference to develop in an applied way the present research and to produce new results to be contrasted in collaboration with different national bricklayers interested in extending their commitment with the environmental sustainability.

2. Types of energy and classification

With the purpose of developing the process of life cycle inventory analysis, which is necessary to quantify the consumption and emissions in a LCA process, field visits are being developed to different bricklayers in Cundinamarca State in order to establish a quantification of Consumptions, emissions and spills, in view of the impact categories that are of interest in this study, such as the indicators of primary energy use (and its consequent embedded energy) and the climate change that is calculated in carbon dioxide Equivalent (CO2-eq) to which a convention is assigned a value of 1.

Within the extraction, processing, transport, distribution and installation of the clay masonry involves several types of energy that have undergone a series of transformations, and their classification depends on their subsequent quantification of energy consumed in the analysis of the cycle inventory lifetime. To do this, we identify the natural elements or resources from which the different types of energy are obtained and how these are presented in nature in a primary form, their transformation into secondary energy and their final presentation used in each of the systems, machinery, equipment, among others.

The water resource in dams is subjected to a height change, which produces electrical energy that is used during the clay masonry production process, in ventilation, lighting, water pumping and grinding, sifting and cutting engines. On the other hand, the resource that are found on underground layers of the earth in solid, liquid and gaseous state that are coal, oil and gas, are transformed into thermal energy used for the operation of furnaces such as coal and chemical energy such as the hydrocarbons used for the operation in vehicles and machinery, and the gas that has been implemented in the production processes. Finally, manual energy is taken into account, which is evidenced when the workers of the plant use their own energy to extract, transport, distribute and install materials, tools and equipment that participate during this stage of the clay masonry life cycle (Fig. 2).

Taking into account the levels of production at the national level of clay masonry elements, the study focuses the analysis of the life cycle of the cradle to the door of clay standard block No. 4 and 5 in the Cundinamarca region in a medium brick factory that has a high degree of technification.

As will be discussed later, inventory analysis is one of the phases of the methodological structure of life cycle analysis that quantifies the impacts of a product, service or process through the recording of inputs and outputs of the system. In this research, a classification of the types of energy involved in the masonry production process is developed to determine in the future the participation of each of these types, and to calculate the total of energy consumptions and estimate the primary energy used, embedded energy and its equivalent in CO2 emissions. This information is key to identifying, interpreting, comparing and evaluating the phases of greater environmental impact in production, as well making decisions to improve the quality of masonry, optimize processes, analyze potentials, evaluate regulations, reduce impacts on The environment (waste, dumping and emissions), and as an environmental product communication strategy.

The aspects to be taken into account in the analysis are grouped by the inputs and outputs that are presented in each of the extraction and manufacturing processes of block No.4; the data are grouped in input of raw material, energy consumption, transport and emissions and for the present study we focus on the energy consumption.

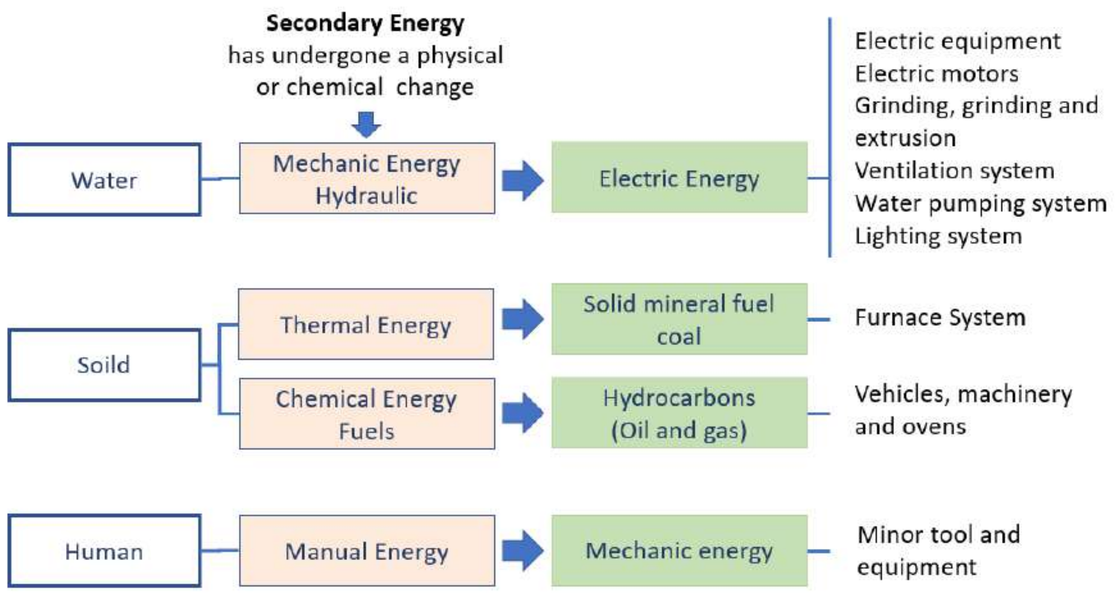

Figure 2: *Types of energy, transformation and uses. Source: self-made*

- IMPUTS

Consumption of raw materials: Sand, silt, water

Energy consumption: materials / fuels - electricity / heat

Transport consumption: as the type of machinery and fuel used

- OUTPUTS

Emissions to water, soil and air

Solid and liquid wastes

In terms of energy consumption, the variables that are in each of the stages within the type of life cycle analysis are given by the types of energy, units of measure, quantities.

3. Process tree and information gathering

For the development of the exercise in order to obtain the first results of the tree of process of the cycle of life of the block, a series of processes were done and are described below:

1. Processes Identification.

Within the methodology for describing the life cycle of any material and specifically the Masonry Block, it is very important to recognize its processes through documentation and through site visits, where each and every one of the methods used can be known in live, from extraction to storage for subsequent shipment to sites for construction and implementation. As a result of this understanding, 8 main processes were identified: "Extraction and maturation of clay in open pit ", "Sorting and selection", "Storage", "Mixing", "Molding", "Drying", "Cooking" and "Storage", each of these processes could be classified, due to its unique characteristics and defined processes in the production plant. For their characterization, photographic material, videos and the testimonies of the different production managers were necessary who delivered the first hand information.

2. Analysis of all processes.

Once the general processes were identified and characterized from the extraction to the delivery of the material (Life cycle from the cradle to the door), each and every one of the processes was analyzed through inputs and outputs described in the following numeral. Both the inputs and the outputs were characterized according to their nature, e.g. transport, mixing, extraction, etc., in which the types of machinery, their type of fuel, types of inputs for their operation were analyzed: water, oil, fuel, etc.

3. Development of the process tree.

A process tree (Fig. 4) is a tool that was thought to be used because it makes easy to describe complex processes in which is found, for example, "Life Cycles of Materials" that in this case is Block No 4. In this case, it is important to emphasize that in the description of any process it is indispensable to know it very well, as a first step, achieving this objective in the visit made to the brick "Arcillas de Colombia". Based on this knowledge, later, it was drown in a clear and objective way to better understanding of the processes.

The guidelines for defining and identifying each of the 8 processes that could be established in the Complete Life Cycle were started, so that three large instances could be identified at the same time: Inputs, process and outputs.

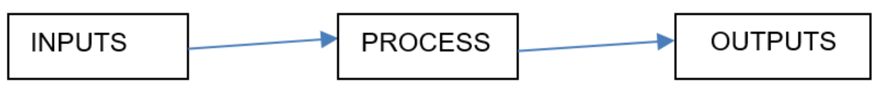

Figure 3: *Processing process tree. Source: self-made.*

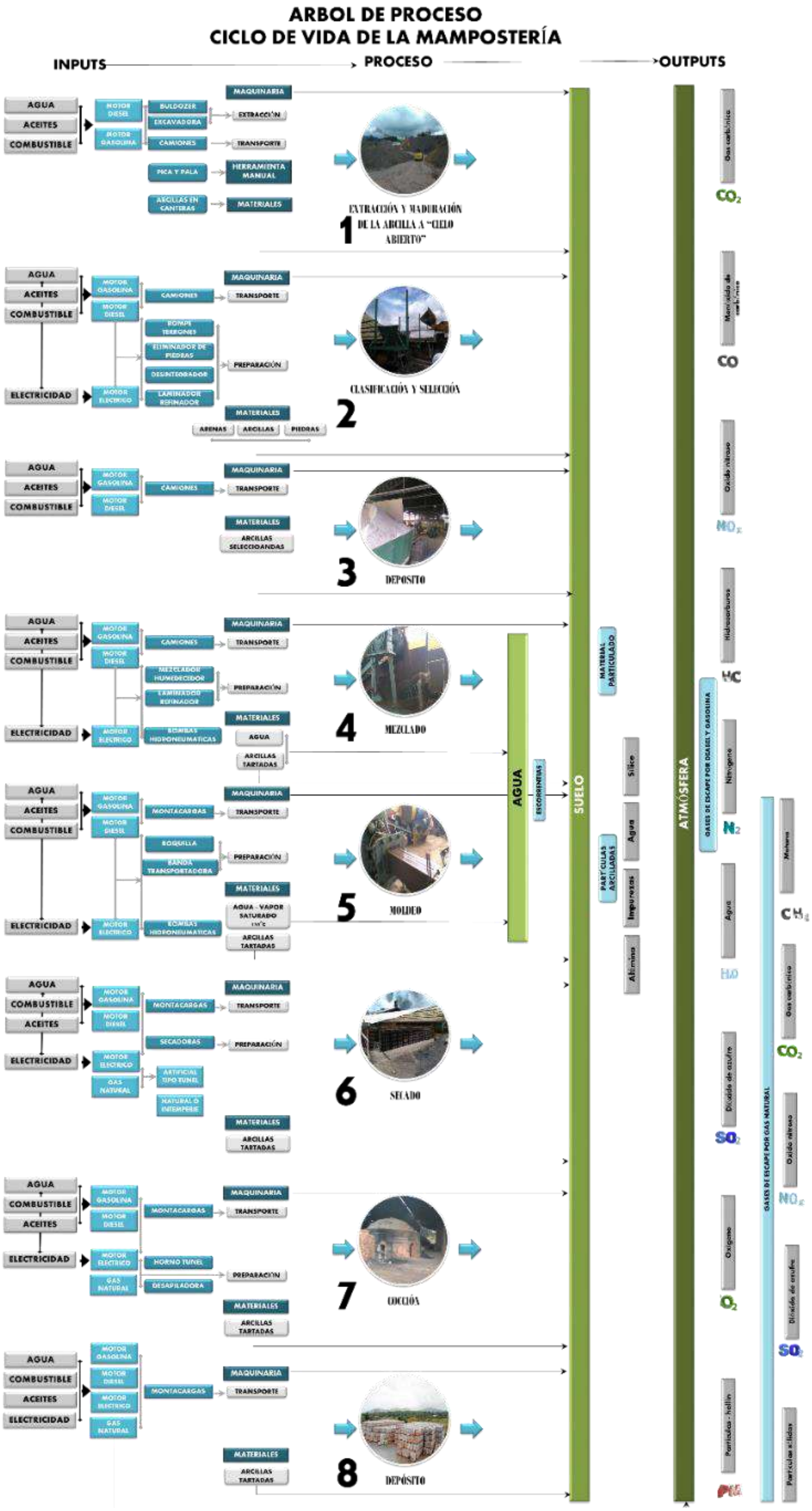

Figure 4: Process tree. Source: self-made.

Inputs: Are the inputs elements of each process, which in this case related to transportation, which for the specific case consists of all inputs needed to move the machines involved in each of the identified activities.

Process: This is the category used to identify the major processes that make up the general cycle of life, that for purposes of this exercise were 8 processes namely: "removing and maturation of the clay open pit", "classification and selection "," storage "," mixing "," molding "," drying "," cooking "and "storage ".

Outputs: Are output elements, resulting from each process that are generally environmental effects, either by air or land route (effects on water, soil, etc.). For the context of the study, they were constituted in the elements resulting from the combustion of the machines involved in each of the processes identified.

4. Built of technical data of quantification of inputs for each processes

As a result of the identification, analysis and developed of the Process Tree, The analysis was made as an example, the scope of this research and the effects of time, the first of the processes called "extraction and maturation of open clay", from which all its inputs were analyzed, which are limited to the transport of the raw material identifying two main sites. The first of them from the original quarry to the site of the plant where they are organized (route 1) and the other (route 2), distributes the clay once matured to take it later to plant and continue with the process.

Later, the types of vehicles that make the routes were analyzed, analyzing model, capacity, brand, type of fuel and consumption of the engine, in order to establish the consumption of fuel according to the route and thus establish with its capacity, which is the percentage of consumption per brick block proportional to its weight, compared to the capacity of each vehicle and type.

Figure 5: *Analysis of the machinery used in the process "Extraction and maturation of open clay", according to its performance and characteristics. Source: self-made.*

In the composition of a brick were analyzed its main components, as well as the average weight that is 2.2 kg, composed of 0.708 kg of water, 1,254 of clay, 0.726 kg of sand and 0.22 kg of Limo. These data were obtained from an investigation carried out by Amalia Sojo, in the document "Applications of Life Cycle Analysis in Building.pdf"

At the same time, consumption and capabilities of vehicles were obtained from the document "table of fuel yields for vehicles, machinery and equipment maintenance"[4]. This document is the product of a similar research, it illustrates in detail many vehicles that participate in the quarries of clay extraction, coinciding with those used in the brick fabric studied.

According to the data analyzed for route number one, it was possible to determine that in Block 1 "Extraction and maturation of open clay" each block No. 5 consumes 0.000268637 liters of fuel. According to the analyzed data for route number two, it was determined that in the the process one "extraction and maturation of open clay" each block No 5 consumes 0.0000048352 liters of fuel. In conclusion, for this process adding the two routes, for each block of brick Number 5 are consumed 0.000316 Liters of diesel fuel.

RECORRIDO 1		
	2,5 km	1litro
	5, 0 Km	2litros
	Arcilla	
	7m3	Capacidad camión International 4700-444
	5,6 Kg	peso de unidad de ladrillo bloque No 5
	2,6 Ton/m3	Peso de la Arcilla
	18,2	
	18,2 Ton	Peso y capacidad del camion International
	18,2 Ton	18200Kg
	16380	16380Kg (10% de desperdicio)
	7445,454545	Cantidad de bloques
	0,000268637	**Litros de combustible por un bloque en ladrillo**
		Composición del tabique artesanal 2.2Kg peso
	0,708	Agua
	1,254	Arcilla
	0,726	Arena
	0,22	Limo
	2,2	

RECORRIDO 2		
	2,5 km	1litro
	0,9 Km	0,36 litros
	Arcilla	
	7m3	Capacidad camión International 4700-444
	5,6 Kg	peso de unidad de ladrillo bloque No 5
	2,6 Ton/m3	Peso de la Arcilla
	18,2	
	18,2 Ton	Peso y capacidad del camion International
	18,2 Ton	18200Kg
	16380	16380Kg (10% de desperdicio)
	7445,454545	Cantidad de bloques
	4,8352E-05	Litros de combustible por un bloque en ladrillo
	0,000316989	**Litros de combustible recorrido 1+ 2 por bloque**

Table 1: *Data retrieval memory traversed one and Data retrieval memory traversed two. Source: self-made.*

5. Conclusions

LCA is a tool for producers of materials that allows them to assess environmental impacts, to ecosystems and human health, that are generated by manufacturing processes and / or processing resources, associated to a product or process that is being developed, with the objective of develop strategies aimed to optimization and subsequently made a public declaration to achieve a greater reputation. The design and implementation of consumption reduction strategies are reflected in the final and operating costs of the building and, consequently, its valorization.

4 http://www.capufe.gob.mx/site/normateca/normas/77_Bases_para_la_Administracion_del_Parque_de_Maquinaria_a_cargo_de_CAPUFE_dic_05/Anexo05.pdf

1.EXTRACCION A CIELO ABIERTO	**Nombre recorrido 1:** Cantera - sitio de acopio Planta	TIPO DE MAQUINARIA- TRANSPORTE Y MOVIMIENTO DE TIERRA					
	PROCESO: TRANSPORTE	Unidad	CAMION	RETROEXCAVADORA	CARGADOR	OTRO:	
	CARACTERISTICAS:						
	DISTANCIA 1	km					
	MARCA	N/A					
	MODELO	N/A					
	CAPACIDAD	M3					
	TIPO DE COMBUSTIBLE	N/A					
	RENDIMIENTO	KM/Lt					
		Lt/h					
2. CLASIFICACION Y SELECCIÓN	**Nombre recorrido:** Sitio de acopio Planta- Sitio de tratamiento y preparaciòn	TIPO DE MAQUINARIA- TRANSPORTE Y MOVIMIENTO DE TIERRA					
	PROCESO: TRANSPORTE	Unidad	CAMION	RETROEXCAVADORA	CARGADOR	OTRO: (1)	OTRO (2):
	CARACTERISTICAS:						
	DISTANCIA 1	km					
	MARCA	N/A					
	MODELO	N/A					
	CAPACIDAD	M3					
	TIPO DE COMBUSTIBLE	N/A					
	RENDIMIENTO	KM/Lt					
		Lt/h					
	PROCESO: TRATAMIENTO Y PREPARACION DE LAS ARCILLAS	TIPO DE MAQUINARIA- CLASIFICACION Y SELECCIÓN					
		Unidad	ROMPE TERRONES	ELIMINADOR DE PIEDRAS	DESINTEGRADOR	LAMINADOR/ REFINADOR	OTRO:
	CARACTERISTICAS:						
	MARCA	N/A					
	MODELO	N/A					
	CAPACIDAD	M3					
	TIPO DE COMBUSTIBLE	N/A					
	RENDIMIENTO	Lt/h					
3.DEPOSITO	**Nombre recorrido:** Sitio preparaciòn- Depòsito	TIPO DE MAQUINARIA- TRANSPORTE					
	PROCESO: TRANSPORTE	Unidad	CAMION	MONTACARGAS	CARGADOR	OTRO:	
	CARACTERISTICAS:						
	DISTANCIA 1	km					
	MARCA	N/A					
	MODELO	N/A					
	CAPACIDAD	M3					
	TIPO DE COMBUSTIBLE	N/A					
	RENDIMIENTO	KM/Lt					
		Lt/h					
4. MEZCLADO	**Nombre recorrido:** Sitio de depòsito- Sitio mezclado	TIPO DE MAQUINARIA- TRANSPORTE					
	PROCESO: TRANSPORTE	Unidad	CAMION	RETROEXCAVADORA	CARGADOR	OTRO: (1)	OTRO: (2)
	CARACTERISTICAS:						
	DISTANCIA 1	km					
	MARCA	N/A					
	MODELO	N/A					
	CAPACIDAD	M3					
	TIPO DE COMBUSTIBLE	N/A					
	RENDIMIENTO	KM/Lt					
		Lt/h					
	PROCESO: MEZCLADO	TIPO DE MAQUINARIA- MEZCLADO					
		Unidad	MEZCLADOR HUMEDECEDOR	LAMINADOR REFINADOR	BOMBAS HIDRONEUMATICAS	LAMINADOR/ REFINADOR	OTRO:
	CARACTERISTICAS:						
	MARCA	N/A					
	MODELO	N/A					
	CAPACIDAD	M3					
	TIPO DE COMBUSTIBLE	N/A					
	RENDIMIENTO	Lt/h					
5. MOLDEO	**Nombre recorrido:** Sitio de mezclado - Sitio de moldeo	TIPO DE MAQUINARIA- TRANSPORTE					
	PROCESO: TRANSPORTE	Unidad	CAMION	RETROEXCAVADORA	CARGADOR	OTRO: (1)	OTRO: (2)
	CARACTERISTICAS:						
	DISTANCIA 1	km					
	MARCA	N/A					
	MODELO	N/A					
	CAPACIDAD	M3					
	TIPO DE COMBUSTIBLE	N/A					
	RENDIMIENTO	KM/Lt					
		Lt/h					
	PROCESO: MOLDEO	TIPO DE MAQUINARIA- MOLDEO					
		Unidad	BOQUILLA	BANDA TRANSPORTADORA	BOMBAS HIDRONEUMATICAS	OTRO: (1)	OTRO: (2)
	CARACTERISTICAS:						
	MARCA	N/A					
	MODELO	N/A					
	CAPACIDAD	M3					
	TIPO DE COMBUSTIBLE	N/A					
	RENDIMIENTO	Lt/h					
6. SECADO	**Nombre recorrido:** Sitio de moldeo - Sitio de secado	TIPO DE MAQUINARIA- TRANSPORTE					
	PROCESO: TRANSPORTE	Unidad	CAMION	RETROEXCAVADORA	CARGADOR	OTRO: (1)	OTRO: (2)
	CARACTERISTICAS:						
	DISTANCIA 1	km /m					
	MARCA	N/A					
	MODELO	N/A					
	CAPACIDAD	M3					
	TIPO DE COMBUSTIBLE	N/A					
	RENDIMIENTO	KM/Lt					
		Lt/h					
	PROCESO: SECADO	TIPO DE MAQUINARIA- SECADORAS					
		Unidad	SECADORA TIPO TUNEL			OTRO: (1)	OTRO: (2)
	CARACTERISTICAS:						
	MARCA	N/A					
	MODELO	N/A					
	CAPACIDAD	M3					
	TIPO DE COMBUSTIBLE	N/A					
	RENDIMIENTO	Lt/h					
7. COCCION	**Nombre recorrido:** Sitio de secado - Sitio de coccion	TIPO DE MAQUINARIA- TRANSPORTE					
	PROCESO: TRANSPORTE	Unidad	CAMION	RETROEXCAVADORA	CARGADOR	OTRO: (1)	OTRO: (2)
	CARACTERISTICAS:						
	DISTANCIA 1	km /m					
	MARCA	N/A					
	MODELO	N/A					
	CAPACIDAD	M3					
	TIPO DE COMBUSTIBLE	N/A					
	RENDIMIENTO	KM/Lt					
		Lt/h					
	PROCESO: COCCION	TIPO DE MAQUINARIA-COCCION					
		Unidad	HORNO TUNEL		DESAPILADORA	OTRO: (1)	OTRO: (2)
	CARACTERISTICAS:						
	MARCA	N/A					
	MODELO	N/A					
	CAPACIDAD	M3					
	TIPO DE COMBUSTIBLE	N/A					
	RENDIMIENTO	Lt/h					
8. DEPOSITO	**Nombre recorrido:** Sitio de coccion- Sitio de depòsito	TIPO DE MAQUINARIA- TRANSPORTE					
	PROCESO: TRANSPORTE	Unidad	CAMION	MONTACARGAS	CARGADOR	OTRO:	
	CARACTERISTICAS:						
	DISTANCIA 1	km					
	MARCA	N/A					
	MODELO	N/A					
	CAPACIDAD	M3					
	TIPO DE COMBUSTIBLE	N/A					
	RENDIMIENTO	KM/Lt					
		Lt/h					

Table 2: *Matrix for the collection of technical data. Source: self-made*

There is progress in the study of energy efficiency and minimization of impacts in the production of the brick industry in Cundinamarca State, taking into account the equipment of burning and / or fuel injection. In the big industry, measures have been taken in areas such as fuel consumption, air supply, fuel system and fuel distribution. fuel injection burning equipment have been analyzed in different types against the combustion process and its proper functioning, which in turn depend on the ratio of the loaded material, product type, time of process, type of furnace and air and fuel requirements made with stoichiometric calculation[5]; This allows to reduce fuel consumption and levels of pollutant concentration that are required by environmental regulations (CAEM, 2013).

Despite these advances and the development of methodologies for eco-labels type I, the LCA in this industry does not constitute a consolidated element that leads to a DAP or eco-label type III. Thanks to the inter-institutional alliances created in the framework of this research, there is an interest of the producers in making their processes much more efficient and sustainable, which implies a minimization of the impacts and their communication. Against this, the methodology established by the ISO 14040: 2006 sees the challenges of data collection in field to develop inventory analysis and quantify their impact on the brick industry, and whose methodological structure is to be fully analyzed by the present investigation in the course of this year.

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The construction of an enabling platform for sustainability at a house hold level. PRIMA cookstove's participatory design process case.

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Abstract

Colombia's conservation Fund 'Patrimonio Natural' through USAID funding carried out the Conservation Landscapes Program (CLP) in an effort to interconnect remaining tropical dry forest patches in the Colombian Caribbean region where campesinos and indigenous communities have long suffered from displacement and only until recently, were able to return to their territories. This landscape approach takes into account adaptive management, including traditional or local knowledge and practice recovery as well as the participation of local people and institutions. As part of this program an efficient wood stove model called PRIMA was developed with the active participation of 6 local communities. A social innovation approach and a participatory design methodology led to the generation of a small social business and furthermore, to the creation of an enabling platform to develop activities at a household level that contribute to the generation and sustainable management of tropical dry forest corridors. This paper explores the broader dimensions of clean cookstoves beyond traditional deployment strategies shown in other conservation programs in Colombia through the PRIMA clean cook stove's development process. The discussion focuses in the potential the participatory stove design has and its use as an enabling platform in conservation programs working with communities to introduce or/and reinforce sustainable practices at a household level. As a result, this approach enabled the design of an appropriate clean cookstove and related services that promote sustainable wood consumption in the region. It also made possible the strengthening of a group of women entrepreneurs and the constitution of a social business that is currently selling clean cook stoves and solar micro-grids in the Montes de María region. The traditional energy grid was expanded and campesinos in 10 different "veredas" are now using alternative energy for their daily activities. New knowledge about the use of biomass for cooking has been transferred to more than 800 people after the implementation phase ended. Finally, the use of stove during the implementation phase generated an enabling platform to strengthened the local cultural identity and increase the different actions of conservation and decision making at a household level to reach more sustainable livelihoods.

Keywords: clean cookstoves, participatory design process, cooking practices, enabling environments.

Introduction

Although not considered state of the art technology, clean coosktoves still play an important role in providing clean and sustainable energy services in underdeveloped countries and non-interconnected areas around the world. Since 1970, the justification for top down interventions in household energy shifted from concerns about deforestation to the incorporation of public health and climate change concerns. Many cookstove programme implementers today see carbon finance as an attractive revenue option to support a commercial scale-up of efforts. (Zerriffi, 2011) It is true that clean-burning, fuel-efficient cookstoves can contribute to climate change mitigation. First, by reducing the demand for wood, stove adoption can relieve pressure on forest resources. This is especially relevant in places around the developing world where wood fuel demand drives deforestation; clean-burning, fuel-efficient cookstoves can slow the loss of forest cover and reduce CO2 emissions by avoiding unsustainable tree harvesting. On average, stoves currently used to generate carbon 59 emission reductions in the Clean Development Mechanism (CDM) reduce wood fuel consumption by more than 50 percent relative to the stoves they replace. Second, traditional cookstoves typically have poor combustion and emit methane (CH4), carbon monoxide (CO), non-methane hydrocarbons (NMHCs) and aerosols. Well-designed stoves can improve airflow and/or raise temperatures in the combustion area, thereby burning more cleanly and reducing emissions of non-CO2 pollutants. Bailis and Haysman, (2011).

The potential benefits besides technical reported of shifting from current cooking technologies to clean-burning, fuel-efficient cookstoves include reduced exposure to harmful indoor air pollution, reduced workloads for wood collectors, lower monthly expenditure on fuel, and reduced burns and injuries in the home. Bailis and Haysman (2011).

Social dimensions regarding the use of cookstoves have remained less explored thant technical evidence due to the difficulty in collecting accurate information. Currently in the cookstoves sector, measuring these benefits—or social impact--is incredibly important. A social impact assessment tool was developed by the GACC and the ICRW as a comprehensive toolkit that allows cookstoves and fuels enterprises to measure how their products empower women and create social change. This tool focuses on how to recollect information improve marketing, increase sales, and even help in developing new products. Global alliance for clean coosktoves (2016).

Shown below, the PRIMA clean cookstove design process and the design of enabling spaces for sustainability pretends to broaden the dimensions of the socio environmental impacts a clean cookstove can have beyond the ones reported in previous research. Also it shoes the advantages and challenges of the implementation of coosktove projects as a conservation program activity.

Conservation landscape Program approach to conservation

From 2014 to 2016, USAID funded Colombia’s conservation fund, Paisajes de conservacion program (Conservation landscapes program) with the purpose of implementing land use management tools at the landscape level to restore connectivity both within the productive matrix and the natural connection patches or linear features such as water courses and their riverine areas. Retrieving sustainable agroforestry practices and silvo pastoral systems to enhance a more biodiversity-friendly landscape matrix that protects soils and water from excessive heat and degradation, complemented by restoration and promotion of a network of hedgerows, live fences, river borders, forest patches, stepping-stone trees in pastures and other related landscape management tools.

Stakeholders linked to the productive matrix in the landscape had an important role to accomplish the program main objectives by applying best practices in agriculture and cattle ranching. Smallholder agroforestry practice, applying connectivity tools in larger agricultural concerns and silvopastoral systems to guarantee sustainability by enhancing ecological connectivity, cover soils to prevent erosion, recover and maintain species diversity while promoting watershed protection directed towards water quality and quantity improvement.

During its implementation the introduction of clean cookstoves became a necessity due mainly to local deforestation on tropical dry forest patches where connectivity actions were being carried out directly with communities living inside the forest. The purpose was to design a stove with the families in order to achieve a context responsive design that would be effectively used and deployed through empowerment instead of assistance based approaches. During the design process, the stove and the act of cooking during the prototype phase became a space for reflecting about dynamics regarding food, water and energy provisioning as well as product harvesting in the plot and new possible objects and ways of living.

1. Methods

The process was divided in 2 stages. First in the development PRIMA stove models and a related social business. The methods used in this phase are taken from the social innovation approach that includes 6 phases: 1) diagnose: This stage involves diagnosing the problem and framing the question in such a way that the root causes of the problem, not just its symptoms, will be tackled. 2) Proposals and ideas: This is the stage of idea generation. This can involve formal methods – such as design or creativity methods to widen the menu of options available. 3) Prototyping and pilots. This is where ideas get tested in practice. The process of refining and testing ideas is particularly important in the social economy because it's through iteration, and trial and error, that coalitions gather strength. 4) Sustaining: This is when the idea becomes everyday practice. It involves sharpening ideas (and often streamlining them), and identifying income streams to ensure the long term financial sustainability of the innovation forward. 5) Scaling and diffusion and 6) Systemic change. This is the ultimate goal of social innovation. Systemic change usually involves the interaction of many elements: social movements, business models, laws and regulations, data and infrastructures, and entirely new ways of thinking and doing. (Murray, 2010).

1. Building a common ground: Understanding the kitchen/Living space in a post conflict arena

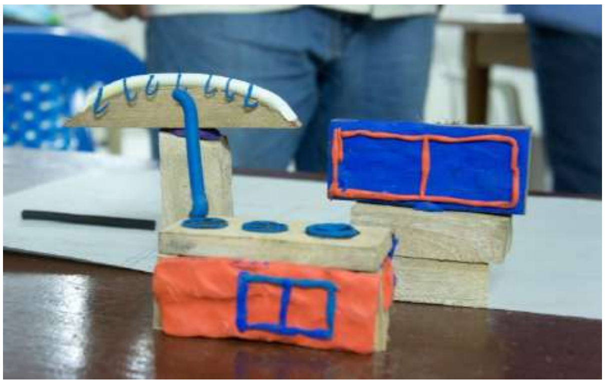
To be able to understand the context in which the new cookstove model would be deployed, a few tools ranging from user centered to participatory design were applied. A social cartography helped in first instance to understand with different stakeholders, the territory and living dynamics that ruled cooking practices.

Social cartography depicting Montes de María in the Past.

This tool proposed a first activity based on the past territory they used to live in and a second describing the current relation with it. The relationship people have with the territory changed significantly in time due to a 10 year major armed conflict that forced the communities to abandon their houses in the countryside and move to nearby towns. After the conflict is over, only men returned to the countryside due to the lack of infrastructure and services that prevented children from getting a proper education and women from developing comfortably any household task.

The lack of infrastructure and the traditional building and cooking knowledge seemingly lost, were taken as inputs to develop tangible models in order to deepen in the expectation families had regarding living in the countryside.

Kitchen space Tangible models-.



A kitchen for the countryside-.

In a first attempt to build the tangible models, only found materials like mud, sticks, leaves and garbage were used. Though, the materials restricted the ability of the participants to express themselves and so, a second attempt using wood blocks and clay eased the construction and detailing of the models.

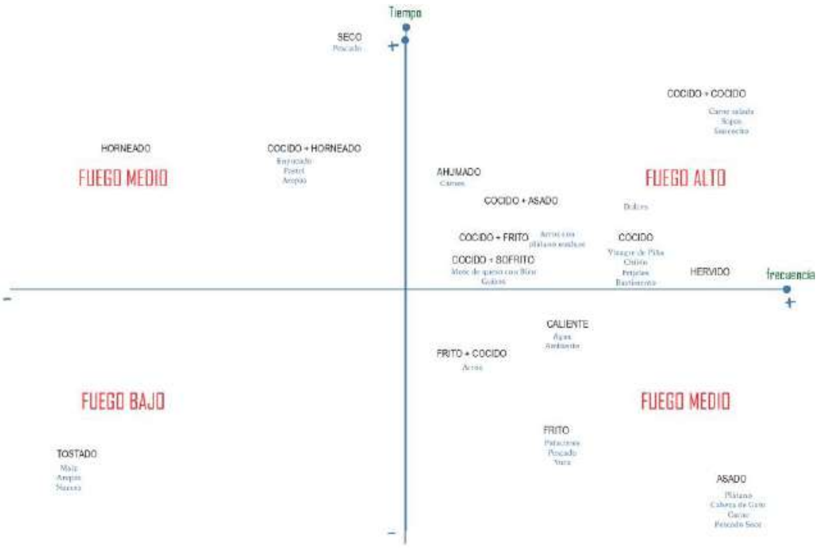
As a result, the activity evidenced new information through stories that people told while creating the model. For example, since coming back, to compensate for the lack of woman in the plot, campesinos created tacit agreements to foster fellowship, trust and teamwork. During Food preparation these tacit agreements become very important because a group of people that needs to eat depended on them.

“The rules were very clear: The first one that arrives lights the stove and begins to make lunch. As other people come, they will help with what is missing”.

When designing ‘The perfect stove’, men focused on designing something that their spouses would appreciate in order to ease their return to the countryside. While women focused on the functionality, designing accessories that would make possible to fry, heat and roast food, always accompanied by nearby spaces to prepare the food.

After this first approach to the community, 22 visits to families houses in the countryside followed and the design of 2 method cards; “What’s on your kitchen” and “Usability cards” plus an usability analysis recollecting traditional recipes and “Navigating the kitchen” took place.

Cooking the traditional ‘Carne desmechada con frititi’-.



2x2 Matrix: mapping information on a time-frequency base.

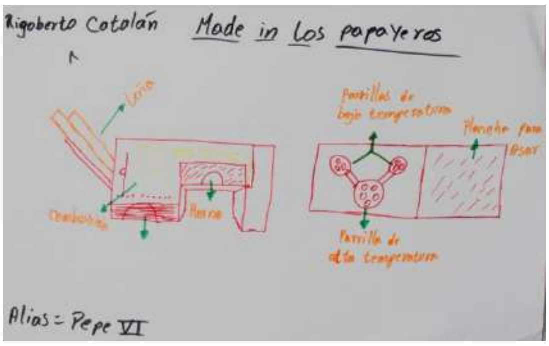
The above mentioned tools helped in clearing the design context, the stove having to respond directly to habitability and willingness to return to the countryside. Also, the first social and functional determinants were found crossing the information obtained during all the activities in a 2x2 matrix visualizing frequency time and the necessary intensity of heat. The interpretation of information was done with the community in order to understand together about what they really needed the stove to deliver. This way, people realized they needed 2 stove tops instead of 4, and those stovetops needed to produce high heat for them to be able to cook the usual recipes.

2. Knowledge sharing and technology appropriation

Using the Aprovecho research Center guide “Designing heating stoves” (Bryden et al, 1996) the key aspects involved in the good design of a clean cookstove were translated into 3 functional prototypes made out of inexpensive metal sheets that demonstrate 3 different technologies that could be used for the design of the stove: rocket type, rocket type with secondary air and gasifiers. Besides the demonstration, it was designed a booklet translating technical information into practical and easy to understand tips for the community to integrate their traditional knowledge about fire with new concepts that will then use in the co-creation workshops.

Co-creating

In the last field workshop, the most important findings were shared with the large community (40 families) to work on generating ideas around the stove.



Technology and context based ideas.

Using just paper and markers, people used the information recollected during the 2 month process and designed 25 stove models were the type of technology and fuel was described as well as its parts and accessories. Not all the participants were able to fully express themselves because sketching is not easy and the freedom of the exercise demanded writing and sketching advanced skills. Probably a specific designed tool such as a refined tangible model including all design determinants found along the process would have eased the construction of stove models and would have produce more detailed ideas. Nonetheless, ideas showed crucial functions the stove needed to deliver and preferences regarding the look and feel of a final product. After finishing the designs, all participants gathered around and each family presented their idea. During this activity, people sorted the ideas into 3 groups: integral stoves, modular stoves and single portable stoves. From there, families voted the best design reflecting about the real needs the participants had discovered during previous exercises.

Winner stove paper prototype.

To finish the co-creation process, a rapid prototype was built using only cardboard and tape. This prototype was then converted into a formal prototype and then into 2 functional prototypes that were tested infield for 6 months.

3.Prototyping stoves and using it in an enabling environment for local sustainability

The second stage relates to the use of the stove to generate an enabling environment first as cooking workshops to generate reflections on the new stove designs and energy and then with a designed space called “Stories by the fire” (Historias junto al fogón) to gather information related to the effectiveness of the stove use, and furthermore for the recognition of the traditional knowledge that the families had over agrobiodiversity in tropical dry forest ecosystems. Later to include these "knowledge" in decision making regarding energy but also land planning and its impact on the conservation, management and the use of forest resources, the use of native seeds, , consumer practices, all key elements for the design and decision making of their territory use and management.

Stove prototypes in this case worked as an object aligning participants to work together in order to achieved a precise goal. In this specific case to be able to align activities regarding the decision making on the new stoves in field, designing ways to disseminate them among the whole community, and reflecting on forest resources, recovering traditional and innovative practices to assure sustainable firewood.
The space “Stories by the fire” focused on Families gathering together to share, create and reflect on different issues related to their productive systems and lifestyles, while preparing traditional foods that were shared and consumed by the community and involve the participation of adults and children. This encounters focused on the recognition and strengthening of capacities through self-research, of a group of twelve (12) young people that were in charge of researching and learning from different traditional carriers and knowledge campesinos aspects related to the productive system, culinary system, oral tradition, agricultural practices, material culture and traditional food as articulating elements to understand the cultural importance of a conservation strategy.

These activities were carried out at the family level with producers and other communities from surrounding areas, who were integrated into activities such as workshops, discussions on seeds and reflections on feeding modes and the use of agrobiodiversity resources as practices that generate well-being and minimize economic dependence.

"Stories by the Fire" encounters.

Results and discussion

This approach enabled the design of an appropriate clean cookstove and related services that promote sustainable wood consumption in the Montes de Maria region. It also made possible the strengthening of a group of women entrepreneurs and the constitution of a social business that is currently selling clean cook stoves, solar micro-grids and Tropical dry forest workshops to help spreading the word about the importance of its conservation and concrete actions to achieve sustainable environments. The traditional energy grid was expanded and campesinos in 10 different "veredas" are now using alternative energy for their daily activities. New knowledge about the use of biomass for cooking has been transferred to more than 800 people after the implementation phase ended. Through the social business, women involved have been able to generate complementary income though the innovation has little options to scale at a national level, regional authorities and other organizations like PNUD are already recognizing the entrepreneurship as a novel way communities in the Caribbean can access information about traditional renewable energy and sustainable practices around the house.

Finally, the use of stove during the implementation phase generated an enabling platform to strengthened the local cultural identity and increase the different actions of conservation and decision making at a household level to reach more sustainable livelihoods.

Inside this platform, 9 cooking workshops with the participation of 180 people were implemented. Spaces for reflection on the importance and use of native Seeds from the perspective of their "guardians" (producers between men and women who give biological, social and cultural value to seeds and implement their own conservation and management strategies). Documentation and characterization of traditional agricultural culinary systems, from which families are making conservation decisions based on the collection, sowing, harvesting, transformation and consumption of agrobiodiversity as a priority measure to ensure their diversity and well-being. The distinction between the socio-environmental and cultural contributions made by men and women from the "creation" of material culture elements with local raw materials, which allows them to use the available resources in their environment for housing, stove and utensils, roofs, poultry yards and orchad desgins among others. Encourage the participation of young people and children in the transmission of traditional knowledge and practices related to agriculture and local cuisine as a mechanism of communication Family and intergenerational. The exchange spaces where families exchange their knowledge, products, seeds and traditional recipes with residents of the urban area, as a way of reducing the gap between the relations between the countryside and the city. Life histories associated with the culinary and agricultural systems according to the distinction of roles, Gender and Generation. To date, 80 life histories of producers, between men and women, have been documented. Young people and children interacting with their elders in the meetings next to the fire. Approximately 50 children have participated in activities with their parents. Three knowledge exchange workshops were held in the village of San José del Peñón on pottery, backpacking in Majagua and knowledge about the orchard and medicinal plants. “stories by the fire” encounters with the families. 10 cooking encounters in San Juan, San José del Peñón, Media Luna, Raicero, El Salado (Santa Clara, El Bálsamo) traditional recipes in food and health, according to the knowledge of men and women. Documentation of approximately 120 traditional recipes with their drawings by hand, recreation and consumption, photographic record. In training, families were introduced to topics on: The importance of Gender / Generation in the conservation of Biodiversity. The importance of safeguarding intangible culture for conservation (agricultural practices, seed conservation, agrobiodiversity consumption, etc.). Training process with twelve (12) local co-investigators in survey and investigation of life histories and documentation in culinary systems. Strengthening and implementation of 20 agrobiodiverse home gardens, by the families of the district of San José del Peñón with the participation of children and young people who were instructed by their parents. Exchange of experiences between producers of the project, allowing to count and show others their achievements in the plot. Training spaces in own trades between parents and children as part of the strengthening of the culinary system: planting, construction of corrals, handling of animals, cooking, and knowledge of plants.

The methodology used for the design and utilization of the stove in enabling spaces for sustainability is aimed to be deployed as activities framed in a conservation program due to its extent and the complexity involved in gathering valuable data to prove social and environmental impacts beyond wood consumption. Achieving the widespread adoption of clean cookstoves is challenging, requiring an understanding of complex social factor. But the understanding and introduction of this social factors in the design and dissemination of clean cookstoves has as a consequence very precise and context based solutions that can hardly be scaled or replicate in the exact same manner in other context.
As Sesan (2014) reports, regarding the empowering potential of participatory development have been challenged by critics who maintain that the practice of participation is constrained by structural inequities and hence is not as radically transformative as the rhetoric would suggest. The transformative potential of participatory approaches can be limited by even slight variations in socioeconomic indicators among members of seemingly homogeneous marginalized groups, thus peeling back an often unrecognized layer of complexity in participatory development practice.

Nevertheless, most of the programs focused only on dissemination that neither take into account local culture, social and economic backgrounds of the target areas, nor did they consider costs or availability of biomass fuel have collapsed soon after donor funding finished. Causes for collapse were usually attributed to: poor implementation strategies, inappropriate technologies, lack of community participation, and lack of training. (Urme, 2014).

5. Conclusions

The methodology shown above can be used as a way to disseminate custom made stove technologies at a small scale and during its development has the potential to impact positively conservation program activities regarding community's livelihoods around the forest. Although it may not always be compatible with mainstream visions of large-scale stove deployment, it brings other benefits that have the potential to scale at a local and regional level in a sustainable way. Also, benefits derived from the intervention can be monitored throughout the long term conservation program implementation.

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Hydrologic model for predicting drought hazard under Climate Change scenarios

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Abstract

Nowadays climate change is one of the main issues human beings face. Its consequences have been reflected on the modification of recurrent patterns of meteorological existing phenomena. One of them, the drought, has been presenting on a more prolonged way and with greater impacts on different areas such as agriculture, the ecosystems, among others. In consequence, a need has surged to develop tools able to predict the behavior of this hazard, thus take the necessary measures to reduce the vulnerability of the exposed elements in anticipation of a drought event. This project proposed a novel methodology in relation with the Latin-American setting based on the most recent probabilistic and geographical system information developments in the subject of drought hazard prediction. In this way, the result was a model with the ability of showing in a graphical and numerical manner the expected response of future events; thereby decision makers could take actions on this aspect by proposing ways to prevent and mitigate the associated damages. The methodology was tested and ratified in a South American basin. For the tested region, the conclusions forecast more extensive drought events with lower intensities. In a general aspect, the implemented process and the application yielded satisfactory results which shown the multiple applications that the model can blend for decision making and a subsequent risk analysis.

Keywords: Drought, Forecasting, Return Period, Copulas, Latin America

1. Introduction

Climatological phenomena such as floods, earthquakes, droughts, among others belong to a group called adverse phenomenon because of its capacity to negatively affect the supply of resources and products with which human being counts. In recent years, global climate models have shown a tendency to more frequent extreme weather events, which implies stronger impacts to those living today (Meza, Corso, & Soza, 2010). In consequence, the need to a better understanding of these phenomena has arisen and, in turn, to design tools so that they can be prepared for their eventual arrival.

Droughts can be defined as a natural hazard resulting from a deficiency of water availability compared to what is expected to be normal, i.e. an imbalance between the supply of atmospheric water and the demand for natural and man-made processes. In general, the procedure of a drought development resumes in a prolonged deficit of rainfall, which generates less input to the hydrological system. The system continues to request water, but is not recharged in any way so the anomaly persists. Variables such as temperature, precipitation and evapotranspiration, called indicators, are directly involved throughout the procedure and are valuable tools for describing a drought. However, these indicators do not constitute a direct form of determining quantitatively the presence of a drought event and its state. Therefore, numerical tools or indexes has been developed with the aim of simplifying the complex relationships behind drought and in this way provide clear and concise information for decision making and as entry to other studies.

Many indexes have been developed and one of them is the Standardized Precipitation Evapotranspiration Index (SPEI), which characterizes for being relatively new, standardized so it can be applied to any region without the need for calibration, multi-temporal able to quantify any type of drought event and recommended by the scientific community to include the effects of climate change by anomalies in the Earth’s temperature. The effects of drought are often accumulated over time. Three important drought characteristics widely used in the literature to assess the cumulative effect are: a) severity, defined as the total impact of the anomaly, b) duration as the total extent and c) intensity as the maximum impact of the event.

Hydrological studies of any hazard are usually made through probabilistic techniques with the purpose of characterize he randomness of climatological phenomena. In general, the process consists in adjusting probability functions to the hydrological variables with results such as determination of return periods of historical events and the estimation of future events magnitude in base of a given return period (Díaz-Granados, 2015). Many studies focus on the future spatial distribution of drought characteristics by applying statistical analysis methods like severity-area-duration (SAD), severity-area-frequency (SAF) and severity-duration frequency (SDF). Most of them make univariate analyses, which mean that the characteristics are treating independently. However, recent studies have shown that this is not true and there is a codependence among each other. Given that, the multiple drought characteristics are correlated, it is proposed to assess drought return periods based on those correlated variables. Copulas based on joint multivariate probability distributions allow modeling a multivariate distribution by separately dealing with marginal distributions and joint dependences among variables (Liu et al., 2016).

The main objective of this study was to develop a drought hazard prediction standardized model that considered the impacts of climate change with the aim to provide the spatiotemporal distribution of the drought characteristics, i.e. severity, intensity and duration. This implied the use of probabilistic tools including copulas to capture all the correlations of the stochastic multivariate behavior of drought events. Additionally, statistical and geographical tools as SDF curves, SAF curves and maps were employed for the presentation of the information. Finally, the proposed model will address the model results when it is applied to a Latin American basin.

2. Methods

The proposed hydrological method consists of multiple steps as shown in Figure 1, each step is explained briefly in this section.

2.1 Hydrological and geographical data

Hydrological data correspond to historical series observed in meteorological stations located in the study area or to projected series, which are calculated from global or regional climate models (GCM and RCM). It is necessary to have a complete and continuous dataset in periods of time greater than or approximately equal to 30 years for all the hydrological variables that the employed index requires. In this case, the necessary datasets correspond to precipitation and temperature. On the other hand, geographical information of the zone such as latitude and grid resolution are essential to the computation of the index and the generation of the final maps respectively.

2.2 Interpolation

Once the data meets the requirements of the past section, it is interpolated to the grid delimited by the study area. This is necessary because the meteorological stations never cover all the study zone and the grid resolution may be different to the one associated to the data of GMC and RCM. For this model, it is use the inverse distance weight method (IDW) for its ease of use and because it is based on a weighted average per the distance from the analysis point to the measured points. This ensures that all interpolated data are in the range of the observed, therefore the results will not be biased (Nagajaran, 2010).

The chosen method has a drawback and is the sensitivity of the power parameter, *p* which is necessary to obtain the interpolation. Thus, the results of the interpolation are very variable since this number can take a value between 0 and 30 to determine how susceptible the point of interest is in relation to known far and near points (Ziary & Safari, 2007). To mitigate this error, it is recommended to choose this parameter through an optimization process based on a cross validation (Burrough, McDonnell, McDonnell, & Lloyd, 2015).

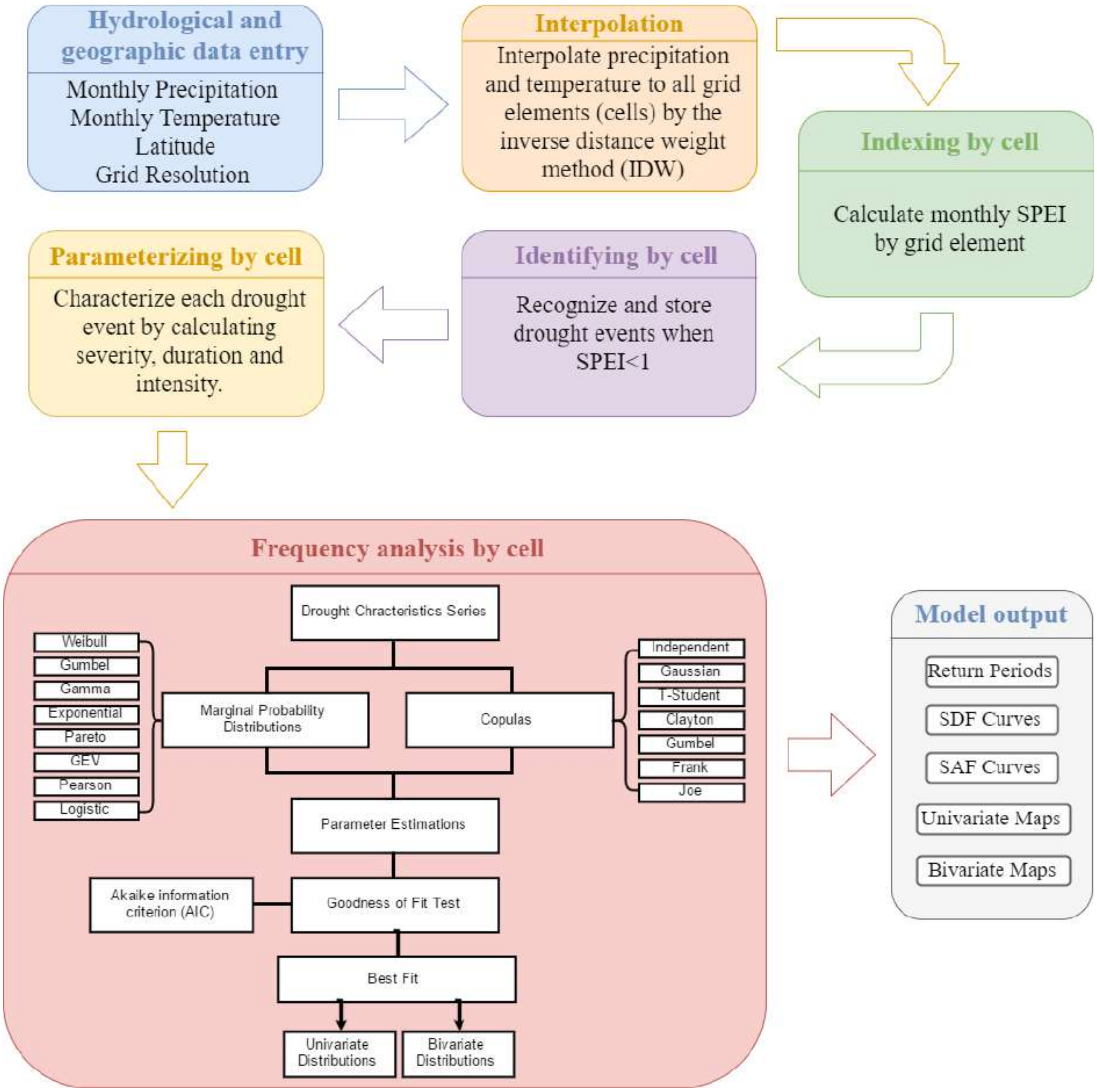

Figure 1. *Complete process of the proposed hydrological model.*

2.3 Indexing

For this model, the SPEI index is used to quantify the drought and categorize it according to Table 1. Its foundations lie in the search for an index with the capacity to be multitemporal, standard and sensitive to the changes in the demand for evaporation which are caused by fluctuations in temperature (Vicente-Serrano, Bergueria, & López-Moreno, 2010). Its hydrological principle is to be a multiscale index that uses the degree of difference between precipitation and evapotranspiration (PET) representing a simple water balance.

Table 1. Categorization of dryness grade by the SPEI

SPEI	Categories
$-0.5 < \text{SPEI}$	Normal or wetness
$-1.0 < \text{SPEI} \leq -0.5$	Slight dryness
$-1.5 < \text{SPEI} \leq -1.0$	Moderate dryness
$-2.0 < \text{SPEI} \leq -1.5$	Severe dryness
$\text{SPEI} \leq -2.0$	Extreme dryness

To perform the calculation of the index, it is necessary to calculate the evapotranspiration in base of temperature and latitude using Thornhwaite equation (Yang, Yan, Yu, & Yang, 2016). Once the evapotranspiration has been calculated, the water balance (D) can be obtained from each period defined by Eq.(1), which translates the subtraction of precipitation with the corresponding PET.

$$D_i = P_i - PET_i \tag{1}$$

With the series of water balance, a three-parameter log-logistic curve adjustment process is performed, corresponding to the cumulative probability function through the L-Moments method. As each month of the year can present different meteorological characteristics a curve adjustment is made for each one and in this way, the combination of normal conditions of a dry month to a rainy one is avoided.

With the adjusted function, it is necessary to standardize the results of each period by applying the Eq.(2). In this equation X is to the probability of exceedance calculated with the cumulative function and in the case, that this probability is greater than 0.5, in the equation of W it is introduced 1- X and the resulting SPEI sign is reversed (Tan, Yan, & Li, 2015).

$$SPEI = W - \frac{C_o + C_1W + C_2W^2}{1 + d_1W + d_2W^2 + d_3W^3} \rightarrow \begin{cases} W = \sqrt{-2\ln(X)} \;\; if\; X \leq 0.5 \\ \quad X = 1 - F(D) \\ C_o = 2.5155 \quad d_1 = 1.4327 \\ C_1 = 0.8028 \quad d_2 = 0.1892 \\ C_2 = 0.0103 \quad d_3 = 0.0013 \end{cases} \tag{2}$$

2.4 Identifying

For the identification of drought events the *run theory* is used (Guerrero-Salazar & Yevjevich, 1975). An event is considered drought when the index in each period is higher than a previously defined threshold. The beginning is marked when the index for the first time exceeds the limit value and ends when it is lower than the set value. For the proposed model the threshold is defined to be less than -1, because at this point the drought is no longer considered as a slight event, as can be detailed in Table 1, and enters to the moderate range which gives the certainty that a strong anomaly is happening and not a normal deviation in the meteorology of the zone. However, this value can be modified per the level of sensitivity desired in the study. This is shown Figure 2.

2.5 Parameterizing

After having defined the existence of a drought event with a clear beginning and end, the methodology proposed proceeded to calculate the severity, intensity and duration of each individual event from Figure 2. In this figure two drought events are shown, the proposed equations correspond to the latter event and for the case of severity and intensity the absolute value is applied, since all the results for this index give negative values and therefore the omission of the sign do not generate mistakes.

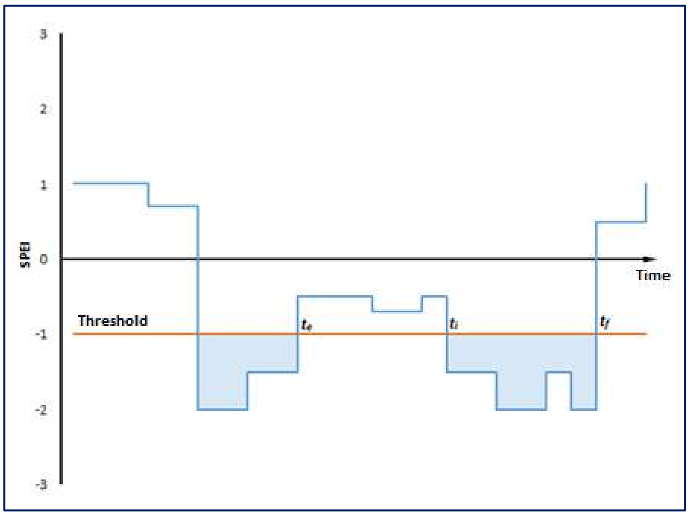

Figure 2. *Drought events definition and characteristics.*

2.6 Frequency Analysis

After having the parameterization of each drought event, the process continued by performing the probabilistic analysis in two steps in which first it is adjust different probability functions to the data and then select the ones that best behave in comparison to the data obtained of severity, duration and intensity. This implies that for each of the previous variables, the result was an associated marginal probability function as well as a joint function between severity-duration and intensity-duration.

2.6.1 Marginal Distributions

In the case of marginal or univariate functions, a large range of options was sought with the aim of greater possibilities of a better adjustment regardless of the area of study. In other words, the objective of adjusting more than one probabilistic curve and choosing the one of a behavior closer to reality is to avoid that the result is altered or biased by a function that does not adequately characterize the hydrological behavior of the drought. In addition, despite all the studies performed regarding the choice of functions, no agreement has been reached on which is the most adequate for the representation of variables (Liu, et al., 2016). To avoid this problem in the model, a group of 8 marginal functions were used: Weibull, Gumbel, Gamma, Exponential, Pareto, GEV, Pearson and Logistic. The parameters of these marginal distributions are estimated by the L-Moments method. This tool was chosen for its ease and better results in small sample sizes, typical in drought studies, compared to other methods such as maximum likelihood estimation method (MLE) that behave better with large samples.

2.6.2 Copulas

In the case of joint functions, the copula theory is used to create such probabilistic functions. A copula is the mathematical tool that allows quantifying the dependence between two random variables, in this model those variables are the characteristics of the drought which behaves in a dependent way.

It is important to highlight that the last two components of the joint density function correspond to the marginal functions of the variables, which have already been calculated in the previous subsection. The only unknown component is the copula. Currently there are many copulas and it has not yet been established which of them is the one that best represents the relation between the characteristics of the drought as in the univariate case, where no consensus has been reached on which probability function is the most appropriate. Therefore, it is used a set of 6 copulas that have been the most successful in hydrological research (Almedeij, 2014; Tosunoglu & Can, 2016; Reddy & Ganguli, 2012): independent, Gaussian, T-student, Clayton, Gumbel, Frank and Joe.

For the estimation of the copula parameters, the maximum pseudo-likelihood method is used. This method ensures that the estimator is the most efficient and although it requires a large mathematical processing it is well described for the selected copulas so that it is known in advance that the problem is not numerically unstable or very slow to obtain results (Hofert, Mächler, & McNeil, 2011).

2.6.3 Goodness of Fit Test

After having made all the adjustments of univariate and bivariate functions for the characteristics of the drought, it is necessary to select the one that best fits the data. This was done using the Akaike information criterion (AIC) which selects the model of a set that best suits an unknown reality, understanding that none of the candidate models is true. AIC encourages improvement of the goodness of fit, and simultaneously avoids the potential to overfit the data.

As for the case of bivariate functions it is used the maximum pseudo-likelihood method, the result can be directly use in the general equation. The univariate functions do not have this information because the L-moments method was used. However, if data errors behave normally, the criterion can be calculated as shown in Eq.(3) and Eq.(4) (Hu, 2007)

$$AIC = n\,ln\left(\frac{RSS}{n}\right) + 2K \rightarrow \begin{cases} RSS = Sum\ of\ quadratic\ residues \\ n = Sample\ size \\ K = Number\ of\ parameters\ of\ fit \end{cases} \qquad (3)$$

$$RSS = \sum_{i=1}^{n} \left(y_i - f(x_i)\right)^2 \rightarrow \begin{cases} y = Observed\ value \\ f(x) = Theorical\ value \end{cases} \qquad (4)$$

The best fit corresponds to the one with the lower AIC value, in other word the goodness of fit is improved when the AIC is smaller.

2.7 Model Output

With the probability functions calculated for each of the characteristics, relevant information can be obtained in terms of return periods, as well as graphical representations called severity-duration frequency curve (SDF), curves of severity-area-frequency (SAF) and for later analysis maps in relation to the characteristics of the behavior of the drought of the zone. In this paper the results are presented only in maps for each Return Period.

2.7.1 Return Periods

The return period can provide effective support for decisions surrounding drought prevention and management. The main interest is to determine the value of a drought characteristics for a given return period. The value of the variable can be calculated from the univariate return times described by Eq. (5) (Shiau & Shen, 2001).

$$T = \frac{E}{1 - F(x)} \rightarrow x = F^{-1}\left(1 - \frac{E}{T}\right) \qquad (5)$$

In the previous equation *E* corresponds to the mean drought inter-arrival time, *T* is the return time, *F* is the accumulated marginal function of the variable and finally *x* is the notation of the variable that can be severity, duration or intensity. It is necessary to detail that the E / T component must be less than one so that the function is in a valid probability range [0,1].

For the bivariate case, the model employs a conditional component because of the need to determine two unknown variables from a single return period (Gräler, y otros, 2013). The proposed methodology consists of determining from the return period the value of one of the variables following the marginal approximation. Subsequently from the conditional function and the same return period the value of the remaining variable is calculated.

2.7.2 Maps

As a last resort and characterized as the most used for risk analysis, maps represent the input of the threat that interacts with vulnerability and exposure. With the proposed methodology, the maps explained in Table 2 can be developed, in which the entries required to make each one and the associated characteristics are shown.

Table 2. *Types of maps generate by the model*

Function class	*Entry type*	*Entry*	*Output type*	*Output*
Univariate	Variable	Severity	Return Period	Return Period Map
		Duration		
		Intensity		
	Return Period	Year	Variable	Severity Map
				Duration Map
				Intensity Map
Bivariate	Variables	Severity and Duration	Return Joint Period	Return Joint Period Map
		Intensity and Duration		
	Return Joint Period	Year	Variable	Two maps: Severity Map and Duration Map
				Two maps: Intensity Map and Duration Map

2.8. Study area and data

The methodology was tested in a Latin-American basin with a computational model generate in the free software R and its hydrological packages. The selected zone corresponded to an estimate area of 116,709km^2 in a tropical region with no seasons, just a dry and a rainy spell in the year. In terms of meteorological data as a single region was analyzed, only precipitation and temperature records were required in the seven stations located at the boundaries of the region. In the selected basin, there were seven stations, from which the historical data can be obtained from the country's meteorological and hydrological information page. The selected period of analysis was included between 1983 and 2012. The geographical location and names of the seven stations in the basin can be seen in Figure 3. The same figure indicates the available hydrological information in each one.

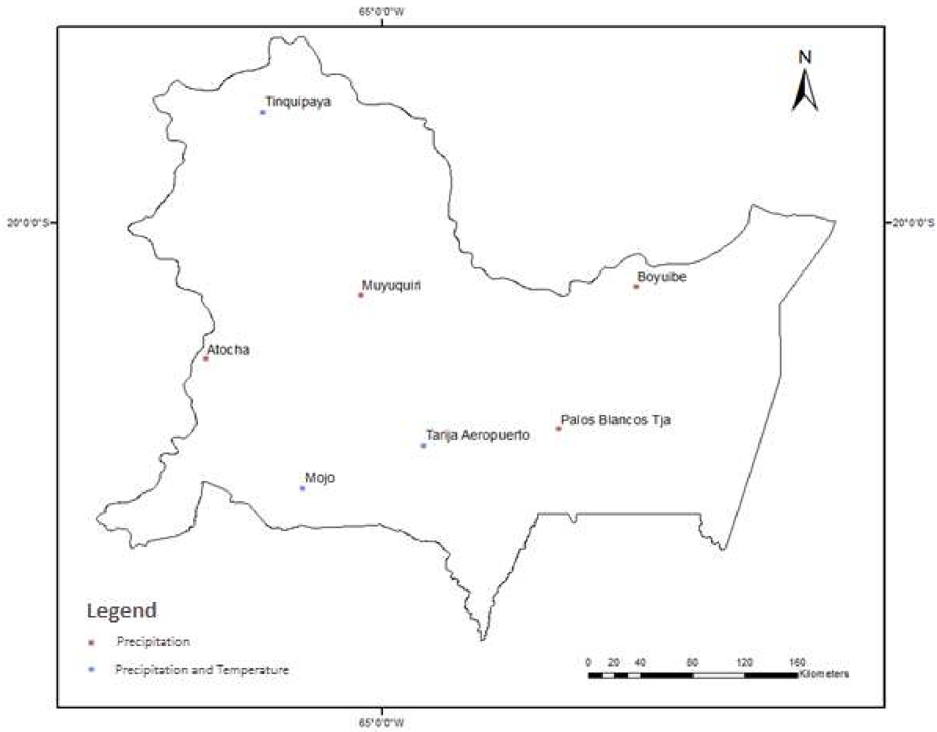

Figure 3. *Meteorological stations in study zone*

For the hydrological method, only those stations with precipitation and temperature data were useful, consequently just three of the seven stations were employed in the study case: *Mojo*, *Tarija Aeropuerto* and *Tinquipaya*,

3. Results and Discussion

The methodology was tested for obtaining return periods and maps. In the Table 3 it is presented the result for one point of analysis, the *Tarija Aeropuerto* meteorological station. The outcomes correspond to the best fit marginal functions, the best fit bivariate functions, the mean drought inter-arrival time and the values of the characteristics for different return periods.

Table 3. *Results for the characterization of a single point located in the study basin.*

Item	Variable	Result		
Best fit marginal function	**Severity**	Pareto		
	Duration	Exponential		
	Intensity	Weibull		
Copula	**Severity - Duration**	Joe		
	Intensity – Duration	Joe		
Mean drought inter-arrival time [years]		1.063		
Return period [years]		**2**	**25**	**100**
Severity		1.82	8.50	16.021
Duration [months]		1.46	4.93	6.84
Intensity		1.44	2.08	2.28

The results were consistent so the univariate values of severity, duration and intensity increase at the same time that the return periods. According to this a normal expected drought will have duration of 2 months while in extreme cases of about half a year. In the case of severity, the difference is more evident and extreme events will have 8 times the impact of a normal event. As it can be seen for extreme events (Return period greater than 100 years) the severity will be higher than 18 or with durations above 7 months.

On the other hand, the hydrological model was tested in the whole region with the associated results and maps. In this paper, maps for 25 and 100 years of return period are presented, each one in Figure 4 and Figure 5 respectively. For the bivariate maps, only those with a 25-year return period, are shown in Figure 6.

Prior to commenting on these results, it is necessary to mention that, having only 3 stations for such a large area, it was not possible to detail all the benefits of the model. The territory located at the east did not have any meteorological station of precipitation and temperature, in consequence it is not possible to assure that the predictions are completely accurate with reality.

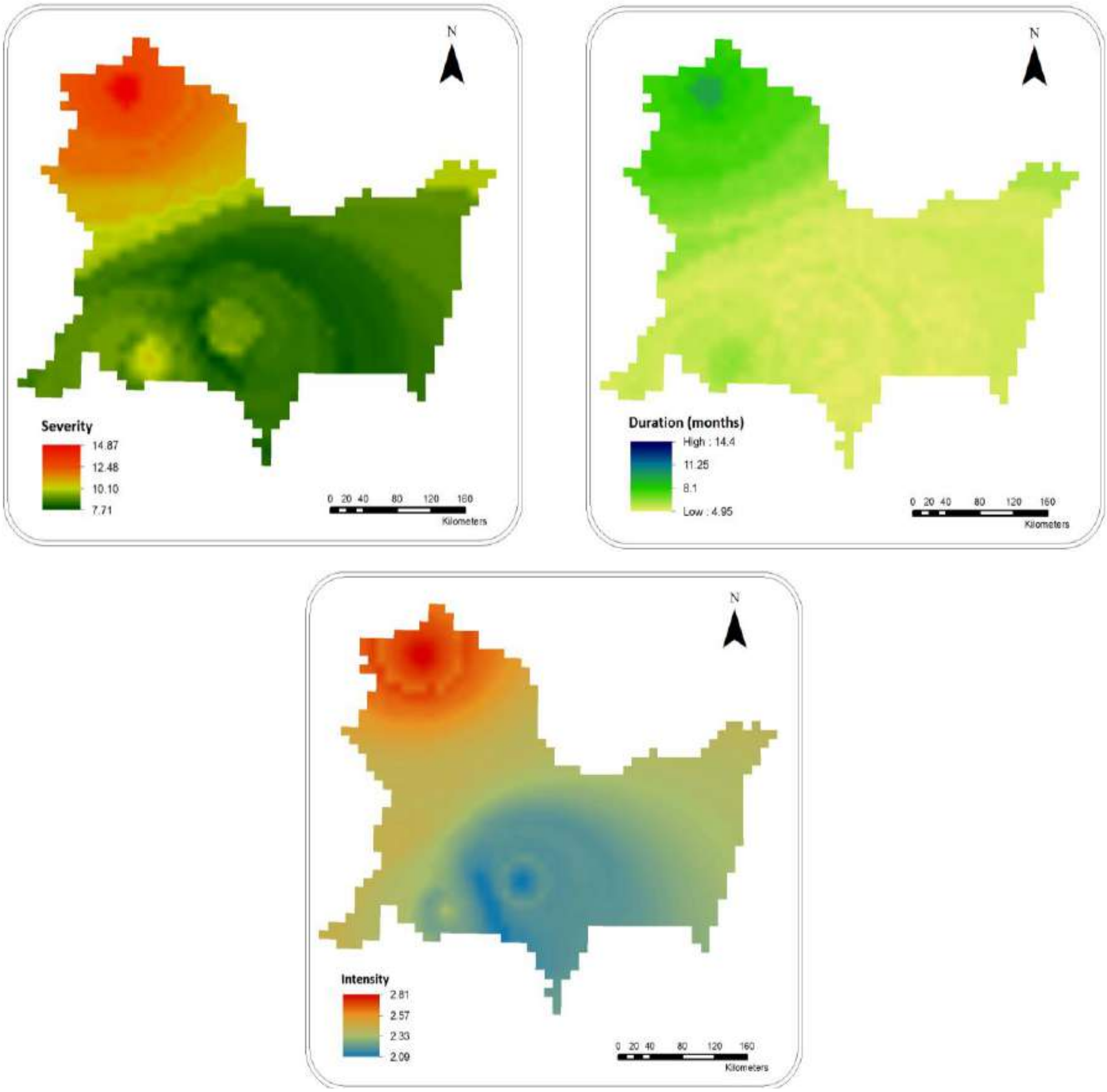

Figure 4. *Spatial distribution of the three drought characteristics with a 25-year return period.*

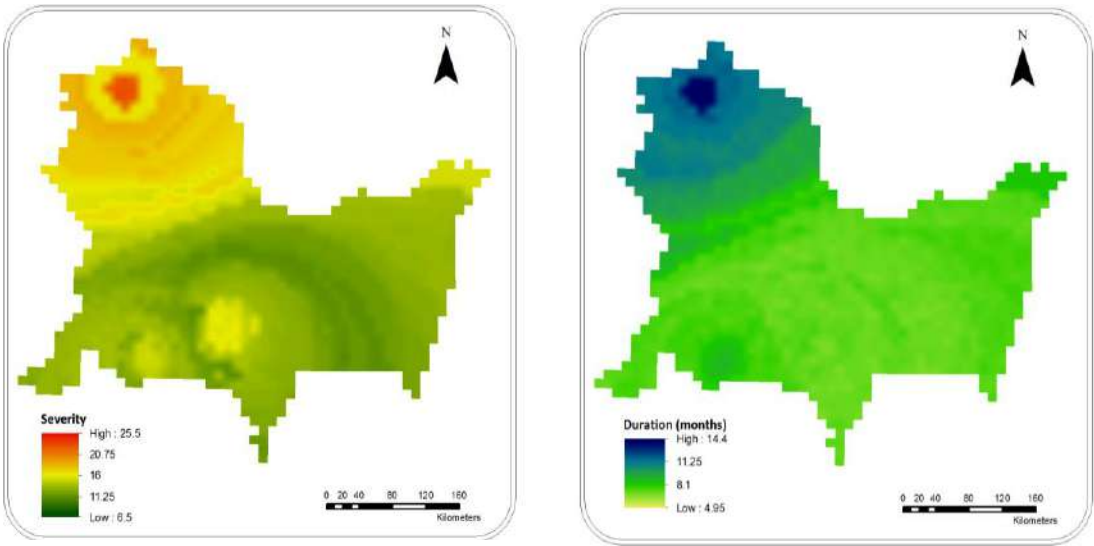

Figure 5*. Spatial distribution of severity and duration with a 100-year return period.*

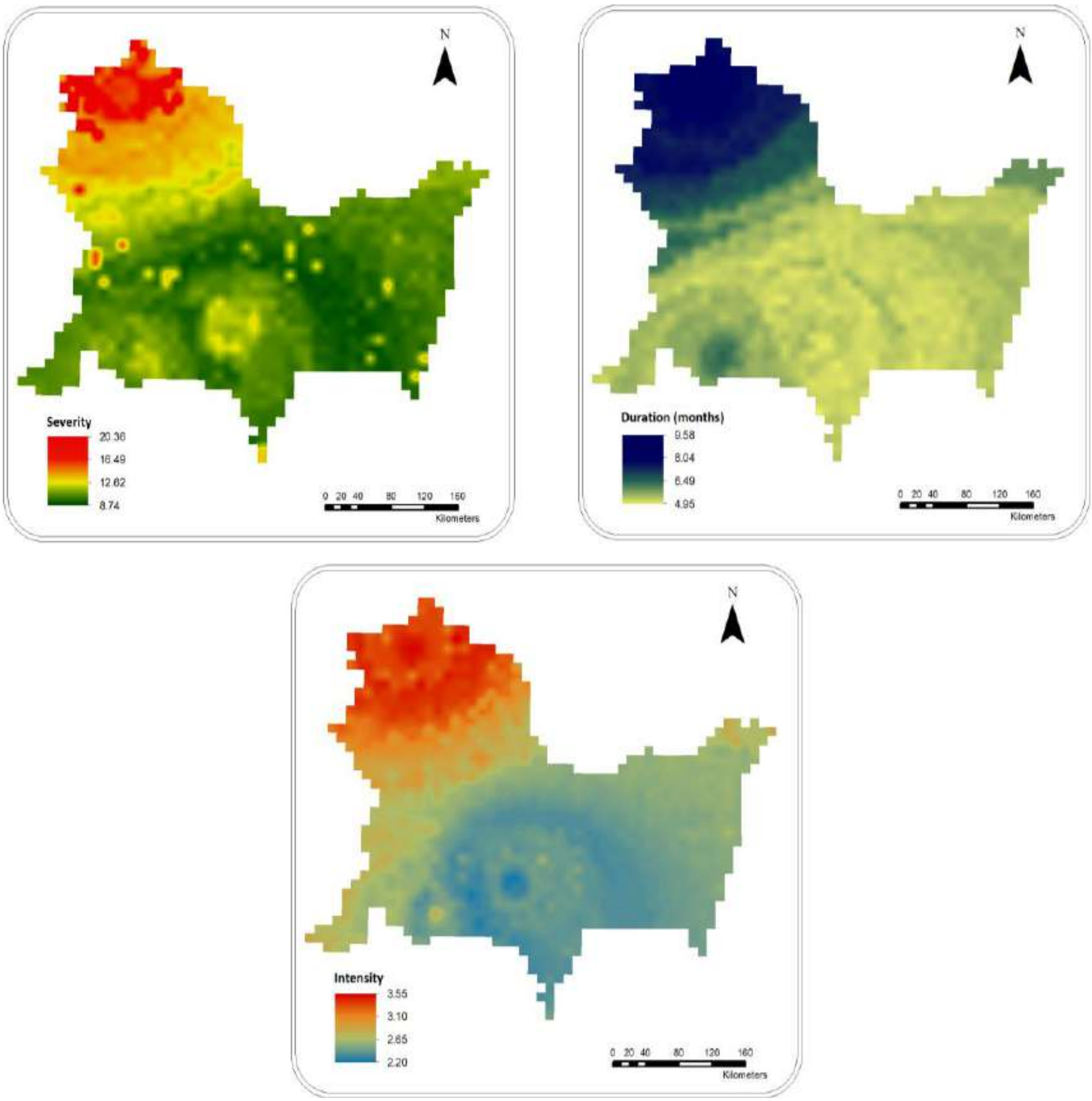

Figure 6. *Spatial bivariate distribution of the three drought characteristics with a 25-year return period.*

The results of Figure 4 portray that the values of the characteristics are in an adequate range so that the model is consistent with the expected range of the numbers. It is also observed that in the spatial distribution the most critical zone corresponds to the north-west, where the events with greater severity, duration and intensity are expected. The latter must be treated with caution because it does not indicate that the variables are going to take these values at the same time, in this case it is necessary to use the bivariate analysis that allows to quantify the joint occurrence values. Finally, a comparison between the severity and duration with a return periods of 25 and a 100 year can be make. Critical areas remain the same in both variables. Nevertheless, the expected value in the duration increases in approximately 3 months, which is a critical time in the field of agriculture and by which preventive measures should be taken.

4. Conclusions

The general objective of developing a standardized model for threat prediction was fulfilled, meeting all stipulated requirements. Additionally, it was possible to implement the model and to review several tests with which the behavior of it was reviewed. The proposed model allows the characterization in different spatial scales of drought, from very limited locations to regions and each case has its specifications and tangible tools to facilitate decision making.

In general aspects, the chosen index for the methodology corresponds to the SPEI, which has great advantages for future studies on climate change. Thus, its multitemporal capacity allows to use the model for research on all types of droughts. Additionally, the methodology covers a set of novel subjects that include the use of bivariate analysis to characterize the events and to be able to quantify the dependence between two variables. Finally, unlike other types of hazards and models, in this case, the drought is not evaluated annually but by event, which allows to obtain more accurate results.

The model was tested in the selected study basin and the general results were shown. The calculated information is consistent with the expected and it allows to establish new characteristics and conclusions, which could not be obtained using only severity as a decision variable. It is necessary to emphasize that there was little information since there were only 3 meteorological stations with precipitation and temperature data. This may give results that are not accurate for the zonal characterization, so it is recommended in this case to use only the one point characterization with SDF curves and with it establish the relevant conclusions.

For future work, it is necessary to take advantage of the benefits of copulas and do more bivariate analysis. Additional to one of three variables to quantify the relationship between the three characteristics present in this study. On the other hand, it can be included a fourth study variable, the magnitude. In order to quantify in a better way the impact of a drought event and to be able to compare it with another

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Adaptive Strategies for Urban Rainwater Drainage Systems in Climate Change Scenarios

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Abstract

Significant changes in the rainwater regime are amongst climate change’s most noticeable consequences. Urban flooding occurs because of drainage systems’ inability to transport all the runoff that is generated. Because of urban floods, cities may present several economic, social and health issues. In this research we attempted to minimize these effects by adapting and not replacing cities’ current drainage infrastructure to the new hydrology conditions. The main objective was to determine the feasibility of implementing temporary storage structures in any big city, regardless of its geographical and socioeconomic context, to reduce rainfall peak flow rates and avoid urban flooding events. This project was developed in cooperation with universities from Colombia, Spain, Portugal and Argentina, and allowed us to create a methodology to optimize the location and volume of these tanks to adapt cities to climate change conditions. Additionally, this project tested a methodology to calculate future rain intensities, so cities can be better prepared to face future challenges. Finally, regarding sustainable development, we concluded that future urban drainage systems should try to imitate the natural drainage that existed in the basin long before cities were built. This is important since human intervention has distanced itself from natural drainage, which is a mistake since natural drainage is more effective than what we have done in the cities as urban drainage.

Keywords: Climate Change, Urban Floods, Storm Tanks, Urban Drainage, SUDS.

1. Introduction

Integrated urban drainage systems were developed as a response to modern issues regarding the management and design of drainage in cities. They allow an integrated management of drainage by regarding the system’s components as a whole. Traditionally, the goal of drainage systems was to evacuate rainwater as fast as possible, and this was done by sending out water outside the city limits. Nowadays, these systems are being planned so they can attenuate peak flow rates that are a result from rain events. Sewer systems have always had an important role in the development of new urban areas, since these systems must be able to adequately control the runoff water generated in the city (runoff water is a consequence of the interaction between anthropic developments and natural water cycle). Rapid urbanization provokes changes in water consumption patterns as well as soil coverage, and these changes may affect drainage systems.

It can be inferred that there is a direct correlation between urbanization rate and increments in runoff flows. However, to analyze an increment in those flows that an urban drainage system transports, environmental effects must be considered, since these could alter the water cycle and modify traditional rainwater regimes. This is where climate change takes part in the present study, as it refers to a significant and persistent variation in climate during an extended period of time. Perhaps climate change’s most noticeable effect is more extreme climate conditions: droughts will present a minor amount of water, while precipitation events in rainy seasons will be more intense (Camilloni et al., 2016).

Regarding urban floods, which is the problem that will occur in some cities, there is a convergence between basins’ runoff water rise and the impossibility of drainage systems to transport it due to a deficit in its capacity. Most of these systems were designed considering different precipitation events from those that are projected in climate change scenarios. Moreover, floods result in economic losses, public health issues and, in the worst-case scenarios, in the loss of human lives. An example of this was the overflow of the Bogotá River on April 2011, where emergency conditions were declared in more than five boroughs of Bogotá due to the rise in rainwater volumes. This incident affected more than 300,000 people in the city (CIACUA, 2013).

To mitigate the previously described damages, it is evident that an intervention of urban drainage systems is required. The first alternative is to resize the pipes and other elements of the entire system, which could result expensive and unfeasible. The other alternative to considerate is store water temporally in the system, like some Sustainable Drainage Systems –SUDS propose, which could be a better approximation to solve the problem. Considering the latter, the research project *Urban Drainage and Climate Change: Towards Future Urban Rainwater Drainage Systems* is proposed, where the goal is to analyze the feasibility of implementing temporary storage structures in an existing sewer network. These structures would be smart, using Real-Time Control Systems strategies (RCS), it would also consider climate change effects on precipitation events and peak flow rates to be transported in the network. This article will be a project’s general description, including the proposed main themes to solve the stated problem.

The first two phases of this research project were sponsored by the pipe manufacturer PAVCO-MEXICEHM COLOMBIA S.A.S. and Colombia’s Administrative Department of Science, Technology and Innovation – COLCIENCIAS. As it was mentioned before, the technical aspects of the research project are developed by a team from different universities: Universidad de Buenos Aires (Argentina), Universitat Politècnica de Valencia (Spain), Universidade de Coimbra (Portugal), Universitat Politècnica de Catalunya (Spain) and the Universidad de los Andes (Colombia). In terms of its duration, three research phases where stated for the project with different objectives: the first two phases, already finished, consisted in knowledge generation for the relevant research themes and implementing it in a physical model to test out the proposed strategies. The third phase will materialize all the acquired knowledge in a prototype, which will be built in the drainage network of a Colombian city.

2. Research Scheme

To achieve all the project's defined goals, it was necessary to divide the research in 5 big areas. In the first area of the project only were required 4 themes, but for the second phase a fifth relevant area was included. The first area oversaw Climate Change projections, its functions were to assess how the new temporary and special distribution of rainfall precipitation events would be when considering this meteorological phenomenon. With that information, it would be possible to generate synthetic rainfall records which will be the starting point for the other research areas.

Secondly, the Peak Flow Rates Reduction area, worked in determining the feasibility of implementing different methodologies to lower peak flow rates in urban drainage systems increasing water storage capacity in the network. Once the existent peak flow reduction techniques were understood, different optimization methodologies were proposed, where the objective was to establish an optimal size and location configuration of these storage structures. To achieve this there were considered two different approaches to the problem, where one of them resulted in the development of a decision model.

In third place, the Computational Modeling area were focused on the development of models and computational tools that permit to simulate efficiently the proposed methodologies by the other research areas. Due to the innovative character of the proposed method of peak flow rate lowering using real-time control, it was required to have proper computational models to observe the network behavior under the proposed changes. Similarly, it was required to create a program to communicate the optimizing software and the hydraulic simulator; this resulted in the creation of a novel and efficient tool.

In fourth place, the Control Strategies area, were focused in the study of real-time control techniques available, which could be applied to real urban drainage systems. The main goal was to find possible modifications on drainage systems, so they could be adapted to respond smartly to situations where there was an important increase in water levels inside the system because of rainwater precipitations which could lead to floods in the city.

Finally, the last area was Physical Modeling, its main goal was to implement all the acquired knowledge by the other areas in a real model. With this information, all the other research areas could be able to validate and adjust their methodologies, so it could be refined all the work for the future research phase.

3. Case Studies

The case studies selection process was required to establish where to test out each of the proposed methodologies in this research. Two existing urban drainage networks in Bogotá were selected to carry out the testing process. The selection criteria considered for these networks is presented below.

1. The network's topology must have a branched form.
2. The network must be complex.
3. The sewerage system must be a separated one (i.e. wastewater and rainwater are carried in separate pipes).
4. It must have redundancy between basins.

5. The network must have surcharges.
6. It must have discharge measurement stations near the network.

After analyzing several existing urban drainage systems alternatives, located in diverse municipalities and cities in Colombia, two drainage systems in the north of Bogotá were selected, known as North Chicó and South Chicó.

3.1 North Chicó Network

This network, depicted in Figure 1, is in the north of Bogotá, Colombia, it was defined according to the Sewerage Management Units (UGA in Spanish) proposed by Bogota's water utility (Empresa de Acueducto y Alcantarillado de Bogotá). This network has a measurement station near the network's discharge point, which could result useful for future hydraulic calibration purposes. In Table 1 is presented a quick view of the network's size in terms of the number of components that forms it.

3.2 South Chicó Network

This network, depicted in Figure 2, is in the north zone of Bogotá, Colombia, next to North Chicó network. As in the previous case, its definition was based on the Sewerage Management Units proposed by Bogotá's water utility. This network has a place where high magnitude floods were previously reported by the users, these were not a consequence of bad hydraulic design, but a consequence of system overcharge. In Table 2 is presented a summary of the network's size.

3.3 South Mini-Chicó Network

This network, depicted in Figure 3, corresponds to a sub-zone in south-eastern South Chicó network. This network was created as a simplified version to make preliminary tests to some methodologies, because at early stages it may be difficult to work with real size networks. This network is a part of South Chicó and its components summary is presented in Table 3.

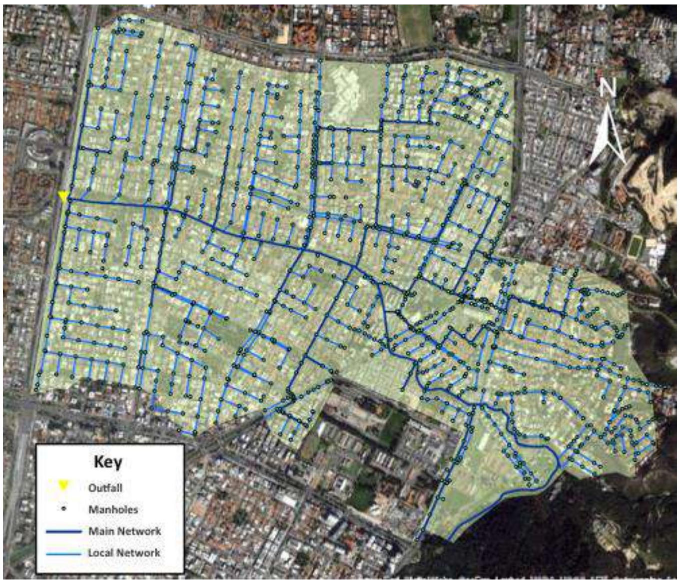


Figure 1. *North Chicó sewerage network.*

Table 1. *North Chicó components summary.*

Component	Quantity
Pipes and Sewers	1293
Manholes	1292
Outfalls	1

Figure 2. South Chicó sewerage network.

Table 2. South Chicó components summary.

Component	Quantity
Pipes and Sewers	510
Manholes	509
Outfalls	1

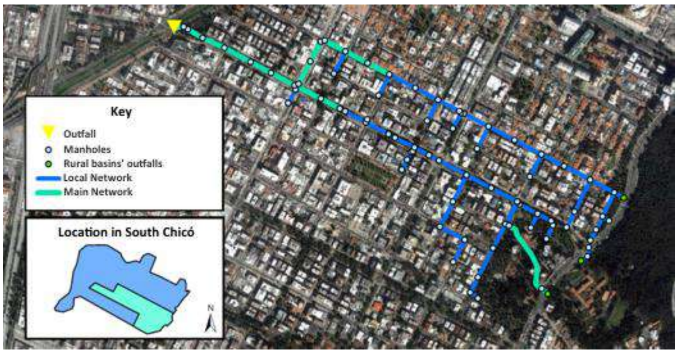


Figure 3. South Mini-Chicó sewerage network.

Table 3. South Mini-Chicó components summary.

Component	Quantity
Pipes and Sewers	83
Manholes	82
Outfalls	1

4. Climate Change Effect on Precipitation Events

4.1 Climate Change

Climate change is defined as the climate conditions alteration, identified by changes in the mean values of variables or in climate variability over an extended period (IPCC, 2013). According to authors and researches such as Solomon *et al.* (2007), to analyze climate change incidences in the long term the climatic system must be studied entirely. A change in the system's functionality could be determined both because its intern dynamics and because of anthropic or natural forces action. Natural forces include the interaction between sun and planet earth, the change in earth's rotational axis, the injection of volcanic aerosols, among others (Camilloni et al., 2016). On the other side, anthropic forces present because of changes in atmospheric composition due to industrial activities and changes in land uses as an effect of deforestation and urbanization processes. These activities increment the radiative energy flux in the atmosphere, measured through radiative forces (Bates et al., 2006).

Hydrological cycle is affected directly by the variation on the radiative forcing because if this index rises there will be an increase in temperature and evaporation. When temperature increases, it also increases the water retention capacity on the atmosphere. When evaporation increases, water vapor content in the atmosphere increases. The combined effect results in cloud coverage increase, the empowerment of greenhouse effect, and a rise in precipitation intensity. So, it is evidenced that climate change will intensify the extreme events occurrence in the world, this means that droughts will be more extreme and high intensity rainfalls much more frequents.

Once the causes and expected effects of climate change at a global scale are understood, it became important for this research to assess how these effects will present in Colombia, focusing in the city of Bogotá. The interest resides in determining the future rainfall records which will be representative for a defined time horizon, to achieve this goal several studies are analyzed. The first one was carried out by the Colombian Institute of Hydrology, Meteorology and Environmental Studies – IDEAM, its focus was in determining the future trends that precipitation effects will have in Colombia, considering climate change scenarios. They found that Bogotá could expect an increase in annual precipitation between 10% and 30% for year 2100 (Garcia et al., 2012). The second study was realized by researchers from the Universidad Nacional de Colombia, it consisted in the determination of frequency changes in the occurrence of precipitation events, based on the statistical analysis system RClimdex. They found that Bogotá lies inside the zones that will present an increase in extreme moderate magnitude precipitation events (Pabon, 2012). Finally, the third study analyzed was also developed by IDEAM, its interest was to find out trends in precipitation and temperature in the country (Mayorga et al., 2011). They found that the general trend indicates that it could be expected an increase in rainfall intensities for most part of the country, Bogotá specifically can expect a 5.4% increase in intensities of strong precipitation events regarding a 10-year average (Benavides, 2011).

4.2 Assessment of Precipitation Events Considering Climate Change

To determine precipitation events considering climate change effects, which were described before, a general methodology to obtain modified Intensity-Duration-Frequency –IDF curves was followed. From these IDF curves it can be obtained a storm profile (i.e. hyetograph) through the instantaneous intensity method. After this method is applied, a downscaling methodology was applied, to obtain a specific rainfall series for Bogotá so the other research areas can use it.

Modified IDF curves to consider climate change effects were obtained from four different approximations, where the main information inputs were the historic daily rainfall records, IDF curves according to the study area and the results obtained from Global Climate Models – GCMs. There were considered four strategies, listed below.

1. Precipitation events with a high return period.
2. Precipitation intensity projections.
3. IDF curves from GCMs.
4. Delta Change.

A detailed and more precise description of the use of GCMs for the first and second phases of this project was presented in 2016 in an article for the Latin-American Hydraulic Congress, in Lima, Peru (Camilloni et al., 2016). Similarly, the second phase of this research project made an important effort finding and adapting different downscaling methodologies to get useful time-series for local scale, this work is detailed in another article presented in the same congress (Camilloni et al., 2016).

5. Peak Flow Rates Reduction Strategies

5.1 Temporary Storage Units

In the 90's runoff water was declared as a harmful environment agent. This resulted in the definition of new objectives for water management, it also resulted in new rainwater management strategies. Within this framework, the concept of Sustainable Urban Drainage Systems – SUDS emerged. These are interventions of the system to manage water cycle in a more sustainable way, where the objective is to mimic natural drainage regimes (Fletcher et al., 2013). These kinds of interventions include retention and infiltration structures, wet wells and green roofs. When one or multiple of these techniques are implemented simultaneously runoff rate flows are reduced significantly, so the existent system is optimized and there are increases in storage capacity without replacing any pipe in the network< this could lead to a lower probability of floods in existent systems.

This research project focused exclusively in storage tanks (Figure 4) implementation as an alternative to reduce peak flow rates. These structures can be classified according to its functionality (i.e. if they are used for flood control or for spills quality control), its constructive typology (i.e. if the tanks are built at ground or underground level, considering legislative, economic and urbanistic criteria), and its connection to the sewage network (i.e. on-line if the tanks are aligned with the pipes path of the system, or off-line if tanks are not in the pipes path and special connection structures are needed).

a) AquaCells (Taken from WAVIN, 2003).

b) GRP Tanks (Taken from AMITECH, 2010).

Figure 4. *Peak flow rates reduction modular structures.*

In terms of new technologies and materials used in storage tanks, this research project focused on three kinds of structures: traditional concrete tans, AquaCells structures and big glass reinforced polyethylene (GRP) tanks. In the first phase of the project only traditional rectangular in-situ concrete tanks were considered, for the second phase of the project AquaCells and GRP tanks were considered, at the end the project has two physical models to test out both storage structures and analyze its use feasibility for a real-size network for the third phase of the research project.

On one side, AquaCells (Figure 4a) are modular structures designed to perform a proper management of rainwater acting as temporary storage structure or acting as infiltration sumps. Due to its modular shape, it can be easily adapted to different requirements of space conditions and different use scales, ranging from local level to big storage structures (WAVIN, 2003). On the other side, GRP tanks (Figure 4b) are presented as modular structures too, the difference lies in the fact that GRP tanks are designed to be used as large-scale temporary storage. It has modules with specific functions, such as recollection and evacuation of waste (AMITECH, 2010).

5.2 Optimal Location and Sizing of Storage Tanks

One of the main research objectives in this project lies in the formulation of a methodology that could lead to an optimal size dimension and location of storage tanks in an existing urban drainage network. Several authors have proposed its own approximations to this problem, such as Vasudevan *et al*. (1985) who presented a simplified method to estimate the capacity of a storage tank, Meredith *et al*. (1990) who developed a methodology that uses historic rainfall records to size a rainwater retention tank. Later, Domenechi *et al.* (2012) presented an approximation to determine the effect of climate variation in already designed storage tanks, the purpose being to analyze the efficiency of these tanks in floods reduction.

An innovative component of this research project lies in providing a connection and integration of a hydraulic simulator software as Storm Water Management Model – SWMM of the United States Environmental Protection Agency –USEPA, with the optimization software created for this project (Martinez-Solano et al., 2016). This software provides a practical tool to find a set of optimal solutions in a defined network, where the objective function is the minimization of floods or the minimization of floods costs. The problem was attacked using two different approaches: the first one looks how to stablish the optimal tank's size passively, without considering real-time control, known as Optimization Without Hydraulic Control. The second approach considered within its decision variables the diameter of the orifice at the tanks' outlet, being this is the way to consider real-time control strategies in the network, known as Optimization with Hydraulic Control.

Optimization Without Hydraulic Control

In this approach, the objective was to optimize the size and number of storage tanks that would be needed in a rainwater drainage network to control floods in the system. In terms of the developed optimization model, this approach was oriented by an objective function guided by the flood level in different nodes in the network, the needed tank's volume and the maximum volume of water stored in the system. This function was solved using a pseudo-genetic algorithm to search for the optimal solution within all the possible solutions in the search space (Iglesias et al., 2014).

As this is a passive approximation method, it was considered actions that does not involved real-time control techniques such as the on/off status of possible pump stations, and the definition of potential size and location of the required storage tanks.

Optimization with Hydraulic Control

In this optimization approach a decision model was proposed, this model oversaw the determination of optimal volume for each one of the potential storage structures in the system as well as the outlet orifice's diameter for the tanks in the urban drainage system. Because of the pre-evaluation of the study zone it was expected that this network presented potential floods. Later, a set of hydraulic, legislative and operative restrictions were stablished; the feasibility of a solution is conditioned by the simultaneous fulfilment of these restrictions (Cunha et al., 2016).

In this approach, simulated annealing was used as optimization technique taking the analogy from a metallurgical industry application: a raw material is heated, and then when it is getting colder, its physical characteristics are changed (Kirkpatrick et al., 1983, Dowsland, 1993). To provide a connection between the optimizing tool and the hydraulic solver it was used the SWMM Toolkit developed for this project (Martinez-Solano et al., 2016), as it was established previously.

6. Computational Modeling

6.1 EPA-SWMM Toolkit

Storm Water Management Model – SWMM is a dynamic simulation model of the flow generated by water contributions from both precipitation events and wastewater, it was developed by the United States Environmental Protection Agency – USEPA and will be used in this research project as hydraulic simulator to support work from different research areas. The USEPA provided several tools that allowed the execution of a simulation from an external application as long as network's topology and other network characteristics were previously defined. These tools were extended to get a functions library for the research project named SWMM Toolkit, this library makes the simulation process, results reading and modification of network's characteristics easily (Martinez-Solano et al., 2016).

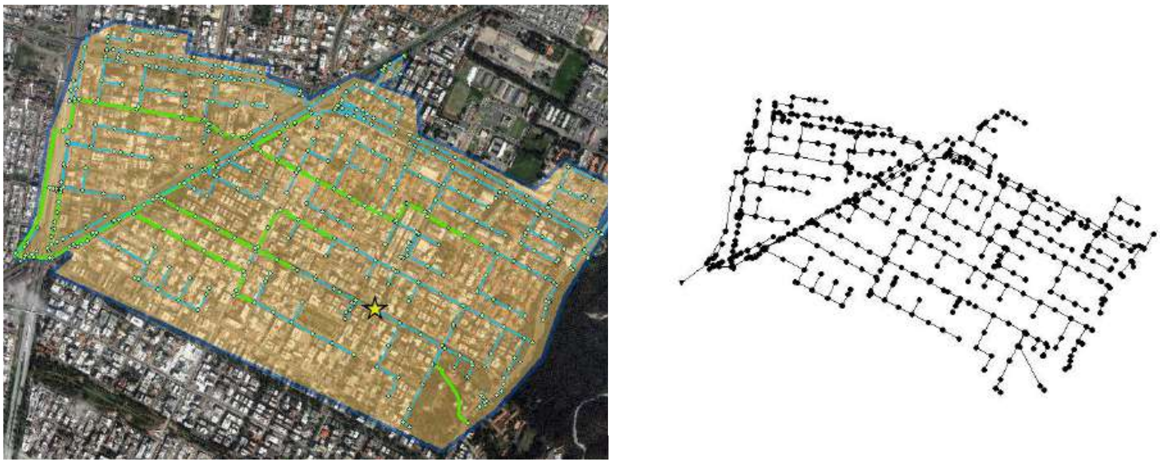
The development of this toolkit is one of the most important and innovative products obtained during the first two phases of this research project. It was defined in the first phase and refined and debugged during the second phase. The toolkit makes the communication process between the hydraulic simulator and the optimization tool in an efficient manner, this is useful to facilitate the solving process of the developed optimization models, being this project a pioneer in the application of this procedures to urban drainage systems problems.

6.2 Hydraulic Model Generation

To test out the methodologies proposed in the first phase of this project it was necessary to create the hydraulic models in EPA-SWMM, which was the selected simulator for this purpose. As it was stated before, the selected case studies were North Chicó and South Chicó, whose cadastral information was available as Geographical Information System – GIS offered by Bogotá's water company (Figure 5a). These GIS files contained pipe's characteristics information such as diameters, slopes, starting and ending elevations, and its material; it also contained manhole's characteristics such as depth and invert elevation. In Figure 5b is presented the result of this modeling process in EPA-SWMM.

It is important to remark that in Bogotá's sewage system, the main network has several big collectors and open channels whilst the local network is composed only by pipes. The hydraulic model's generation process will be described below.

1. Creation of connections between the main and local pipe networks.
2. Correction of extreme values in ground levels.
3. Ground elevation interpolation.
4. Pipe slopes check.
5. Basins creation.
6. Basins parameters quantification.
7. Topology creation in SWMM input file format (i.e. inp file).
8. Include unevenness between sections.



a) Cadastral information in ArcGIS. *b) Hydraulic model in EPA-SWMM.*

Figure 5. *Construction of a hydraulic model in EPA-SWMM from the GIS information available.*

6.3 Computational Time Reduction

After the hydraulic models in EPA-SWMM were created, it started the test process to evaluate the hydraulic behavior of the model. During the first phase of the project, a first test consisted in increasing the number of network nodes with a lateral flow contribution and registering the variation in the elapsed time to complete the hydraulic simulation. As it was expected, tis test concluded that an increase in the number of contributing nodes represented an increase in computational time. A network with 1360 nodes would take up to 2 minutes to sort out he simulation process, as this is a real-time decision problem, 2 minutes would be unacceptable, so it was required the implementation to reduce the computational time for each simulation.

During the second phase of the project the second test was realized; in this test the computational time was evaluated using the optimization tool specially designed for the project. This test gave similar results to those obtained in the first test, an increase in the number of nodes in the network will result in additional computational time. The problem here relied in the fact that each demand node added to the network resulted in another potential location for a tank to be designed, so if the number of nodes is big enough, the problem would take up to 3 days to get the results (CIACUA, 2016).

Three actions were defined to reduce computational time and overcome problems in both tests (Iglesias et al., 2014), these actions are described below.

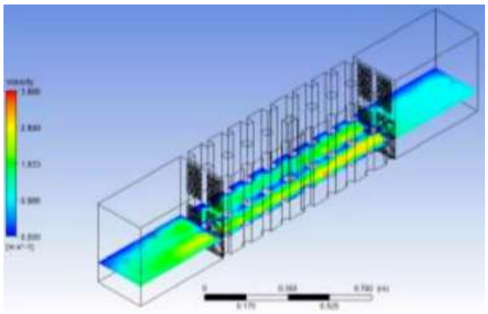
1. New Toolkit: development of a new toolkit that allowed the team to make hydraulic calculations in EPA-SWMM from the toolkit, this means that it was not needed the execution of SWMM's graphic interface.
2. Rainfall-runoff models: the execution of the rainfall-runoff model each time a hydraulic simulation was performed was time consuming and unnecessary, so the solution algorithm was changed and the rainfall-runoff model was executed just once, and for the latter executions the flow rate was replaced for an equivalent contribution in each node in the network.
3. Skeletonization: it consists in network's size reduction in terms of the number of elements in the system, the idea was to provide an equivalent network with less components but without information losses.

6.4 AquaCells CFD Characterization

In the second phase of this research project a physical model of AquaCells structures was made. To complete the characterization process of this kind of storage structure in urban drainage systems it was developed a Computational Fluid Dynamics – CFD model to get more information about this modular deposit type. CFD allowed to make simulations of different tanks configuration, this was useful to determine important aspects such as energy dissipation in these structures, and provided information to stablish comparative points between AquaCells and conventional storage tanks (CIACUA, 2016).

These CFD models (Figure 6b) have been validated by an experimental prototype built in laboratory for the research project (Figure 6a). This consisted of a channel along which several modular blocks are disposed to analyze both, circulating flows and water levels reached at different points of the system. The result is a validated and calibrated model that allows to represent the behavior of this kind of structures in high intensity storms (Sanchez-Beltran et al., 2016).

a) AquaCells physical model.



b) AquaCells CFD model.

Figure 6. *Construction of a physical laboratory controlled model and creation of a CFD model for AquaCells structures.*

7. Real –Time Control

7.1 Real-Time Control and Urban Drainage Systems

When real-time control systems (RCS) are implemented in urban drainage systems, it is expected that the automated system has the ability to respond properly to situations where drastic variations in precipitation events are presented. Likewise, it can be said that an urban drainage system is real-time controlled if process variables are monitored and used continuously to handle the actuators during its operation (Schütze et al., 2003). RCS algorithms consist in a set of rules that can determine which control action will be taken as a response to the current conditions of the drainage system.

Historically, the main objective of real-time control in urban drainage systems has been the reduction of flood volumes, or the number of floods, without extending the current system infrastructure. Other common control objectives include the prevention of urban floods, the contamination reduction of the water body that receives wastewater and the minimization of operational costs. More recently, other objectives regarding water quality have been considered. Real-time control can manage more than one objective simultaneously if multi-objective control strategies are designed.

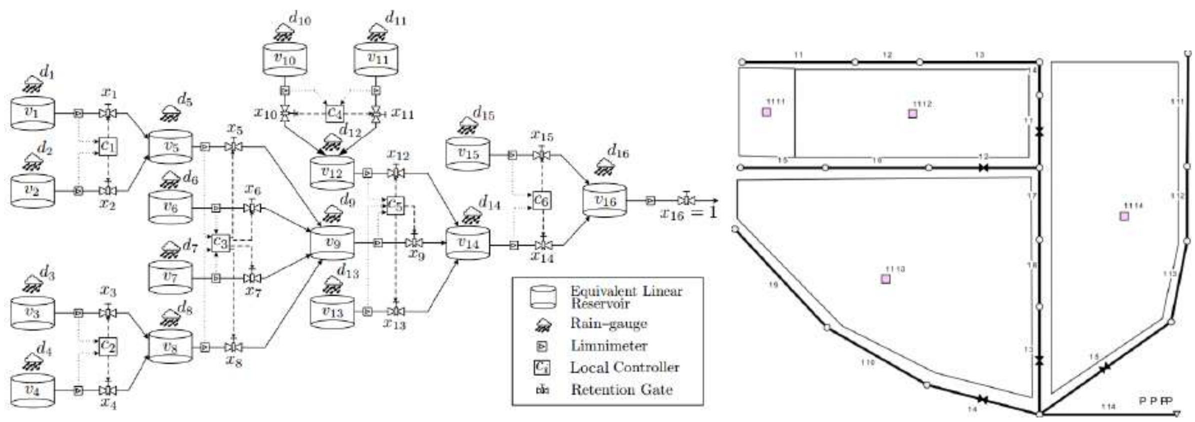
It has been shown that the proper design of real-time control techniques is a reliable, adaptive and cost-efficient solution towards the significant improvement of the urban drainage systems performance (Schütze et al., 2003, Schilling et al., 1996). The main reasons to affirm that real-time control has a positive effect in the urban drainage operation are listed below (Garcia et al., 2015).

1. Most urban drainage systems are planned considering static design rules. However, these systems are operated under dynamic charge/discharge conditions.
2. Climate change makes necessary that drainage systems with a decade's lifespan adapts to new charge conditions. Climate phenomena as global warming just exacerbate this problem.

For this research project, three real-time control techniques have been analyzed to establish the suitability of their implementation in large-scale urban drainage systems. These techniques are:

1. Model predictive control (MPC)
2. Evolutionary games (EG)
3. Differential games (MFG).

In Figures 7a) and 7b), simplified models of the south Chicó network, which are used to validate the algorithms, are shown. Furthermore, MatSWMM (Riaño-Briceño et al., 2016), an open-source toolbox for designing real-time control of urban drainage systems, has been developed to test the control algorithms.



a) Simplified South Chicó model. *b) Model of a branch in the South Chicó network.*

Figure 7. *Simplified models used to validate control algorithms. Figure a) is taken from Barreiro-Gomez et al. (2015c), and Figure b) is taken from Ramirez-Jaime et al. (2016).*

7.2 Results and Discussion of Real Time Control

The mentioned control algorithms have been tested in the south Chicó network, and all of them (MPC, EG, and DG) have shown significant improvements in terms of reduction of flooding volumes and flooding events for critical rain scenarios (Barreiro-Gomez et al., 2015a), (Barreiro-Gomez et al., 2015b), (Barreiro-Gomez et al., 2015c), (Barreiro-Gomez et al., 2015d). The results obtained with the ED-based technique for a typical rain scenario (see runoff hydrograph in Figure 8) in the south Chicó system (see Figure 7a)) are presented in Figure 8.

It is shown that the storm water is better distributed throughout the network for the decentralized control case. The upstream reservoirs get more filled and their capacity of use increases to almost the double. The flow downstream is relieved and flooding is avoided. The use of the proposed decentralized controllers and the cascade topology guarantee that the capacities of the reservoirs upstream are more effectively used. The basic hydraulic design is oriented to evacuate the runoff as fast as possible. However, this design approach can lead to flooding events in terminal nodes as seen in Figure 8f). In the case where control is used, reaching the steady state for reservoirs takes more time compared to the uncontrolled case, and this is a consequence of the retaining property provided by the controller. The control objective, i.e., reducing overflows by distributing better the water resource, is satisfied.

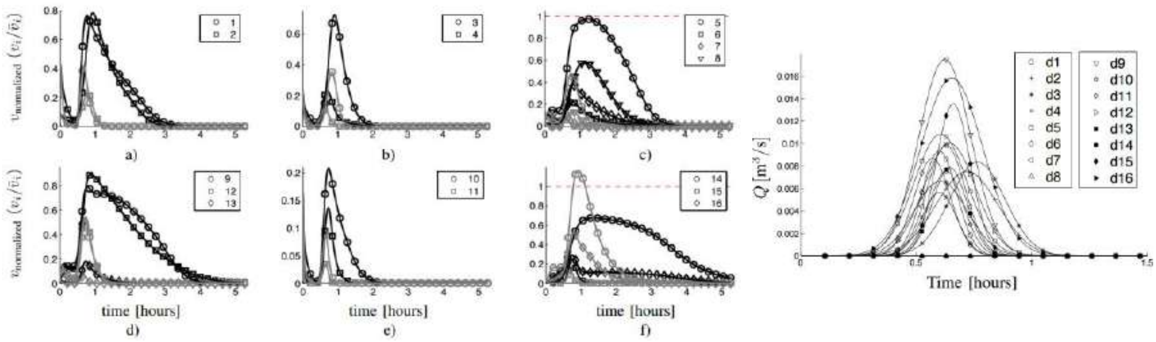
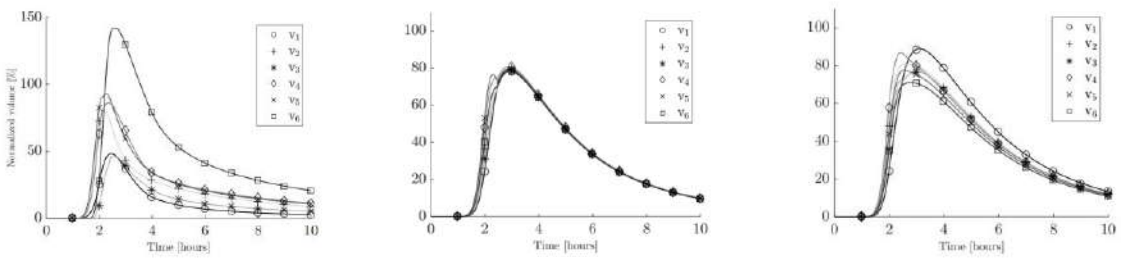


Figure 8. *Evolution of the filling ratios in the 16 reservoir modules of the simplified south Chicó system. Gray lines correspond to a scenario without control, and black lines correspond to a scenario with the decentralized controller. Figures a), b), c), d), e), and f) show the reservoirs for the controllers 1,2,3,4,5, and 6, respectively. Labels refer to the different reservoirs in the UDS. The direct runoff hydrograph of the tested rain scenario is on the right side. This This Figure is taken from (Barreiro-Gomez et al., 2015c).*

Additionally, it has been shown that decentralized control techniques not only require less communication infrastructure, but also reductions of flooding events are guaranteed (Barreiro-Gomez et al., 2015c). For instance, in Ramirez-Jaime et al. (2016), this can be evidenced due to results comparing centralized MPC control with DG-based control (see Figure 9). In this work, a consensus-based algorithm is used to equally distribute the runoff among all the reservoirs in one of the branches of the south Chicó system (see Figure7b)). As a result, the controlled system has no flooding.



a) Open-loop response

b) MPC controller on the loop

c) DG-based controller on the loop

Figure 9. *Response of the branch system a) without control, b) with MPC control, c) with a DG-based controller. The filling ratio of six branches of the network is controlled. This Figure is taken from Ramirez-Jaime et al. (2016).*

8. Conclusions and Future Work

After completing the first and second phases of the research project *Urban Drainage and Climate Change: Towards Future Urban Rainwater Drainage Systems* it was possible to obtain different conclusions as a part of the knowledge generation process. So far, obtained results seem to indicate that the adopted approach for the project has been proper and urban drainage systems floods could be minimized trough the implementation of temporary storage structures and real-time control strategies, even when climate change effects occurs within the established time framework.

Secondly, it is important to remark that this paper just intends to present an introduction to the project and give a background to the reader in the development of the research, which will follow its course in the thirds phase of the project. For further details on each project area, we suggest the reader to follow the suggested references throughout this article.

Finally, regarding future work, a third phase of this research is planned, its main goal is to materialize all the acquired knowledge through the first two phases in a real-size prototype in an urban drainage system in Bogotá, Colombia (CIACUA, 2016).

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A scientifically-driven approach for the sustainable development of Arctic coastal zone

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Abstract

The Arctic coast has been strongly influenced by the effects of climate changes. Accelerating global warming and impact of storms imply a rapid permafrost degradation and drastic shoreline retreat in an Arctic coastal zone. In many regions shoreline retreat exceeds 30 meters per year. Impact of storms on permafrost coast causes much faster processes than it has been expected. These processes impose large impacts on social and economic conditions in the region including quality of life, housing, infrastructure and developments. The observed processes significantly affect activities in the Arctic area and have also drastic effects on the degradation of glaciers by accelerating breaking and melting processes and, in consequence, accelerate climate changes. More effort is necessary to reduce negative impacts of climate changes on polar areas. These require a new approach to predict and control changes in the Arctic coastal environment. It is also worthwhile to develop knowledge on increased coastal erosions through better recognition and understanding of physical processes as well as reliable modelling of permafrost thaw and shoreline shift. A novel approach to this problem has been proposed and its programme is currently under implementation. The approach is based on original experimental investigations on wave-induced erosion of permafrost, a series of field measurement campaigns, and numerical modelling of erosion processes in Arctic conditions. Extensive experimental studies have been conducted to identify physical processes responsible for increased sediment transport rates of the frozen sandy bottom. Experimental data and theoretical analysis indicate that the new approach provide novel results of significant importance for understanding of erosion processes in polar areas.

Keywords: Climate Changes, Permafrost Erosion, Sediment Transport, Arctic Coasts

1. Introduction

Arctic coastal regions experience nowadays dramatic changes resulting from global warming effects. As a result, rapid permafrost degradation and drastic shoreline retreat modify the topography and bathymetry of the Arctic coastal region. The area of the Arctic Ocean covered by ice constantly decreases and, together with extended season of open waters, results in more severe storms and higher waves approaching polar coasts (Atkinson, 2005). The reduction of shore-fast sea ice is expected to continue as the rise of mean temperature in Arctic region is predicted to reach 2.5 ºC in 50 years and even 7-9 ºC till the end of the century (Kattsov and Källén, 2007). As the presence of ice limits the effect of waves and storm surges actions on the Arctic coast, duration of the open water season (OWS) becomes one of the most important factors influencing erosion rate. Lantuit et al. (2012; 2013) claim that, in case of the Arctic coast, an average erosion rate is 0.5 m/year with regional variability. The longer open water season that expanded at a rate of 1.75 day/year over a period 1979-2009, is believed to be responsible for shoreline retreats reaching more than 17 m/year in many areas (Barnhart et al., 2014; Aguirre et al., 2008; Overeem et al., 2011). As a result, the vulnerability of Arctic coasts to geomorphic change, inundation, and damage of infrastructure increases (Barnhart et al. 2014) and the escalated erosion may occur and affect biological and human systems (Rachold et al., 2005). Despite these threats, coastal dynamics of polar areas are still not sufficiently recognised and are seldom modelled (Lantuit et al., 2012; Reda et al., 2015).

A new approach to the problem of the erosion of the Arctic coasts arising from climate changes was introduced in the frame of an ARCOASTS project (Reda et al., 2015, Sulisz et al. 2015). The primary motivation of the study was the development of appropriate tools for the Arctic coastal protection and management taking into account limited amount of data on wave climate, geomorphology, etc. The special attention was given to the effect of ocean waves and current on permafrost thaw, shoreline shift, and sediment transport (Paprota et al., 2016, Majewski et al., 2016, Sulisz and Paprota, 2016). The main objective of the project was to recognize physical processes responsible for erosion of the Arctic shore including sediment transport, permafrost vulnerability to erosion, thermodynamic processes in polar waters induced by sea waves, and the reduction of sea ice. Therefore, new methods were developed in order to achieve defined goals.

In the present study an original methodology is applied to assess vulnerability of the polar coastlines to erosion and to provide data for policymakers, stakeholders, and end-users involved in integrated coastal zone management of polar regions. It is a common practice in handling this kind of complex problems to introduce indexes or indicators facilitating a description of a complicated system affected by many physical processes and their interdependences in a different spatial and temporal scales. Taking into account specific nature of the polar environment, an extended Polar Coastal Risk Index (PCRI) is introduced to characterise the coastlines of the Arctic area with respect to their vulnerability to erosion. In the next section, a description of various tools used for coastal vulnerability assessment are provided and the definition of the Polar Coastal Risk Index is presented. Then, the results of the application of the PCRI approach to the arctic coastline are discussed and compared with the previous studies on PCRI calculated by applying a lower number of risk parameters. Finally, the consequences of using original and extended PCRI index are summarised and the conclusions are specified..

2. Methods

The problem of the vulnerability to erosion of coasts at different temporal and spatial scales may be addressed by applying (Ramieri et al., 2011): (a) index-based methods (Gornitz, 1990; Gornitz et al., 1991), (b) indicator-based approaches (Marchand et al., 2010), (c) GIS-based decision support techniques (Mocenni et al., 2009; Schirmer et al., 2003), and (d) methods based on dynamic computer models (Hinkel, 2005; Hinkel et al., 2010). The problem is that available approaches cannot be directly applied to the Arctic region. An apparent need to develop a new scientifically-driven approach to incorporate processes characteristic for polar regions into coastal erosion management motivated the present study.

The analyses of available data led to the conclusion that in case of polar regions it is reasonable to use an index-based method for coastal erosion risk assessment (Sulisz et al., 2017). Therefore, a concept of Polar Coastal Risk Index (PRCI) is introduced to evaluate spatial risk distribution of the whole Arctic coastline. The PCRI is calculated as a square root of a product of ranked variables (x_n) divided by the number of variables (N), namely:

$$PCRI_N = \sqrt{\prod_{n=1}^{N} x_n} \qquad (1)$$

Variables, x_n, represent geomorphology of the coast, erosion rate (m/year), coastal slope (^{o}), wave climate defined by a representative wave height (m), surge height (m), mean tidal range (m), duration of an open water season (%), ground ice content (%). A sea level rise, which is often included in vulnerability assessment in other studies, is neglected as it is about three orders of magnitude lower than the height of waves and surges. The proposed PCRI covers two additional region-specific variables: the duration of the open water season and ground ice content which are defined as a percentage of the total time and volume, respectively. The presence of shore-fast sea ice results in weaker erosion of coasts caused by waves due to limited fetch of wind energy transfer to waves. The ground ice content is another variable, which is particularly important in ice rich permafrost bluffs (Barnhart et al., 2014). The presented Table 1 includes all considered PCRI component variables that are relevant to polar coastal erosion risk assessment.

Table 1. *Risk ranking of PCRI component variables.*

VULNERABILITY	**Very low**	**Low**	**Moderate**	**High**	**Very high**
VARIABLE	**1**	**2**	**3**	**4**	**5**
a) Geomorphology	Cliffs		Shore terraces	Flat beaches	Deltas, lagoons
b) Erosion rate (m/year)	<-0.50	-0.50- 0	0-0.5	0.5-1.5	>1.5
c) Coastal slope (º)	> 1.50	0.75-1.50	0.25-0.75	0.12-0.25	≤ 0.12
d) Wave height (m)	<2.5	2.5-3.5	3.5-5	5-6.5	>6.5
e) Surge height (m)	< 0.45	0.45-0.60	0.60-0.83	0.83-1.05	≥ 1.05
f) Mean tide range (m)	> 1.00	0.70-1.00	0.35-0.70	0.25-0.35	≤ 0.25
g) Duration of open water season (%)	< 30	30-40	40-55	55-80	> 80
h) Ground ice content (%)	≤ 10	10-20	20-30	30-50	>50

The set of available values is split into five subsets corresponding to a comparable length of a coastline. The subsets are assigned a particular risk in increasing order. A value of 1 corresponds to the lowest and 5 to the highest risk. A risk ranking is assigned to ranges of numerical variables, while the non-numerical geomorphology variable is ranked according to the relative resistance of a given landform to erosion.

3. Results and discussion

Two databases coupled together consist of 1984 segments covering the whole Arctic coastline. Unfortunately, some information is missing for a certain number of segments. A set of 369 segments lack the data on geomorphology, 589 segments on erosion rates, and 259 segments do not include data on ground ice content. Therefore, the indexes are calculated in two different ways. The first PCRI-6 corresponds to whole set of segments, but includes only six component variables - neglecting the erosion rate and the ground ice content variables. The second PCRI-8 is calculated based only on a limited number of segments having complete information.

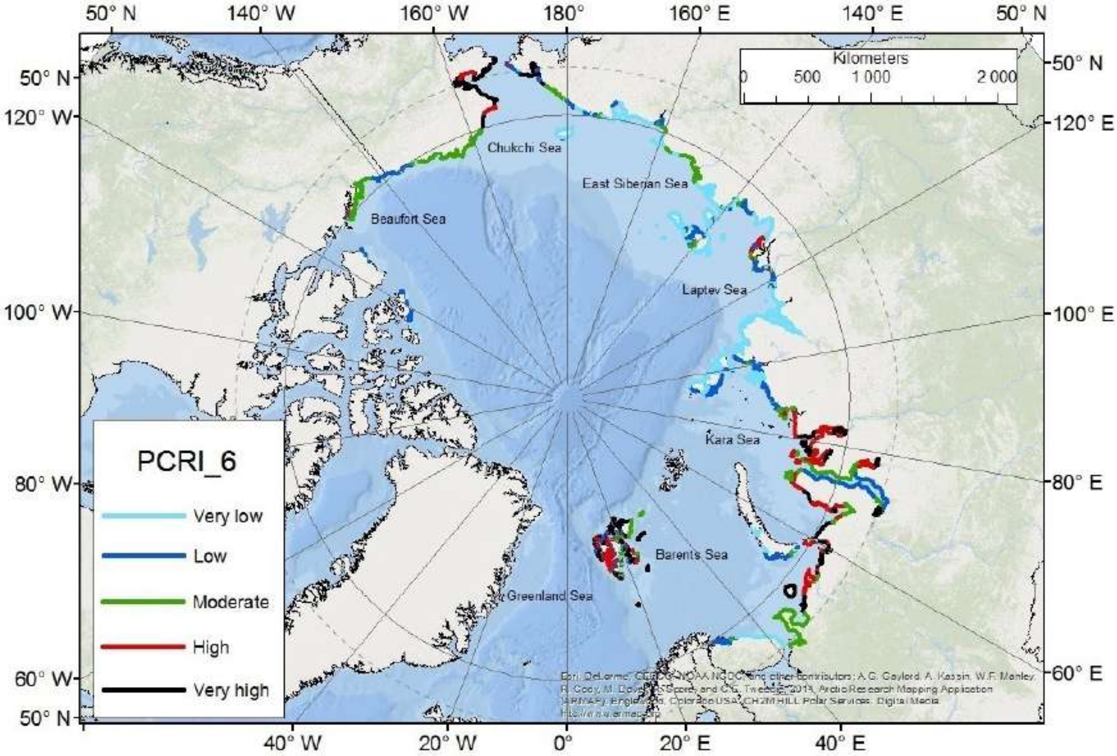

Figure 1. Polar Coastal Risk Index PCRI-6 along the Arctic coastline.

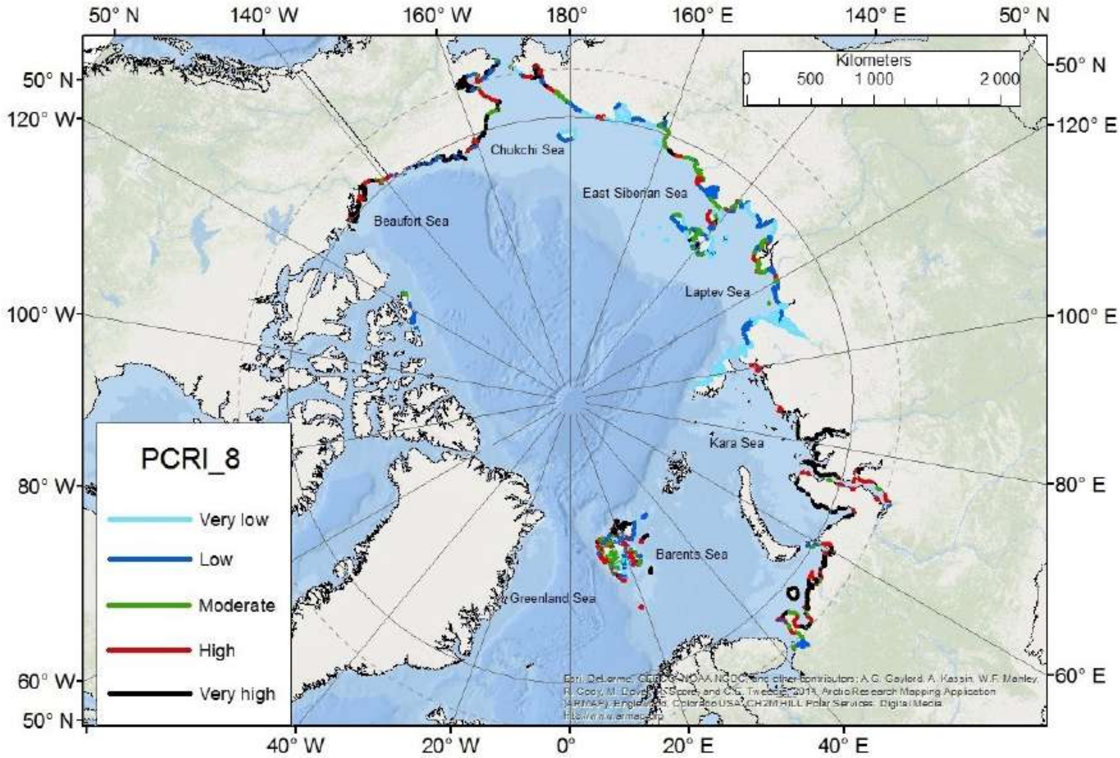

Figure 2. Polar Coastal Risk Index PCRI-8 along the Arctic coastline.

The vulnerability to erosion of the arctic coastline is assessed separately for PCRI-6 and PCRI-8. In Fig. 1, 1604 segments of the calculated PCRI-6 values are displayed. PCRI-6 ranges from 1.15 to 22.36 and the mean PCRI-6 value is equal to 7.46. Fig. 3 shows the variability of the calculated PCRI-6 along the coastline for 1241 segments. The PCRI-8 value ranges from 1.41 to 54.77 while the mean PCRI-8 value is 12.73. The contours of coastlines without colors represent the segments with missing information on one or more variables.

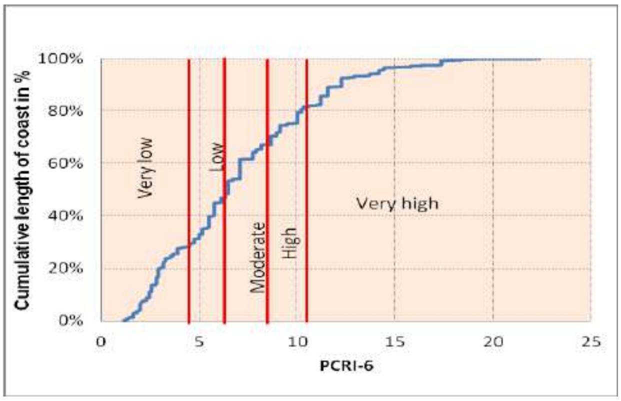

Figure 3. *Cumulative distribution of PCRI-6.*

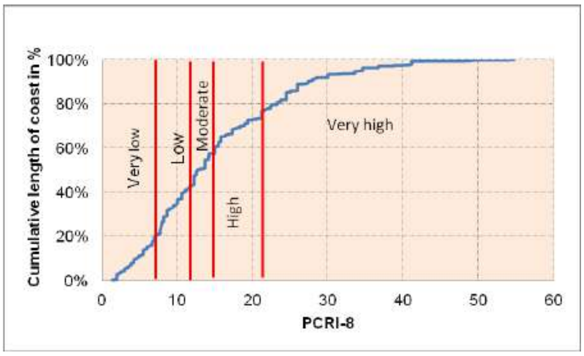

Figure 4. *Cumulative distribution of PCRI-8.*

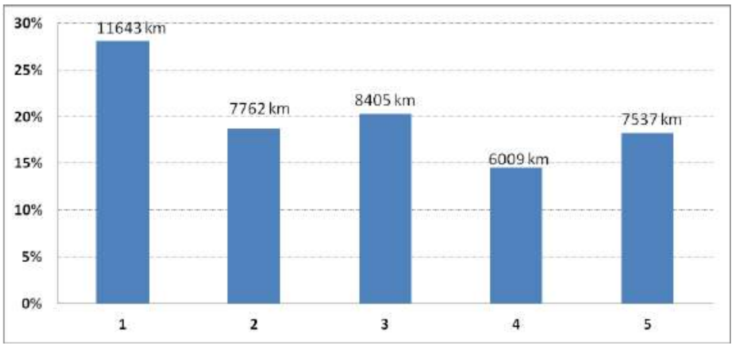

Figure 5. *Length of the shoreline in each risk category for PCRI-6.*

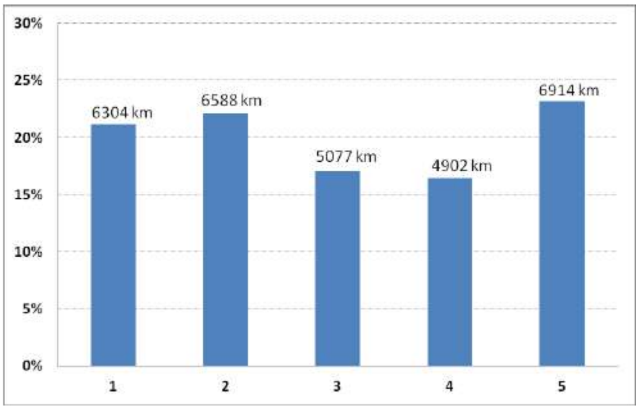

Figure 6. *Length of the shoreline in each risk category for PCRI-8.*

The cumulative distributions of PCRI-8 and PCRI-8 values are presented in Figs. 3 and 4. In Figs. 5 and 6, the bar graph indicating the length of the Arctic coastline in each risk category is plotted. The PCRI values are split into very low, low, moderate high, and very high risk categories based on approximately equal coastline length. Calculated PCRI-6 and PCRI-8 vary along the coast. The highest calculated risks for both indexes cover Russian coast of the Barents Sea, the western coast of the Yamal Peninsula, the coast of the Kara Sea, the northern coast of Alaska and some fragments of the Spitsbergen Archipelago, including the northern coast of the Nordaustlandet Island and the smaller islands of eastern Spitsbergen. Additionally, the highest value of PCRI-6 covers the western coast of Alaska and the northern coast of the Chukchi Peninsula in Russia and also the coast of the Kara Sea for which PCRI-8 is missing due to the lack of information on erosion rates. The simplified PCRI-6 index can be used to determine the most vulnerable coastlines in case of a lack of all necessary values to calculate PCRI-8. The lowest calculated values of PCRI-8 vary spatially in the similar way as the highest ones. They cover the coastlines of the East Siberian Sea, the Laptev Sea, the Greenland Sea and the Canadian Archipelago and some small fragments of Alaska coasts. Additionally, the PCRI-6 index indicates the lowest risk for some fragments of the Kara Sea which were overlooked by PCRI-8 index due to missing erosion rate data. In Table 2 the coastline length for all calculated risk categories are presented separately for each Arctic sea.

Table 2. *Length of coastline in subsequent risk categories.*

		PCRI-6					PCRI-8						
Sea	**Risk rank**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**No of all segments**	**Length of all segments [km]**
Barents Sea		6,7	7,6	12,6	7,4	9,0	0	3,3	4,6	5,6	11,5	265	11 567
Canadian Beaufort Sea		0,2	13,6	46,1	0,8	0	0	0,1	3,6	15,5	33,8	104	2 195
Chukchi Sea		21,7	26,6	24,8	3,7	36,1	13,3	18,2	20,7	29,0	19,0	44	1 381
East Siberian Sea		63,1	20,0	16,9	0	0	29,3	33,0	26,3	8,0	3,4	104	5 338
Greenland Sea and Canadian Archipelago		3,3	10,3	0	0	0	0,3	10,6	2,6	0	0	152	2 418
Kara Sea		8,8	21,6	14,6	20,3	14,3	0,1	0,1	0,4	4,0	10,6	477	14 793
Laptev Sea		76,7	12,1	6,8	4,4	0	54,6	25,4	16,0	3,6	0,4	199	7 398
Svalbard		0	0	10,4	6,3	32,8	7,8	24,7	23,3	25,1	19,1	478	5 102
US Beaufort Sea		0,7	23,7	75,6	0	0	7,0	21,0	3,2	12,0	56,8	75	1 013
US Chukchi Sea		0	0	21,0	12,7	66,4	1,6	15,1	9,7	24,2	49,4	76	2 524

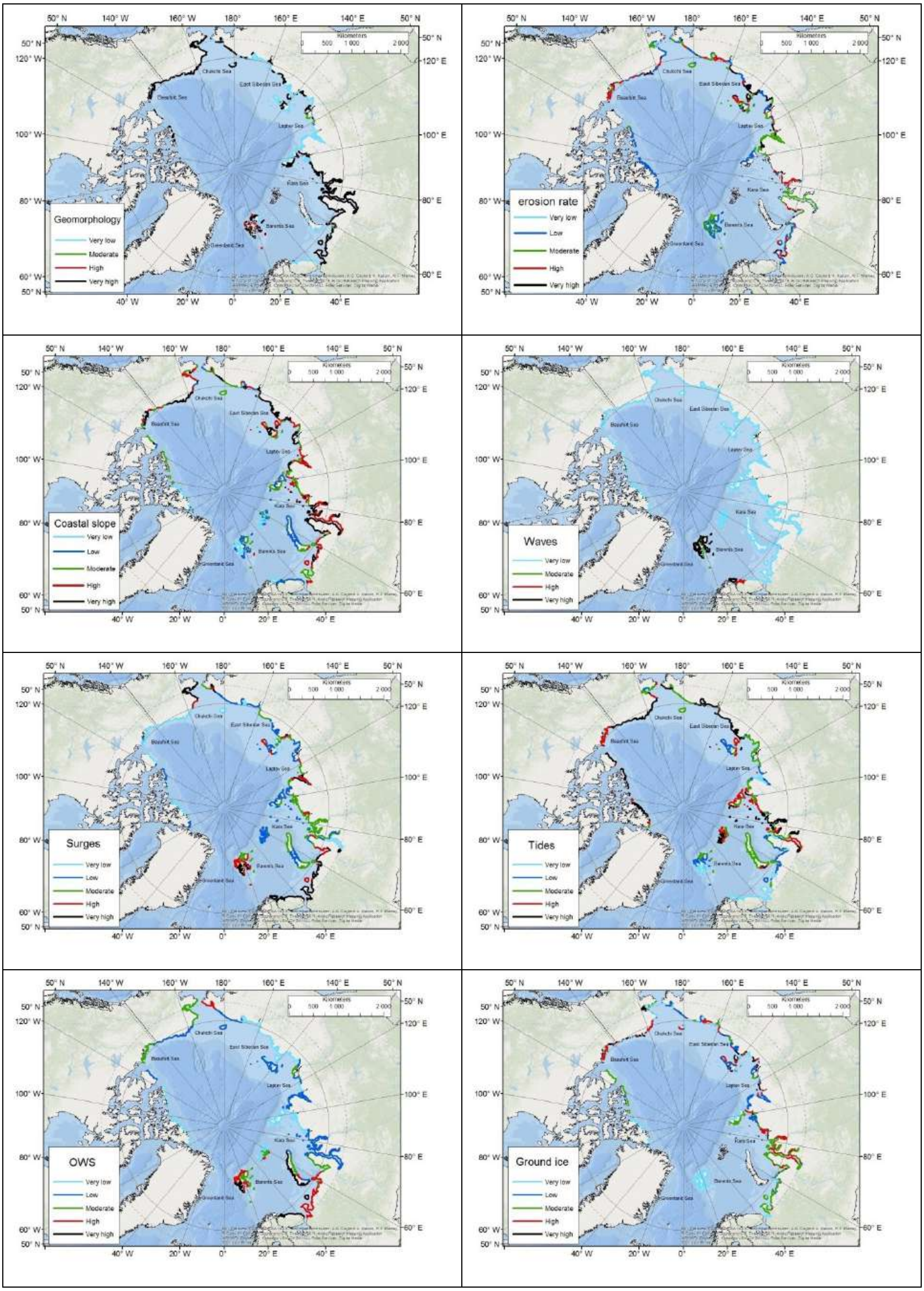

***Figure 7.** PCRI component variables along the Arctic coastline.*

The values of the PCRI components along the Arctic coastline are presented in Fig. 9. The maps provide information on risk corresponding to geomorphology, erosion rate, coastal slope, wave climate, surges, tide ranges, the period of open water season, and ground ice content. With regard to geomorphology the lowest risk was assigned to 24.5% of the total length and it covers parts of the Barents Sea, the Laptev Sea, the East Siberian Sea, the Chukchi Sea and Svalbard, whereas 48.4% was assigned to the highest risk and it covers most of the Kara Sea, the Chukchi Sea, the US Chukchi Sea, the Barents Sea and most of Svalbard. The erosion rate describes accretion or erosion in meters per year. Although this variable is of significant importance, only 70% of segments include data on erosion rate. The highest erosion occurs in the Laptev Sea, the East Siberian Sea, the US Beaufort Sea, and in the northern part of Alaska. The coastal slope ranges between 0.006º and 4.77º. The highest coastal slopes occur mainly in the Yamal Peninsula, and along the coast of the East Siberian Sea and the US Beaufort Sea. In turn, the coasts of the Greenland Sea, the Barents Sea and the Severnaya Zemlya Archipelago are characterised by the lowest coastal slopes. As far as the wave climate is concerned, the highest risk corresponding to waves greater than 6.5 m occurs in Svalbard and near the coast of the Barents Sea. Other coasts are assigned lower risk. The surge height corresponding to 1 in 100-year extreme sea level implies the highest risk in the Barents Sea, the western coast of Svalbard and in the US Chukchi Sea. Next variable taken into considerations is the mean tidal range. As it was indicated by Thieler et al. (1999), the macrotides have less influence on inundation than microtides. This concept was used herein. The highest risk has been determined for the coastline of the East Siberian Sea, the US Chukchi Sea, and the Greenland Sea. The lowest risk has been assigned to the Barents Sea, Svalbard, and the Laptev Sea. Based on everyday satellite images of the ice edge in the Arctic available from OSISAF application of EUMETSAT, the percentage of OWS was calculated. For OWS lower than 10% of the total time, the risk value is assumed as equal to 1 and for OWS greater than 50% the risk is equal 5, which means that the ice cover for half of the total time does not sufficiently protect the coastline against wave action. The intermediate OWS values are given in Table 1. Taking into account data from the period 2012-2016, the maximum risk was assigned to the Kola Peninsula, the Novaya Zemlya, and the western coast of Svalbard covering 35% of total Svalbard coastline. The minimum was assigned to the East Siberian Sea where the ice cover was detected for the whole considered period. The maximum risk related to ground ice content may be observed in the coast of Alaska and in several places of Russian coast mainly in the Taymyr Peninsula, the Bykovsky Peninsula, and in the Eastern Oyagoss Cape of the East Siberian Sea. The lowest ground ice content risk is assigned to the coasts of Svalbard, the coasts of the Greenland Sea, the Laptev Sea, and the Chukchi Sea.

4. Conclusions

Climate changes significantly affects the coastlines in Arctic regions. Global warming and an increased impact of storms imply a rapid permafrost degradation and, in consequence, a drastic shoreline retreat in an Arctic coastal zone. A novel approach to assess the vulnerability to erosion for Arctic coastline is proposed. An original concept of a Polar Coastal Risk Index is introduced to facilitate description of wave-induced erosion of polar coastal regions. The PCRI is calculated by applying data from the DIVA and ACD databases. Due to a lack of available data, two PCRI indexes including a different number of component variables are defined. The calculated indexes are applied to the whole Arctic coastline and their ability to reflect a distribution of risk is discussed. The derived concept seems to be better method of determining the vulnerability to erosion for polar coastal regions than previous approaches. The proposed PCRI provides a simple numerical tool for ranking sections of Arctic coastline in terms of their potential for erosion that can be used by managers and policymakers to identify regions where risks may be relatively high.

5. Acknowledgements

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The Nature Sports Chart of Arrábida: promoting sustainable visitation of a sensitive area

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Abstract

The coastal mountain range of Arrábida is a limestone massif with a Mediterranean microclimate exposed to the open Atlantic, located 30 km south of Lisbon. It was one of the natural warmer sanctuaries during the Ice Ages and has been used by Humankind since Palaeolithic times. This setting created a unique and diverse mosaic of natural and cultural landscapes, biodiversity and geodiversity, a place of outstanding beauty. This combination of factors led to the creation of the Nature Park of Arrábida covering 170 km^2, including 50 km^2 of a Marine Park). The are is subject to great pressure for tourism and recreation, because Arrábida is one of the few near-natural territories inside the Metropolitan Area of Lisbon. This paper reports on the development of the Nature Sports Chart of Arrábida. The goal of the project was to regulate visiting in the more sensitive areas of the Park, especially by outdoors enthusiasts: trekking, trail running, mountain biking, horse riding, rock climbing, caving, coasteering, bird- and dolphin-watching, snorkelling, scuba diving, kayaking, sailing, hang gliding and paragliding. The underlying philosophy is that a near-natural area subject to many pressures is best protected by people who love and live in it; hence, we must create conditions for low-impact visitation and the education of visitors, with some benefit for local inhabitants. Our methodology comprehended: literature review of best practice of outdoor sports in sensitive areas; identification and quantification of outdoor activities in Arrábida; identification of stakeholders (municipalities, nature sports clubs, federations who organize competitions, active tourism business, landowners, local inhabitants, official agencies like the maritime authority and the regional tourism office); personal meetings with key stakeholders; systematic review of actual and potential conflicts, both between users and with nature conservation restrictions; construction of an online platform and georeferenced data base; definition of preferred sites for outdoor activities based on best practice, careful management of conflicts and available public access. The most difficult task was the definition of trekking routes, because 90% of Arrábida is privately owned. Our strategy, put to practice with the willing cooperation of many stakeholders, was successful: we were able to generate a notable consensus, and the Nature Sports Chart is now ready for implementation, pending legal procedures. The Chart is one tool among a complex set of tools that includes land use planning, financing sources, fiscalization, and Nature conservation policy.

Keywords: Arrábida Natural Park, outdoor recreation and sports, protected areas, land use management and planning, Nature conservation

1. Introduction

Arrábida is a coastal mountain range, facing the open Atlantic, located on the southwest of the peninsula of Setúbal, 30 km south of Lisbon, Portugal. Remarkable geological features, unique floristic diversity and historical and cultural heritage all converge to create in Arrábida a unique landscape of exceptional value and beauty.

The outstanding characteristics of the area led to the creation of the Arrábida Natural Park in July 1976. This classification envisioned the protection of the geological, ecological and landscape values, but also cultural and historical values in the area. In 1998 the Park boundaries were expanded to encompass 170 km^2, including the newly created Luiz Saldanha Marine Park with an area of 50 km^2. The Park is located in three municipalities: Setúbal, Palmela and Sesimbra.

Due to its inclusion in the most densely populated area in Portugal, the Metropolitan Area of Lisbon, Arrábida has always been a very popular tourism destination, all year round but particularly during summer. In the last decade, there has been an increase in the number and type of visitors, as a more urban population seek outdoor recreation and contact with natural areas. Visitor pressure has increased in Arrábida, especially by outdoor sports enthusiasts.

Nature-based sports and recreational activities are a legitimate and desirable use of natural protected areas. However, as such activities may have significant negative environmental impacts, managing outdoors recreation has proved a constant challenge. Damage and loss of natural values, ecological degradation and conflicts between different users are some of the common problems associated with poor planning and management of recreational activities in parks. All these problems have been identified in Arrábida Natural Park. The need to promote sustainable use and visitation prompted the development of the Nature Sports Chart of Arrábida. This project began in 2015, commissioned by the Portuguese nature conservation authority, Instituto de Conservação da Natureza e Florestas (ICNF), to the Center for Environmental and Sustainability Research (CENSE) at the New University of Lisbon.

2. Methods

The underlying philosophy of our approach is that a near-natural area subject to many pressures like Arrábida is best protected by people who love and live in it; every planning process should be based on dialogue and social learning between all stakeholders. The success of the project depends upon creating conditions for low-impact visitation and promoting the education of visitors, while adding some benefit for local inhabitants. The best way to achieve this is through collaborative action and consensus building — an approach supported by both our long field experience and the international literature.

Our methodology comprehended:

- A literature review focusing on best practice in outdoor sports and recreational activities in sensitive areas; environmental impacts of outdoor sports; visitor use impact management and planning in protected areas.
- Exhaustive identification of stakeholders: national and local authorities, nature sports clubs and organizations, sports federations, outdoor tourism operators, other tourism and economic agents, landowners, local communities, Park visitors including formal and informal organized groups;
- Diagnosis of the current situation of outdoor recreation in Arrábida: state of natural and cultural heritage; identification of sensitive or critical areas for conservation; identification and quantification of outdoor sports and activities in Arrábida; identification and mapping of practice sites and trails; trends and patterns of practice; identification of existing conflicts, between different users, with Park regulations, conservation efforts, and protection of sensitive areas;
- Views and expectations of the various stakeholders towards Arrábida Park visitor use, impacts of visitation and management practices.

There was an extensive work of analysis of satellite imagery and online research and data collection from news, thematic forums, social networks, and GPS track sharing websites. The project team developed a website to disseminate the project to the general population. It contained an upload area where users could share relevant georeferenced information (e.g. gpx/kml tracks, pictures); the platform was based on a Google Maps API where users could draw locations (markers), trails (polyline) or areas (polygons), identifying preferential outdoor practice sites or areas of concern, qualify areas and patterns of use, justify their choice of area and present their suggestions and concerns.

A large amount of time and effort was dedicated to direct involvement of stakeholders: through large public meetings with local population and landowners, organized groups of Arrábida visitors, sports clubs, associations and federations, and tourism operators; or through personal meetings with key stakeholders (land management and maritime agencies, landowners with property trespassing problems, sports federations to discuss specific strategies for each activity).

3. Results and discussion

After a systematic review of actual and potential conflicts, both between users and with nature conservation restrictions, the project team was able to define preferred sites for outdoor activities based on best practice, careful management of conflicts and available public access. Defined outdoor sports practice areas shall be both published in various media (Internet, mobile apps, paper), and clearly marked on the field. Less sensitive areas will deliberately be subject to more intensive use, to avoid excessive pressure on more sensitive areas.

The most difficult task was the definition of trekking routes, because 90% of the land of Arrábida is privately owned. Most of the hiking trails defined are circular, with start and finish points located next to public transports or parking/rest areas. All crossings of private property were authorized by the landowners. The pedestrian network, shown in Figure 1, includes 19 main short trails, divided by municipality, and a long distance trail (with two variants) that connects the three municipal seats and is linked to the Portuguese network of long distance treks.

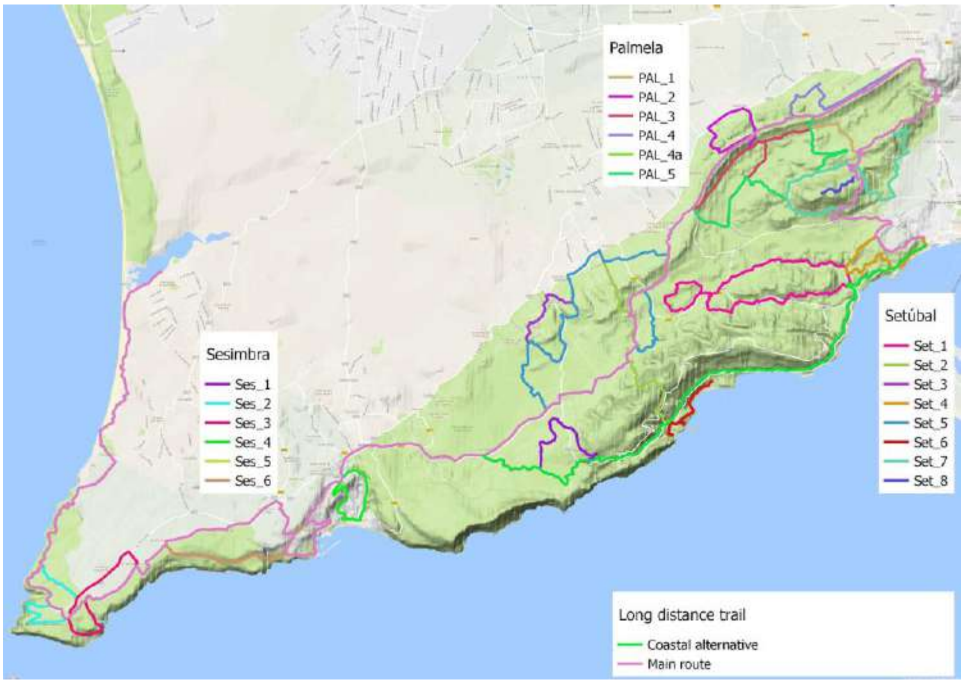

Figure 1. *Network of hiking trails in Arrábida.*

For the cycling routes (Figure 2), the strategy was to define a long distance circular route and several connecting routes, in fact creating a network that cyclists can use at will. Different portions of the network bring different challenges, be it in terrain type (from asphalt to loose sand), slope variation or path layout. This approach creates a network that is appropriate for cyclotourism but also appealing for more extreme cycling disciplines. It introduces variety for those training frequently in Arrábida, in order to prevent the opening of new routes in sensitive areas.

The maritime activities are subject both to the Portuguese maritime regulations and to the protection status of the Luiz Saldanha Marine Park. Figure 3 shows the allowed areas for sea activities in Arrábida. Any non-motorized activity that considers the crossing from Setúbal to Sesimbra (or vice-versa) is subject to information to the maritime authorities and must be accompanied by a motorized vessel.

The best areas for hang gliding and paragliding in Arrábida are located in the coastline, due to prevailing winds from the northwest. Flying is forbidden during the official beach season, as the landing sites coincide with beach use.

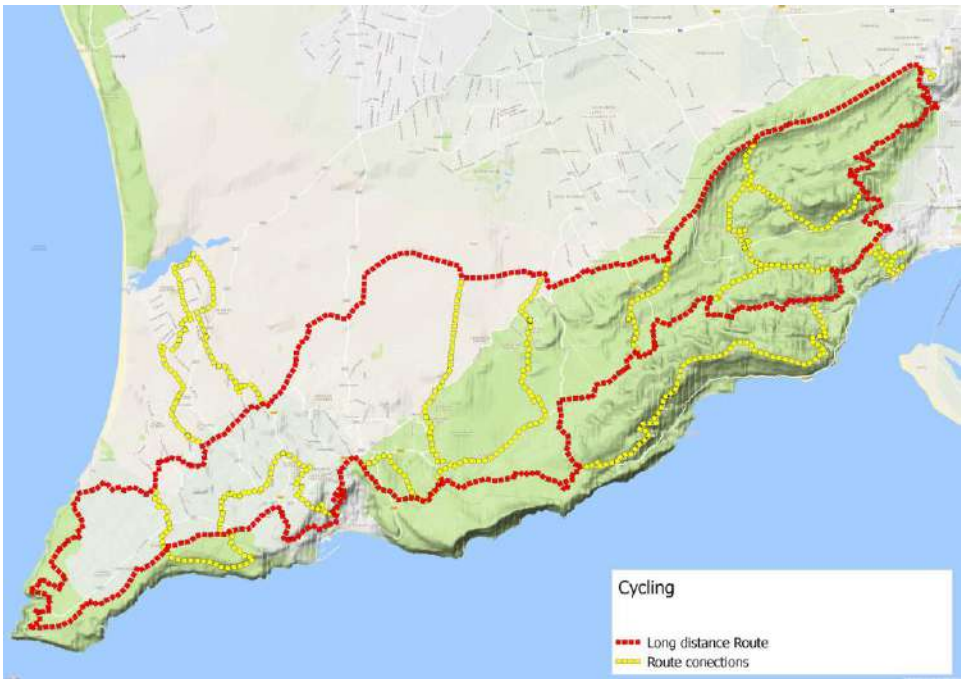

Figure 2. *Cycling routes in Arrábida.*

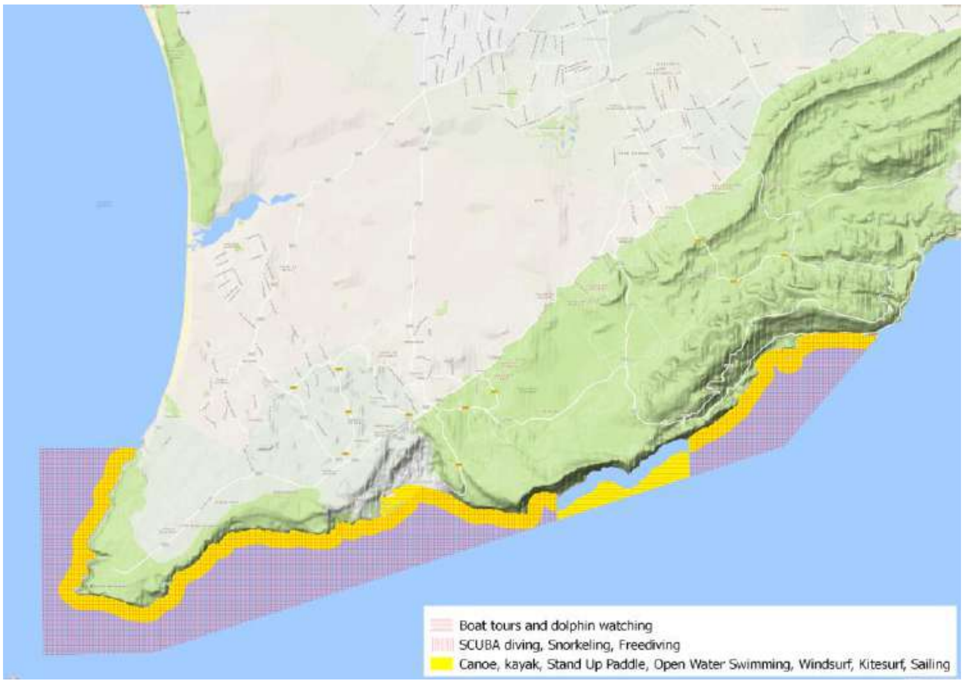

Figure 3. *Marine sports activities in Arrábida.*

The restricted areas for coasteering derive both from maritime protection areas from Luiz Saldanha Park, and from terrestrial protection areas from the Natural Park Plan, as this activity occurs in the interface land water.

One of the problems regarding climbing in Arrábida was the proliferation of different access trails to the climbing areas (some of them created by fishermen), therefore the chart presents the only allowed accesses to the climbing spots.

Spelunking is authorized only in designated caves under supervision of experienced speleologists.

Figure 4 shows the practice areas defined for hang gliding and paragliding, climbing and coasteering.

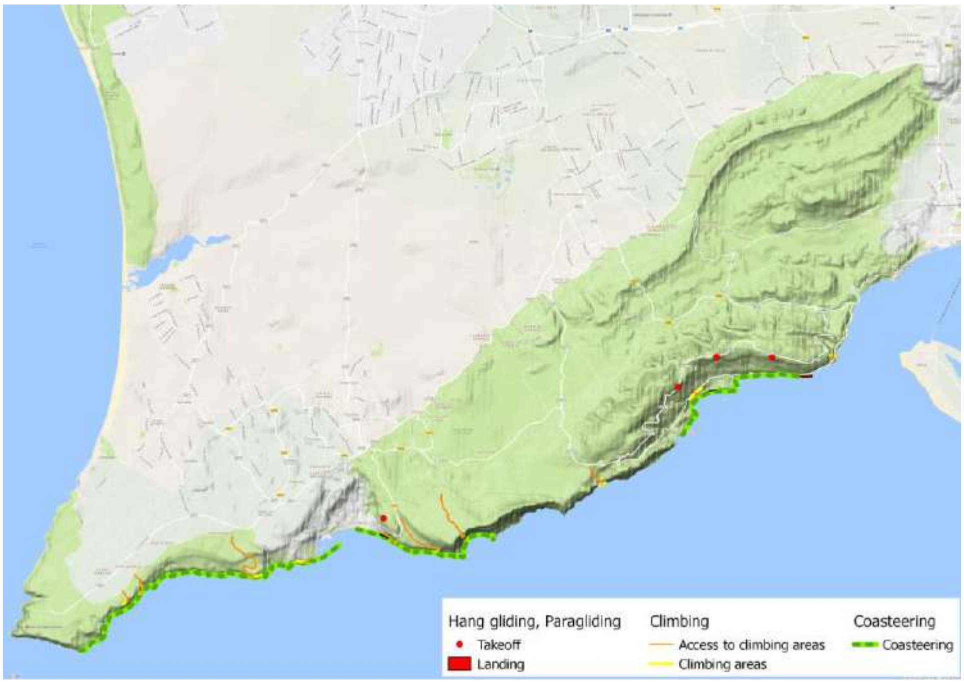

Figure 4. *Areas for hang gliding and paragliding, climbing and coasteering in Arrábida.*

4. Conclusion

Outdoor recreation activities have grown in importance and popularity in our society. The Natural Park of Arrábida is a very sought-after destination among nature sports fans, with perfect practice conditions for a wide variety of outdoor activities.

The Nature Sports Chart of Arrábida is as a tool to promote sustainable visitor use and regulate outdoor activities in Arrábida, preserving natural, cultural and historical values. Collaboration between stakeholders is imperative when developing any park management plan. The work on the Nature Sports Chart also intended to promote a collaborative model between park managers, local communities and park visitors. Our strategy, put to practice with the willing cooperation of many stakeholders, was quite successful: we were able to generate a notable consensus, and the Nature Sports Chart is now ready for implementation, pending legal procedures.

It should be noted the Chart is only one tool among a complex set of tools that includes land use planning, financing sources, fiscalization, and Nature conservation policy.

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Multi-criteria methods for prioritizing wetland restoration and creation sites based on ecological, biophysical and socio-economic factors

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Abstract

Wetland restoration is now recognized as a useful tool for improving water quality. Many studies focused on getting proper strategies and models to optimize the wetlands performance. However, some important aspects to consider for placing a wetland have not been taken into account. Due to the importance of integrating environmental, biophysical and socio-economic factors in wetlands restoration projects, a comparison of two multi-criteria methods (a suitability model and a greedy algorithm) was conducted. With the main goal of removing nitrates, the suitability model was applied considering the "terrain slope", the "proximity to watercourses" and the "soil permeability" while the greedy algorithm was performed by means of the "availability of public lands" and the "project costs of wetland restoration". These factors were chosen based on a similar previous experience in Eu Life-CREAMAgua Flumen River project and in order to obtain a more effective and comprehensive priority selection of places by contrasting both methods. Both the suitability model and the greedy algorithm provided critical information for siting a wetland and demonstrated the compatibility of both approaches. Suitability model described the priority sub-basins for wetlands restoration under biophysical criteria and greedy algorithm reported the availability of public lands or works to be performed in each instance. This research and its possible adaptations could be used by decision makers for the integration of ecosystem restoration in sustainable land use planning, particularly in territories under extensive and intensive agricultural uses. It can be also applied for land-use offsetting planning in other type of territories after selecting specific criteria.

Keywords: wetlands, nitrate removal, environmental planning, watershed management, multi-criteria

1. Introduction

The role played by natural mosaics of ecosystems regulating pollutants is lost in extensively transformed territories for irrigated agriculture (Mitsch and Jorgensen, 2003). Nitrogen, phosphorus, suspended solids and many other pollutants are discharged from irrigated agriculture all around the world polluting terrestrial and aquatic ecosystems (Carpenter et al., 1998; Sutton et al., 2011). To get back a sustainable productive system the restoration of natural ecosystems integrated as a mosaic in the landscape is required (Comin et al., 2014).

Reduction of nitrogen concentrations in freshwater bodies will improve their quality but requires interventions during all stages of nitrogen flow through the landscape including improved land use to reduce general nutrient losses (Schimming et al., 2001), the restoration of buffer zones in groundwater discharge areas (Haycock et al., 1993; Hoffmann et al., 2000), and the restoration of surface flow wetlands located in the river network (Leonardson et al., 1994). It is, a sustainable use of natural ecosystems to buffer impacts from pollutants in territories intensive and extensively used for agrarian production,

The use of wetlands for water quality management is widely accepted. A growing number of policy makers are faced with the problem of identifying a suitable location for the creation or restoration of a wetland system (Palmieri and Trepel, 2002). Wetlands restoration and wetlands construction are effective measures to combat eutrophication of aquatic ecosystems (Trepel and Palmieri, 2002). However ecosystem offset practices to compensate for impacts and destruction of wetlands require tested standards. Many wetland management and restoration projects fail because of poor planning and design (Mitsch and Wilson 1996), improper location of the mitigation site relative to other landscape features (Van Lonkhuyzen et al., 2004); also many projects fail to incorporate the preferences of local people (Comín et al., 2005, 2014).

Many researchers used GIS-tools for landscape and environmental planning both at regional (Baban and Wan-Yusof 2003) and at catchment scales (Wang et al., 2004; Saroinsong et al., 2007; Jasrotia et al., 2009). However, watersheds and land uses are very different between regions and societies, hindering the development of protocols that can be adapted to different areas of study. The analysis of ecological, biophysical and socioeconomic factors is essential to plan and perform this type of projects.

Here we show two different approaches that can be used to identify suitable sites for wetland placement in a watershed to remove nitrates from water exceeding agricultural irrigation: a suitability model weighting different biophysical factors and a greedy algorithm that combines socioeconomic criteria with nitrate removal capacity. These are based on previous experience after the EU Life Project CREAMAgua (http://www.creamagua.com) performed to restore wetlands in the study area. The objective of this study is to compare how these two methodologies provide a hierarchical allocation of sites suitable to integrate wetland restoration inland use at a watershed scale.

2. Methods

The methodologies developed in this study are mainly composed of two steps: sizing the appropriate area for nitrate removal and siting surface flow wetlands. We applied this approach to the semi-arid Flumen River basin (1,431 km^2) (Huesca,Aragón, Spain) in the north-central part of the Ebro River catchment (80,093 km^2, NE Spain). Here, this approach is applied only to the agricultural part of the basin, as the major influence of the irrigation return flows on the river water quality has been clearly demonstrated (Darwiche-Criado et al., 2015).

SWAT (Soil and Water Assessment Tool) was used to classify the agricultural area of Flumen River basin into 38 sub-basins and 15 inter-river areas according to the hydrographic network obtained from the digital elevation model (DEM) with a 20 m grid resolution (offered by CHE-Confederación Hidrográfica del Ebro). Nitrate concentration was selected for wetland siting and sizing because it has been recognized as the most relevant pollutant for water quality degradation in the study area (Martin-Queller et al., 2010, Comín et al. 2014). SWAT modeling estimates the water flows and nitrate concentrations and therefore, the outflowing nitrate load in each sub-watershed (Fig. 1) based on nitrate concentrations and hydrological data recorded at long-term (Darwiche-Criado et al., 2015).

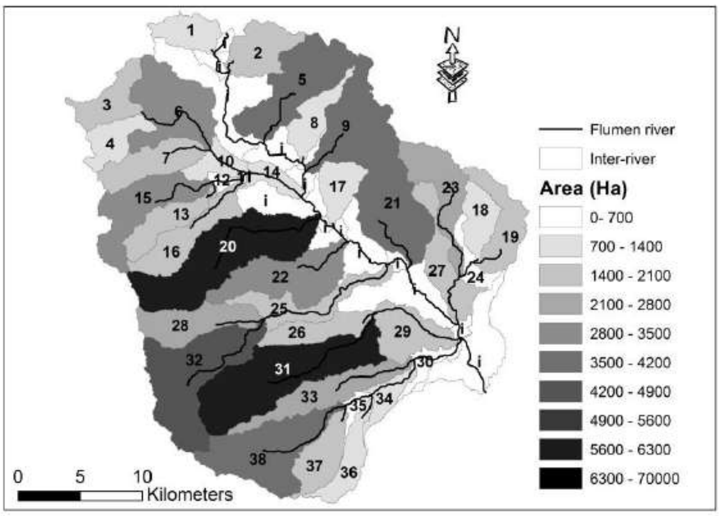

***Figure 1**. Sub-basins of the agricultural area of the Flumen river watershed.*

The first-order areal removal model developed by Kadlec and Knight (1996) was used to estimate the required area of surface-flow wetlands:

$$A = (0.0365*(Q/k)) \times (\ln (C_i\text{-}C^*/C_o\text{-}C^*) ,$$

where A is the wetland area (ha), C_i is the inlet concentration (mg/L), ,C_o is the target outlet concentration, here defined as 5 mg/L, C^* is the base-flow nitrate concentration in a surface-flow wetland, here set at 2 mg/L, Q is the water flow rate (m^3/d), ,and k is the experimental first-order area rate constant (35 m/yr, from Kadlec and Knight (1996). Detailed dimensioning parameters were described in Comín et al. (2014).

Two methods were used in order to select sites to restore wetlands: The suitability model was applied using ecological and biophysical criteria while for the greedy algorithm, economic and social factors were taking into account. The outflowing nitrate load in each sub-basin was considered for both methods.

Four data layers were used for applying the suitability model. A GIS based score system (ArcMap 10.2.1, ESRI Inc.) was developed to identify the best potential locations for surface wetlands creation and restoration. Score values varied from -3 to +3 which represented the lowest and highest suitability respectively. Values were based on professional judgement from previous wetlands restoration experience in the study zone. Negative values designated unsuitability and positive ones represented suitable sites. The items in each data layer and their specific score values are showed in Table 1. Data layers were as follows. Outflowing nitrate load was scored so that the wetlands creation was prioritized in the most polluted sub-basins. Thus, the highest loads were scored with +3 and the lower with -3. The slope was calculated from a 20 m grid resolution DEM. Slope is a restrictive factor in wetland construction and restoration because steep slopes are naturally unsuitable for this purpose. The lower terrain slopes received the highest score. The distance to water streams was calculated from the digital river network. Restoring in-stream wetlands is feasible as water flows naturally through draining areas to streams while the cost of wetlands restoration increases if the wetland is allocated far from a stream as channels to transport and dikes to contain the water are required. Very suitable areas were considered those within 500 m from a frequently flowing stream. Soil permeability Due to the semiarid conditions of the study area, soil permeability is a limiting factor in wetland construction and restoration. This data layer was created from existing regional maps coming from Aragon Government at scale 1:300000. The score values were based on the infiltration capacity of soils. Both high soil permeability zones and impermeable soil areas received low scores because these features make it impossible to build a wetland without expensive interventions.

The suitability model used was:

Suitability = (1.5*outflowing nitrate load + 1.3*slope + 1.1* distance to water streams + soil permeability) / *Max* (1.5*outflowing nitrate loads + 1.3*slope + 1.1* distance to water streams+ soil permeability).

The highest weight (1.5) was assigned to “outflowing nitrate load”, a high weight (1.3) was also assigned to “slope” and a weight of 1.1 was given to “Distance to water streams”. “Soil permeability” was scored with a weight of 1. Then the values obtained were normalized between -1 and +1 by dividing them by the maximum value of the sum of the real values of all data layers. Thus, low, negative, values indicated less suitable areas and high, positive, values indicated suitable areas to restore a wetland.

The greedy algorithm used considers the outflowing nitrate load, social (availability of public lands) and economic factors (costs of wetland restoration works).. The ownership of the sites identified as appropriate for wetland restoration or creation in each sub-watershed was determined using public land records kept by the regional and local governments. In order to reduce project costs, only public plots which can be offered free for wetland restoration were considered. The costs of construction works in each sub-basin were calculated based on those of the Eu Life-CREAMAgua Flumen River project. In this case, wetlands in sub-basins whose construction costs were lower were prioritized establishing a descending order.This algorithm consisted of several successive steps integrating the hierarchical order of data layers. (Fig. 1).

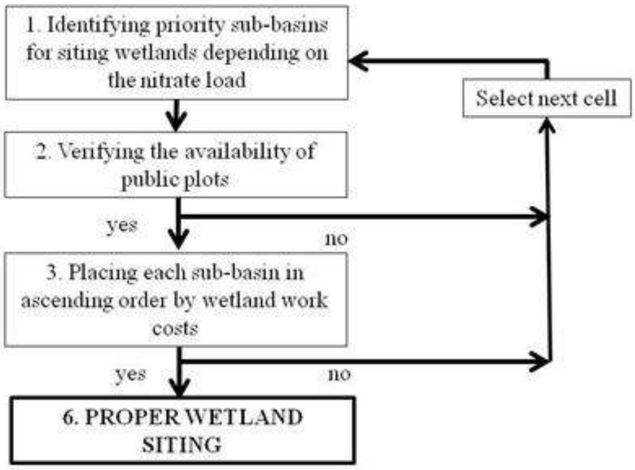

Figure 2*. Greedy algorithm to prioritize sites for wetlands restoration and creation***.**

3. Results

The estimation of needed area to reduce the nitrate concentration to 5 mg/L reported that sub-basins 3, 18, 28, 36 and 37 would require a wetland area less than 1.04 ha to achieve this goal. Sub-basins 1, 4, 8, 13, 17, 26 and 32 would require a wetland area between 1.04 and 1.45 ha. Sub-basins 16, 19, 23, 33 and 38 would need a wetland area between 1.45 and 1.86 ha. Sub-basins 2, 7, 15 and 22 would require between 1.86 and 2.48 ha. In sub-basins 5, 9, 12, 20, 21, 24 and 35, wetlands should have an area ranging 2.48 to 3.48 ha. Sub-basins 6, 11, 25, 29 and 34 would require a wetland area between 3.48 and 6.04 ha and sub-basins 10, 27 and 30 between 6.04 and 9.13 ha. Lastly, sub-basin 14 would require a wetland area of 15.88 ha in order to decrease the nitrate concentration to 5 mg/L.

The suitability model resulted in values between -0.7 and 0.7. Higher values indicated the priority sub-basins for wetlands location while the lowest values showed less priority sub-basins for this purpose. Sub-basin 14 showed the highest priority for wetland location but sub-basins 10, 11, 12 and 29 were found in the same range of values that indicated a higher priority (0.6 to 0.8). Sub-basins 11, 12, 29 and 30 also showed good suitability (0.4 to 0.7). Sub-basins 1, 27, 30, 34 and 35 were ranged between 0.2 and 0.4, and sub-basins 2, 6 and 25 showed a moderate priority (0 to 0.2). The rest of sub-basins were not suitable for siting a wetland.

The greedy algorithm indicated those criteria satisfied by each sub-basin. Thereby, those sub-basins fulfilling the 3 criteria were considered priority sites for wetland location. Sub-basins 6, 10, 11, 12, 14, 25, 27, 29, 30 and 34 met the 3 criteria and thus, showed the highest priority. Sub-basins 2, 5, 7, 15, 9, 16, 20, 21, 22, and 35 met 2 conditions and the remaining sub-basins only fulfilled the first criterion.

Both methods assign first priority to sub-basins 14, 10, 11, 29, and quite similar order of priority is obtained for the rest of sub-basins (Table 1).

Table 1. *Priority order of sub-basins for Greedy algorithm and Suitability Model.*

Priority order	Sub-basins in Greedy Algorithm	Sub-basins in Suitability Model
1	***14***	***14***
2	***10***	***10***
3	***11***	***11***
4	***29***	***29***
5	30	12
6	6	30
7	34	35
8	25	34
9	31	1
10	12	27
11	27	25
12	35	6
13	22	2
14	16	22
15	20	8
16	5	17
17	2	5
18	9	21
19	21	26
20	15	31
21	7	7
22	1	24
23	38	23
24	13	15
25	24	16
26	3	13
27	37	9
28	33	19
29	17	38
30	4	33
31	32	20
32	8	3
33	26	36
34	36	37
35	28	32
36	23	4
37	19	18
38	18	28

4. Discussion

In the last decades a variety of applications of multicriteria evaluation and spatial analysis have been conducted for proper selection of sites. Several researches applied suitability models (White and Fennessy, 2005; Moreno-Mateos et al., 2010) or greedy algorithms (Newbold, 2005; Comín et al., 2014) in order to find the most optimal place to locate wetlands and, therefore, to improve its efficiency for water quality improvement.

The objectives in each work considerably influence the choice of factors involved in development of each approach. In case of suitability model, using GIS makes decision-making a majorobjective, but there is some subjectivity associated to scoring values of data layers (Baban and Wan-Yusof, 2003Greedy algorithms do not offer an optimal solution for a defined problem (Underhill, 1994) because when a site is selected, it cannot be unselected.

Both models were useful tools for planning wetlands location, but availability of required information can be a limiting factor. Layers resolution was good enough for this study, but smaller areas would need more precise layers (Moreno-Mateos et al., 2010). In this regard, efficiency of modeling tools as SWAT also depends on data availability and quality. Delineating smaller sub-basins would result in the identification of many sites with no relevant water or nitrate discharges and would yield a multitude of potential wetlands without a significant impact on the project objective. On the other hand, larger sub-watersheds discharging greater amounts of nitrates would require very large areas that might not meet the hydrogeomorphic or the social-availability criteria (Comín et al., 2014).

Both approaches indicated that sub-basins 10, 11, 12 and 29 were the highest priority for siting a wetland. After the suitability model, they were the only sub-basins that reached the greatest range of adequacy but the greedy algorithm also reported sub-basins 6, 25, 27, 31, 30 and 34 met the 3 criteria. Sub-basins 6, 25, 27, 30 and 34 also achieved positive values with the suitability model. However, differences were observed in the results from both approaches. The suitability model showed sub-basins 1 and 35 with high priority for wetlands location. According to the algorithm results, sub-basin 35 met the first 2 criteria, which means that requirements in terms of project costs were not adequate in these sub-basins. Sub-basin 1 fulfilled only the first criterion, so in addition to the project costs, the availability of public lands also failed. Here, the social criterion comes to be fundamental in terms of availability of public lands. Integration of social criteria, which is an essential aspect of sustainable development, is essential in restoration projects (Comín et al., 2005; Petursdottir et al., 2012) and is not commonly implemented in such actions. For example, Newbold (2005) suggested a similar algorithm including economic aspect but not social. He also reported that in restoration projects, the cost per hectare may triple if land purchase is needed. Although sub-basin 1 had the required nitrate load for siting a wetland, the project budget should be higher for land purchasing. From our experience after the Eu Life project CREAMAgua we know that for sub-basin 1, the initial budget for restoration works (20,078.5 €) should be increased to purchase private lands. In addition, non-inclusion of economic criteria in suitability model caused that both sub-basins were defined as “suitable” in spite of the fact that their actual restoration costs were much over the average because it will be necessary to buy the land for it.

On the other hand, greedy algorithm showed that sub-basins 3, 25 and 31 met the socio-economical criteria. However, suitability model scored these sub-basins with low values or a negative score in case of sub-basin 31. In this respect, omitting the biophysical factors could also affect to the project budget. Trepel and Palmieri (2002) took into account the importance of soil substrate for wetlands placement through scores depending on soil infiltration capacity and considered that suitability for surface flow wetlands restoration decreased with the distance from the nearest river. Likewise, Moreno-Mateos et al. (2010) reported an increase of construction costs by including long canals or installation of layers in high soil permeability areas, in addition to make wetlands less natural. These authors also stated that the distance from frequently flowing streams strongly influenced on the total budget of wetland creation project. Steep slopes also imply greater earthmoving and therefore, an increase of construction costs. Hence, the economic aspect becomes crucial because projects intended to restore multiple wetlands within a watershed in which sites and actions are not defined at the outset, must base its budget on previous restoration-cost experience (Comín et al., 2014).

Both the suitability model and the greedy algorithm provided critical information for siting wetlands at watershed scale to improve the quality of the water (remove nitrate in this study) discharged to rivers. The suitability model showed a priority ranking of each sub-basin in terms of biophysical conditions while greedy algorithm reported the socioeconomic criteria met in each case. In this regard, our results indicated that consideration of both perspectives is also compatible since there was a high coincidence between both methods. Both models can be adapted to conditions and objectives of other areas but an overall knowledge of the study zone is necessary for proper use (Zedler, 2003). The use of either ranking must be linked to the conditions and ability of each project. The combined use of both methods will give an additional value. The suitability model will display the priority order of areas for planning wetlands restoration in the watershed while the greedy algorithm will report the practical information about priority sites for wetland restoration required (land availability, costs or restoration) to implement a restoration project at watershed scale.

The approach presented here has a high potential for wetland offsetting in territories with intensive and extensive agricultural uses. The methods presented join the combination of social, economic and environmental aspects require for land-use planning of this type of zones.

5. Conclusions

Combining suitability and greedy algorithm methods is a good approach to prioritize sites for wetland restoration in territories with extensive and intensive agricultural uses as they combine the efficient role of wetlands to remove pollutants with the social and economic aspects required for sustainable land-use planning. This approach can be applied for land-use offsetting plans in other types of territories; specific criteria should be incorporated for each one of these types of territories.

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The application of earth observation information for land use change in Brazil: an analysis of user needs

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Abstract

Brazil is a country with some of the most important forest ecosystems and natural resources in the world. The expansion of agriculture, livestock, demand for food production, extractive industries, illegal logging, land conflicts, hydropower projects, deforestation and fire are some of the main pressures associated with land use and land use change in different regions of Brazil. Despite the attempts of different institutions aiming to promote the use of earth observation to support land use management and conservation projects in Brazil, established institutions at the national and state level are encountering several problems to implement environmental policies and to improve the quality of services provided for the Brazilian society. The specific agenda and lack of communication between institutions, finance, bureaucracy, legal frameworks, politics, finance and the user knowledge to access and apply all the geospatial technologies and remote sensing data available are some of the issues across a wide range of public and private organizations. Expanding on recent debates in environmental governance and political issues associated with deforestation levels, we show the challenges to promote the use of earth observation and how institutions are dealing with political and economic instabilities to apply environmental policies. The conflict of interests, historic political agendas, pressure groups within national and state governments and the lack of coordination and the conflict of national policies on specific agendas to promote the expansion of agribusiness and environmental policies at the same time. The use of earth observation and advanced technologies is very important to assist policy-making, but is just one essential factor to help governments to promote sustainable development and to reduce the complexity of institutions arrangements and particular agendas in different sectors.

Keywords: Earth Observation, indicators, land use, environmental policy, sustainable development.

1.Introduction

Earth Observation (EO) is an exciting technology of the 21st century as costs of building and launching satellites fall along with improvements in terms of resolution, frequency of coverage, ability to penetrate cloud cover and automating interpretation. Some EO data are currently available free to users, from agencies such as the United States Geological Survey (USGS) European Space Agency (ESA) and the Brazilian National Research Institute (INPE). EO data can potentially be used, and indeed are sued to some extent, in wide range of applications, including monitoring natural resources, weather forecasting, agriculture, urban growth, land management, transport and education (INPE, 2016). In Brazil, a country with a population of approximately 206 million (IBGE, 2016) and having significant challenges with regard to managing its natural resources sustainably, Spatial Data Infrastructures (SDIs) and the diffusion of EO information to users is very important to support decision making (Câmara et al., 2006). For example, Câmara et al. (2006) stated that the availability of free EO data for the public and the free software SPRING (developed by INPE) that integrates Geographical Information Systems (GIS) and EO image processing is essential for the development of emerging nations such as Brazil.

However, there are some key questions surrounding the extent of current use of EO data, what it is used for (and by whom) and what could be done to facilitate better use. For example, Câmara et al. (2006) describes an SDI-user as someone who is able to combine spatial data from different sources and produce new information for a particular context (Câmara et al., 2006). But users are not homogeneous and are likely to span a wide range of groups, from the general public at one end of the spectrum (or some of them at least), to policy makes and managers at the other end. In between these users and the raw EO data (e.g. images) there will be experts responsible for using software such as SPRING to help translate the data into information that can be used. Indeed it is likely that different users within the public (farmers, researchers, environmental consultants, politicians, civil servants etc.) will have different needs. But little, if anything, is known about the uses of EO-based information, including what the uses are, the extent to which this is happening, who are the users and what can facilitate or hinder use. The few publications that do exist attempt to provide an analysis of the needs of users of EO and at the same time highlight the factors that facilitate or hinder the uses of EO data. It is possible that factors such as institutional dynamics, a lack of communication, limited financial resources, availability of trained personnel, necessary equipment, bureaucracy, or even the absence of the right type of EO information to suit the user's needs are all factors that could limit the uptake of EO data.

The first analysis of the users of CBERS satellite data was published by Epiphanio (2007), who described the benefits of free data policy and the distribution of the satellite images CBERS 2 via INPE. Epiphanio (2007) indicated that the success of free data is proved by the high numbers of image downloads by users, but this does not necessarily mean that the images were used. Epiphanio suggests that the free EO data policy provided by INPE had a benefit in different public organizations such as IBAMA, INCRA, EMBRAPA and other organizations at the state level. Silva et al. (2009) also undertook a survey on the of CBERS images carried by INPE in 2009. This study was based on a sample of 205 participants out of a total of 31,515 registered users. The survey aimed to understand the needs of users, the reason they downloaded the image, their knowledge about CBERS and their application of the images. The results showed that 44.9% of the users had an undergraduate degree, 22.6% had a Masters level degree, 7.9% a PhD, 1.5% had Post-Doctoral training, 18% had undertaken specific training in E and only 5.1% of the users had no formal advanced education (Silva et al. 2009). The majority of EO data users worked in agriculture, forestry and environmental sectors. The next section explains the methods applied to understand the use of EO at the national level in Brazil. However, while there are a few studies which explored categories of those using EO data and a broad sense of sector, there is little, if anything, on the use of EO derived data in Brazil and how this can best be facilitated. Hence the aim of the research reported here was to address the following questions:

1. To what extent is EO data currently used in Brazil? Who is using the information and for what purpose?
2. Identify examples where the use of EO data is good and where it is not so good. This needs to include a definition of what is meant by 'good' in this context.
3. What are the factors that help or hinder the use of EO data by potential users?

2.Methods

The research employed grounded theory approach by applying open-ended questions to address the questions given above. The data is based on the main author's work experience and extensive in depth semi- structured interviews at the National Space Research of Brazil (INPE), federal institutions in Brasilia (the capitol city) and different institutions at the state level. The data collection included 43 semi-structured in depth interviews with different ministries and civil servants and a total of 50 hours of interviews.

Grounded theory (GT) comprises systematic and flexible guidelines for collecting and analysing qualitative data to construct theories 'grounded' in the data (Charmaz, 2006) rather than setting a theory in advance of the data collection. Strauss (1998) highlights the importance of the grounded theory approach to set up different research parameters and to define the main research problem by using intensive data collection and a constant analysis of the fieldwork data. The patterns emerging from the data analysis includes a microanalysis of the data to understand the patterns and relationship between different categories (Strauss, 1998). The methods of analysis of this paper is based on the data that emerged from the 43 semi-structured interviews .In order to protect the interviewer and to avoid issues with the interview data, all the names are kept unanimous. The interviews were conducted with respondents in the following institutions:

Location and institutions	Interviews
Brasilia (Ministries and federal organizations)	27
Sao Jose dos Campos (INPE, National Institute for Space Research)	8
Sao Jose dos Campos (AGROTOOLS, Environmental consultancy company)	1
Campinas(EMBRAPA, Brazilian Agricultural Research Corporation)	3

Campinas (CEPAGRI, meteorology centre)	1
Curitiba (SIMEPAR, EMATER AND ITCG, state and federal organizations)	3
Total interviews	**43**

Table 1. Institutions and number of interviews

The initial selection of interviews was based on suggestions of INPE senior scientist recommendations about the main organisations associated with agriculture and forestry at the national level. Added to this was an element of snowballing whereby respondents would suggest others who should be interviewed. Each interview was semi-structured and the goals are set out in Figure 1.

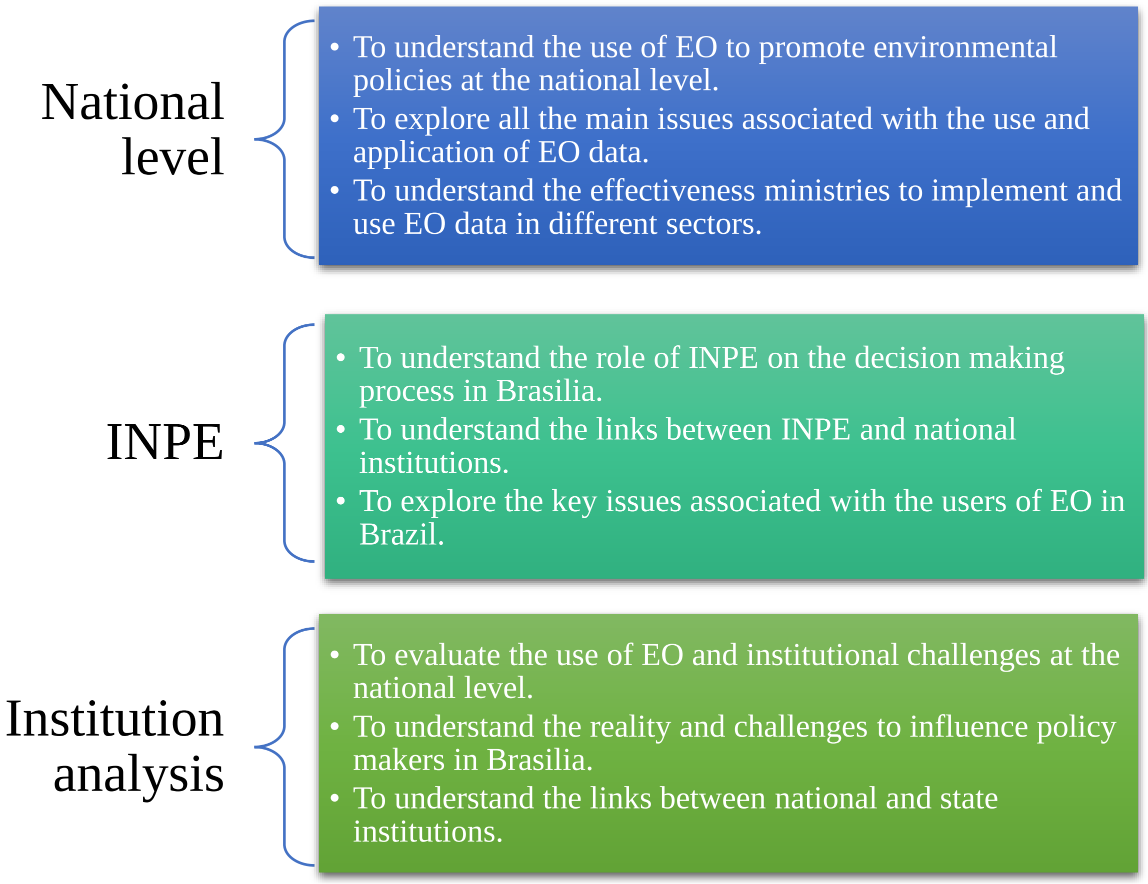

Figure 1 Main goals of the interviews.

3.Results

The results of the research have been set out here in terms of the following themes:

- EO data producer and EO data users in Brazil
- EO and sustainable development

Quotations have been used to illustrate points within each of these themes and key phrases and coments have been highlighted in bold text and underlined.

3.1 EO Data producer and EO data users in Brazil

Acces to EO data emerged as a key concern amongst respondents. Firstly in terms of availability but later in terms of being able to process the quantities of data that became available. Senior scientists at INPE and at the Brazilian Space Agency (AEB) illustrated the points raised on the questions above :

"Brazil is one of the ***largest users of*** **remote sensing in the world**. *Private enterprises, agriculture, pulp and paper, and so one.* ***It is a consolidated market and old"***

(Senior scientist D from INPE)

"*Data was difficult to acquire,* ***data used to be expensive,*** *no free access, and when the data become free and data is relatively easy to acquire now, the bottleneck of access was solved. Then, the key point is the limitations of who interpret the data. Or better, the needs of scientific background or technical capacity of the person who will interpret the data. Image interpretation is not easy, it is not easy because it is not only data images for EO, they are acquired in spectrum bands and are not visible. The interpretation of physical elements of the land surface is not obvious for who does not have a specific training in the physics of remote sensing. Therefore, the model now passed from a bottleneck of access, data become free and many people are using.* ***Now, the bottleneck is processing.*** *Intellectual capacity, formation of human resources, technical capacity to manage too much data"* [1]

(*Senior scientist A from INPE)*

"Today, we have the Ministry of Cities, Ministry of Environment, Ministry of Defense, and Ministry of Planning. Basically, ***there is no ministry that one point, secretaries, groups, or a project that do not use data from remote sensing in certain level.*** *This not only at the federal level, state and municipal level as well. Systems to control buses, control taxes, land use regulation at local level. The demand is explosive to a point that is difficult for any organization in Brazil to clearly understand how much the Brazilian state demand in terms of EO images"*

(Senior staff at the Brazilian Space Agency, AEB)

There are many institutions that produces data derived from EO. A senior scientist from the Ministry of Environment in Brasilia highlighted the importance of two important institutions:

"In Brazil, the institutions that produces EO information and make the data available for the user is basically ***INPE and EMBRAPA*** *at the federal level"*

(Senior scientist B from the Ministry of Environment)

[1] First authors interview with a senior scientist A from INPE, Sao Jose dos Campos, November 2016.

The capacity of institutions to deliver and use EO data and products available in different land monitoring programs was mentioned by different researchers. The following example illustrate the views of a senior staff from IBAMA in Brasilia and from INPE :

"*Our focus is to control illegal deforestation with the main focus basically in the Amazon region. Theoretically, we should monitor the entire country, but* have **financial restrictions and lack of personnel**, *so we are focus our work in the Amazon"* [2]

(Senior staff A from IBAMA)

"The use of information, this is another problem, when the information is used for fiscalization. The information is ***so rich and intense,*** *and that fiscalization is not prepare to execute everything. We deliver 100,000 polygons annually and they provide the evidence that if they check 1,000 polygons is too much, IBAMA is visiting less than that"*

(Senior scientist B from INPE) [3]

"*Images with high resolution have a limitation and time is important. For example: someone is causing deforestation in the Amazon and* ***we cannot have an image every 30 days****. We do not have the conditions to monitor the Amazon regions with high resolution images. So, in this way of fiscalization we need to keep using the resolution of LANDSAT images"*

(Senior staff A from IBAMA)

The interview at IBAMA cover many factors as to why IBAMA is not using all the information provided by INPE.

"*We cannot monitor all the polygons identified in the images. The* ***cost of dislocation is not financially viable****. Priorities of deforestation. We send the most important polygons for the people in the field. We have rules for that…The ideal scenario to visit all the polygons of deforestation in the field is unattainable"*

(Senior staff A from IBAMA)

"In my opinion, the principal limitation factor to use data from EO is the **lack of a national database system** *or governmental and I think INPE could lead this"* [4]

(Senior staff A from IBAMA)

"Capacity of storage in the clouds and Google is doing this. The ***technical capacity*** *of Google staff is incomparable with the capacity of workers in public organizations in Brazil. I think this is the principal limitation we face today"*

(Senior staff A from IBAMA)

Similar observation was also shared by an infrastructure analyst at the Ministry of Defense in Brasilia:

"We have resources to detect, but we do not have money to act in the field. ***Sometimes lack of money and people.*** *Probably if we have money and people, it lack helicopter because the areas are huge"*

(Infrastructure analyst, Ministry of Defense)

[2] First authors interview with a senior staff A from IBAMA, Brasilia, November 2016.
[3] First authors interview with a senior scientist B from INPE, Sao Jose dos Campos, November 2016
[4] First authors interview with a senior staff A from IBAMA, Brasilia, November 2016.

3.1.2 Why the data is not well used?

The interview at the National Institute of Colonization and Agrarian Reform (INCRA) in Brasilia shows some of the problems associated with the uses of EO data:

*"Lack of knowledge and qualified workers with technical knowledge to generate the information for our managers… I need **infrastructure, images and people** to generate the information with the data"*

(Strategic analyst A, INCRA)

*"Data is not a problem and we use a lot of data, the problem we have is the **capacity to use and process all the data"***

(Ministry of Environment ICMBIO)

*"The focus here is on units of conservation. As you can see, **our team is very small.** We have interns and two more interns. We do not have the capacity to generate information, we use the information from INPE. All the data about deforestation and fire is from INPE. We produce the data for the areas that were affected by fire in units of conservation"*

(Ministry of Environment ICMBIO A)

*"Institutions, there is a sense of completion instead of a synergy[5]. The National Indian Foundation (FUNAI) receives the data of deforestation maps we make and complements for indigenous land. This complement our work and goes beyond. ICMBIO (Chico Mendes Institute for Biodiversity Conservation) more or less the same, but it is difficult to maintain the team. **The change of staff is too constant"***

(Senior scientist B from INPE)

The user changed and the capacity of the institutions also changed. For example, the views from a senior staff at the Brazilian Space Agency (AEB) in Brasilia:

"Mobile phones rather than workstation. The world changed and the user changed completely"

(Senior staff at the Brazilian Space Agency, AEB)

"Bring the user to the data rather than the data to the user"

(*Senior scientist A from INPE*)

"I think the information of EO is a base for everything. Everyone uses Google Earth, this is a trend. The user uses the information all the time"

(Ministry of Environment B)

The intensive of use of mobile devices also required institutions to adapt with the new reality and how users are accessing the information. The problem of the capacity to use the data was also underlined various times at the Ministry of Mines and Energy:

*"I will say it again. This is the problem of **work capacity. People think they know, but they do not know**. Open shape files, projections, scales, image treatment and mix bands. The ministry will not know this. The ministry needs to know what type of information is available and I do not know if the ministry is aware about the potential of the information"*

[5] First authors interview with a senior scientist B from INPE, Sao Jose dos Campos, November 2016

(Infrastructure analyst B, Ministry of Mines and Energy)

The institutional challenges and the capacity of the user to process and use EO information was mentioned by different public organizations. The next subsections shows some of the views associated with the challenges and conflicts of sharing EO and geospatial data between institutions. The issues to understand the potential to use the information in different institutions was highlighted by a senior staff at the Brazilian Forest Service (BSF) in Brasilia:

Author one question: *Do you think there is a potential to use the information in different institutions?*

"I think so. I think lack a ***connection between the image alone and the use.*** *There are applications. For example: a mobile phone access to facilitate that work in real time. We still have a barrier. For example: I do not see a city council prepared to use the information not even from CAR (National land registration) not even satellites images. We need you to understand the use of satellite images to make a product for someone to take a decision, and you need that person that have the power to take the decision to value that information, we still have this issue. Things are still on the political arena.* ***We need to work towards political decisions primarily based on the images and on the facts****. This is the first step: decisions based on the information and knowledge"*

(Senior staff at the Brazilian Forest Service, BFS)

The political factors that limit the use of EO data were mentioned in different interviews. For example: Senior scientist from INPE suggested a restructure of how organizations interact with each other :

"For me, exist a sector with technical capacity, what does not exist is a logical to restructure the sector. We have a different history and institutional arrangements are different. ***What we need to do is restructure the system.*** *The institutional arrangements today are different than in the past"*

(Senior scientist D from INPE)

"I think in this sector the problem is more the **institutional analysis and politics of government"** [6]

(Senior scientist D from INPE)

For example, Rajão and Georgiadou (2014) illustrates the blame-avoidance of institutions associated with environmental crises in Brazil, in particular factors that underlines much of political, institutional behaviour in practice and bureaucratic actors. The next section explains the links between the use of EO and sustainable development in various ministries and organizations at the national level.

3.2 EO and sustainable development

The key question is how the use of EO data and geotechnologies could help to reduce the lack of communication or common views of development between Ministries. The opportunities are several when interacting with public policies as mentioned by the director of department of policies and programs for social inclusion:

[6] Senior scientist D from INPE, Sao Jose dos Campos, November 2016

"I see that geotechnologies, georeferencing and satellites for research, social inclusion, and regional *development only have results when there is an interaction with public policies.* ***<u>It cannot be an isolated technology"</u>***

(Director of the department of policies and programs for social inclusion, Ministry of Science, Technology and Communications)[7]

"The ***<u>solution is not at the technical level</u>****, at the time of implementation we have different views of development"*

(Senior policymaker A at the Ministry of Environment)

"We who are the formulators policy makers, we at the end are who identify the type of information we want to receive. So, it is not a spontaneous action, for example the people of science that delivers the information. They can be important and we listen, but assimilate the information is a second stage. On the other hand, some questions are fundamental. The question of monitoring and make it consistent is the most relevant for us who develop the policies and follow how efficient those policies were to address the issues we were discussing. In my case is the reduction of deforestation. One is on the sense that you identified the problem, we constructed the public policies, plans of actions, preventive measures, and then you need and instrument to monitor. In the case of deforestation, this instrument is based on satellite images that ***<u>cover the entire region with the frequency we need</u>****."* [8]

(Senior policymaker A at the Ministry of Environment)

The answer and the solution is not straightforward as mentioned by a senior policymaker at the Ministry of Environment. The power to influence decision makers and the limitation of civil servant to influence the decision was a problem stated in different institutions in Brasilia:

"*Different knowledge is not sufficient to stimulate a public policy. Sometimes they are not convinced that a particular policy will bring benefits. It will generate a series of commitments to states, cities and we build the policies at the federal level, but it depends of the implementation at the state level"*

(Senior policymaker A at the Ministry of Environment)

"The main challenge is dissemination even that we have been working for more than 20 years in this area. ***<u>People do not understand the importance of geospatial information</u>*** *and how this influence to decision making, business, the civil servant, one politician cannot have this dimension and as a consequence this is not taking to a level of decision making to jump in quality. Despite the fact that I have excellent technicians, we get to develop excellent products, for this information to arrive at the civil servant, at the president of FUNAI, Ministry of Justice and the Ministry of Lower House. They cannot realize the importance of this and how this can change lives of people"*

(General Coordinatinator of territorial monitoring, FUNAI A)

"Knowledge and interaction between institutions… One of the main problems of FUNAI is ***<u>communication between ourselves and other institutions</u>****"*

(Manager of Information and technology B, FUNAI)

Nevertheless, the problem is interaction between institutions is not the only problem. The internal issues of communication plays an important role on how institutions communicate their ideas and data

[7] Director of the department of policies and programs for social inclusion, Brasilia, November 2016
[8] Senior policymaker A at the Ministry of Environment, Brasilia, November 2016

with other organizations. The issues associated with the use of EO are various. The next section discuss the most important points of the interviews and includes a critical analysis on how to answer some of the problems encountered in different interviews at the national level in Brasilia.

4.Discussion

The interviews explored the uses of EO by different organizations in Brazil.The results of the interviews indicates a lack of capacity of public institutions to process and analyse all the information derived from remote sensing information. The capacity of institutions to cope with the demand of environmental challenges and the lack of qualified personnel at federal and state institutions were mentioned across a wide range of organizations. The institutional challenges and institutional arrangments of public institutions was stated as one of the most serious problems on the cooperation work between and within organizations. The institutional challenges limits the potential of land use managment rather than the technical and EO expertise in institutions such as INPE, EMBRAPA, CONAB and the Ministry of Environment.

The interviews did not include the Brazilian Institute of Geography and Statistics(IBGE), an institution mentioned in different organizations as one of the most important players to promote the use of EO and geotechnologies at the national level in Brazil. The factors that limits the use of EO are many and it changes depending of the organization and location. The current political factors and economic situation was a very strong element of all the interviews and the constant changes of government was blamed as one of the main reasons why the space programs are not developing as fast as expected. The legal framework to hire new people and increase the technical capacity to process and provide accurate EO information for decision makers was mentioned in many interviews.The institutional needs are not directly linked with the technical capacity of the workers or with the failure of the institutions to provide good and reliable EO data information. The main causes are associated with the capacity of public institutions to work with other organizations, share information and to efficiently work with private partners and academia at the national level. There is a greater potential for future interaction between the public sector, private enterprises,NGOs and academia.

Nevertheless, the main examples stated in the interviews shows some of the main problems regard the use of EO by public organizations in Brazil. The main question is how to measure the needs and the potential of EO and geospatial information in public organizations at the national level. One way forward to understand the linkages betweeen all the institutions is develop a new institutional framework to improve the use of EO in different organizations. However, internal and external communications issues are enourmous and difficult to explain the main reasons behind it. Policy- making systems are complex systems (Cairney, 2015). For example, Cairney (2015) explains the challenges of civil servants to work with the policy cycle and the relationship between different actors, shift of policies decisions and the interactions between policymakers, government ministers and civil servants.

The main challenges to measure and understand the influence of pressure groups and political advisers rather than civil servants and technical groups involved on the implementation process to use and apply information from remote sensing in different levels of governance will require further investigations. It appears that the use of Earth Observation and advanced technologies is very important to assist policy-making. However, there are many factors undermine those decisions and the institutional arrangements of institutions is one key factor that is up taking further use of EO at higher level. This links between science, policy making and implementation in different levels of the government. As Arts and Tatenhove (2004) describes the institutional capacity and complexity of the institutional embeddedness of multi of multi-actor policy processes associated with the government structures.Other possible way is the use of sustainable indicators to measure and understand the complexity of factors associated with the uses of EO at the national level in Brazil.

The lack of use of publications surrounding the use of EO data associated with sustainability indicators, there are literatures that provide some insights. (Morse, 2015),for example, has highlighted the importance of developing Sustainable Indicators (SIs) to help on the practical aspects of sustainable development and to inform policy makers on complex environmental issues. Indicators and indices are one possible route that could help facilitate the better use of EO information in Brazil as these tools are designed to help translate what can be very complex datasets to users who may not be technical experts in the relevant field (Morse, 2015).An indicator may help with communication barriers if they exist, but further understanding of the issues at both national and state level is required to understand the links between indicators and uses of EO in different geographical locations. Such indicators and indices might be useful in terms of both ‘external’ (public) and ‘internal’ (within and between agencies) facing communication.

Associated questions related to Sustainable Indicators:

- Is there a role for indicators and indices in helping to make better use of EO data for land use change/land degradation in Brazil? If so then, what would be the most appropriate indicators?
- To what extent do indicators derived from EO data currently assist particular projects in Brazil?

Nevertheless, the interactions between policy-makers, users of EO and the use of indicators may be one way to answer some of the problems highlighted on the results. The critical analysis of all the institutions included on the interviews will require further analysis in the future. As a result, the partial analysis of some of the interviews represented only some of the views linked to all the 43 interviews.

5.Conclusions

The issues associated with the use of EO is directly linked with the institutional arrangments in public institutions at the national level in Brazil.It shows the various problems why the data of EO is not well used in some Ministries and the problems encountered by senior staff in various public institutions. The lack of resources available, financially or skilled workers, are some of the issues that limit the use of EO in different Ministries. At the same time, institutions blame each other for the lack of capacity to deliver better results is based on the historic development of institutions in Brazil. The techincal knowledge of each institution and personnel is unique. Likewise, the funding available to contract new personnel and the legal framework of each institutions varies according to the federal demand to hire new workers. This research is the initial stage of different field work interviews in Brazil. The additional data of additional interviews in May and June of 2017 will improve the quality of the information at the same institutions and several other federal organizations.

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Envisioning versus realizing products for use in poor communities: The case of Victor Papanek and Nordic designers

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Abstract

An increasing number of people is currently living under poor conditions in enclaves of rapidly growing urban areas. They lack basic equipment for living a healthy and decent life. The products have to be simple, cheap and useable for people with different cultural and geographical backgrounds. Methods to realize the design, production and implementation of such appliances is a matter of urgency. Therefore, the ideas of the Austrian-American designer Victor Papanek (1923-98) have gained new actuality. During the 1960s and 1970s Papanek played a significant role in the international design community. The hot topic was the growing Western affluence and waist in contrast to the so called Third World's increasing poverty. His ideal was the less polluting design traditions of indigenous people, made by simple methods in local materials. His basic idea of design was to create "survival kits" based on local indigenous traditions. He had many supporters among design students in Scandinavia and Finland. Some of them tried to adapt their work practice to his ideology. Design from these countries was reputed for its democratic approach, innovative simplicity and use of natural local materials and handicrafts and constituted a platform for fruitful cooperation. The aim of the paper is to investigate what impact his ideas had on the Nordic design community, and particularly whether it was followed up by stakeholders and eventually reached the target groups. Success factors and failures are displayed and discussed to clarify how the ideas might be utilized in today's situation. The empiric study is based on literary reviews, and additionally of interviews with designers in Denmark, Finland, Norway and Sweden. The investigation shows that Papanek's ideas made a tremendous and lasting impact on designers in the Nordic countries including some of their work. Workshops at the design schools and local communities disengaged great creativity and ideas for products. Still, design and production for indigenous people in least developed countries seldom occurred, as he and his followers refused to interfere with stakeholders like politicians and producers. Therefore, they had little impact on the lives of the target groups. One of the few exceptions was the foundation of the Norwegian organization "Design without Borders", which was mainly financed by the government, i.e.by ways of political decisions. In conclusion, without contact and cooperation with stakeholders, particularly the political and commercial sector, and users in the local communities on the other hand, it is not possible to realize ideas of this kind in the form of products and their use. The paper deals with ideas that directly support a sustainable development, which factors that are necessary to realize it. Considering the new interest that Papanek's ideas newly has gained, it is of vital importance to analyse, present and discuss these factors to secure a fruitful utilization of them in our era and with our set of problems.

Keywords: Victor Papanek, The Nordic countries, Design for less developed countries, Poor communities

1. Introduction

An increasing number of people is currently living under poor conditions in enclaves of rapidly growing urban areas. Many of them live in, or originate from indigenous societies. They lack basic equipment for living a healthy and decent life. They are in need of basic and cheap products, and have to be simple, cheap and adaptable to people with different cultural and geographical backgrounds. Methods to design, produce and implement such appliances in a successful way is a matter of urgency. Therefore, the ideas of the Austrian-American designer Victor Papanek (1923-98) have gained new actuality.

During the 1960s and 1970s Papanek played a significant role in the international design community. The hot topic was the growing Western affluence and waist in contrast to the so called Third world's increasing poverty. His ideal was the less polluting design traditions of indigenous people, made by simple methods in local materials. His basic idea of design was to create "survival kits" based on local indigenous traditions. He had many supporters among design students in Scandinavia and Finland. Some of them tried to adapt their work practice to his ideology. Design from these countries was reputed for its democratic approach, innovative simplicity and use of natural local materials and handicrafts. It therefore constituted a platform for fruitful cooperation between Papanek and designers from this region.

The aim of the paper is to investigate what impact his ideas had on the Nordic design community, and particularly whether it was followed up by stakeholders and producers, and eventually reached the target groups. Success factors and failures are displayed and discussed to clarify how the ideas might be utilized in today's situation.

2. Methods

The empiric study is based on literary reviews, and additionally of interviews with designers in Denmark, Finland, Norway and Sweden, and Papanek's last wife Harlanne Roberts. The Victor J. Papanek Archive at the University of Applied Arts Vienna has also been consulted.

3. Results and Discussion

Papanek immigrated to the US in the 1930s. He started out as a student of art and architecture, but soon turned to design and started his own design studio. He became an apprentice of Frank Lloyd Wright and was particularly influenced by his preference for hexagons, colour scheme of black, white and read, interest in Eastern cultures and his conception of Modernity's close relation with nature and the environment. Likewise, his encounter with Richard Buckminster Fuller and his ideas of "making less for more", engagement with sustainability and thinking globally as a student at Massachusetts Institute of Technology was groundbreaking for his conception of design as something that should facilitate everyday life. He also took interest in organic forms and North America Indian art (Fineder and Geisler, 2009).

On the basis of previous impressions and his engagement in environmental questions, combined with the growing affluence in the Western world, he developed a new approach to design. His definition on the activity was broad, comprising both professional and lay persons and their shaping of the surroundings: "All men are designers. All that we do, almost all the time. For design is basic to all human activity. The planning and patterning of any act towards a desired, foreseeable end constitutes the design process" (Papanek, 1971). At the same time he attacked the designer profession for contributing to the creation of superfluous objects and affluent consumption: "There are professions more harmful than industrial design, but only a very few of them. … By designing criminally unsafe automobiles that kill or maim nearly one million people around the world each year, by creating whole new species of permanent garbage to clutter up the landscape, and by choosing materials and processes that pollute the air we breathe, designers have become a dangerous breed." (Ibid.). Rather than designing superfluous products that stimulated consumption, his idea of design was to create objects that covered basic needs and could be produced locally by cheap or used materials. The users of such objects were those who needed it most, i.e. people in the so-called Third world (Ibid.).

In 1964 he got a position as leader of the Department of Art and Design at Purdue University of Indiana. A major part of his teaching consisted of letting the students design prototypes based on these ideas. He transmitted his provocative viewpoints in mass media by making TV programs and films, and thereby became known in the US as well as abroad. In the 1960s he got his first commissions for UNESCO, and thereby got an opportunity to realise his ideas. One of the most significant products was the Tin-Can radio. It was to be made of a used juice can made of tin, with a burnt top made of copper fringed "antennae," and connected with wires to a nail and radio transistor. The background for this was that in 1962 he was approached with a problem by representatives of the U.S. Army. They needed help to make a device that could deliver a radio signal to people living in remote parts of the world: Villages which were primarily illiterate, unaware of the fact that they lived in a nation-state, and had no electricity, money for batteries, or access to broadcast news. This tin can was a prototype solution by Papanek and one of his students, George Seegers. This was not a new invention. It had been around since the early 1930s and was often built by Boy Scouts. But he message of the Papanek version was the promise of sustainability (Gowan 2015). The tin can was able to act as a one-transistor radio, and it was non-directional, which meant it could only pick up one radio signal. Used tin cans were in abundance around the world, and the radio could be fueled by dried cow dung, paper, wax, or generally anything else that caught on fire. The heat produced would then rise to the top, and was converted to energy which would power an earplug speaker. Its manufacturing cost was 9 cents. It should function as a communication device for preliterate areas of the world, and was given to the U.N. for use in villages in Indonesia (Catanese, 2017). The decoration was to be done by the local users, but out of the two examples of which there is photographic documentation, made be an Indonesian user, one followed Papanek's preferred colour scheme of black, white and red. How many, if any of these radios that were actually produced and how they were received by the users, is not known. That was not of Papanek's primary concern. Making a radio was that worked was seen as an act of empowerment of those who made it (Gowan, 2015).

As a representative of the American Environmental Movement, which got much attention among design students in the Nordic countries, he and Buckminster Fuller were invited by the Scandinavian Design Students Organisation (SDO) to a seminar on work environments at The Institute of Industrial Art in Helsinki, Finland (later Aalto University). This took place in 1967. The initiative came from Yrjö Sotamaa, who later became a leading figure in Finnish design education (Sotamaa, 2017). Papanek's charismatic contribution, performed with great rhetoric skill and with a sense of humor, constituted a breakthrough of the radical views, and placed himself as a "guru". It led to a series of invitations to the design schools in the Nordic countries. Nonetheless, the interest and impact varied from country to country.

Although Finland was the country he was originally invited to and later visited many times to lead workshops, Sweden was the country where his message most clearly led to a dissemination of his ideas (Söderholm, 2008). At his first visit to The University College of Arts, Crafts and Design in Stockholm in 1968, he held an eight hours speech, which created both disgust and enthusiasm. Some were provoked by his radical views, others reacted positively and immediately approved to his views and way of presentation. To the textile student Maria Benktzon his message constituted an "eye opener to the world" (Benktzon, 2017). It lead her to change her direction and work in the field of industrial design, creating basic ergonomic everyday tools. His message had similar impact on other of the students. As for designing for the Third world it was something they wished to do, but that was not possible at that point of time (Ibid.). Papanek's invitation was initiated by the design student Olof Johansson. He also helped him to get in contact with the publishing house Bonnier, which published the very first, Swedish edition of his book *Design for the Real World, Miljö för Miljonerna* (Papanek, 1970). At the other hand, the impact was reciprocal. In his book he included an illustration of traditional wooden shoes, an example of Swedish vernacular design.

More importantly, some of his later students' projects at Purdue University resembled products he had seen in Sweden, like Henrik Wahlforss' electric wheelchair (Veryday, 2016).

Papanek probably visited Norway for the first time in 1969. He gave a lecture at the Oslo College of Art and Design (now part of the Oslo Academy of the Arts). According to one of the attendants he, in spite of the fact that a teacher hinted that he might be a delegate from an Eastern block country, was: "completely calm and sober-minded and greatly fertilized the 1968 generation's desire to break with the conformal and nurtured the question of how and what we designed: Shortly, about taking in a broad social design responsibility" (Gusrud, 2017).

The work of the furniture designer Terje Ekstrøm was probably inspired by Papanek, like his loudspeekers with hexagonical forms (Ibid.). Mostly, the impact seems to be of a more general kind, feeding the wish to design with social awareness and with an increased concern about the poorer parts of the world. That was the case with the design student Peter Opsvik, who later became one of Norway's most influential furniture designers. In 2001 he was the initiator of the foundation of the Norwegian organization *Design without Borders* (DWB). The aim of the organization was to utilize design expertise to make highly needed and useful products in the Southern hemisphere (Ramberg and Verdu-Isachsen, eds., 2012). Since then the mainly officially funded organization has executed projects mainly in Uganda and Guatemala, many of them successfully. The organization still exists. It is probably the most prominent example of what the ideas of Papanek and the Environmental Movement could lead to.

In Denmark it seems that his message made less impact. It was mainly his ideas of sustainability, not so much those of the significance of indigenous design that was appreciated. He visited Denmark in 1973, in the aftermath of the 1968 revolt. He was a visiting professor at the Department of Industrial design at the Royal Academy of Art in Copenhagen, and stayed for several months. He was invited by Professor Erik Herløw, one of the leading figures in Danish industrial design, who also had his own design studio where he worked on the ideas of sustainability. Papanek held lectures and led workshops, and was once interviewed in a TV program (Høilund, 2017). He enjoyed the teaching, even the left wing political setting a relaxed attitude. He has left the following humoristic account: "Eight or nine students and a teacher sat around a table making drawings and working on a project while 30 or 40 other students taking the class sat around them on the floor, reading, smoking pot, and eating potato chips." (Gowan, 2015).

According to one of the students, "the exiting thing about Papanek was his consciousness about global resources, and the examples of it that he integrated in his assignments. This was a basic attitude that was in accordance with the one at our department. … He was an inspiring lecturer, but at the same time part of a shred in our consciousness about the fact that resources were scarce." (Ibid.)

Papanek was a devoted and successful mediator of his ideas towards design students. But he never promoted them towards business enterprises or other commercial stakeholders, nor to politicians. The efforts to realise his and his students' prototypes were limited to projects in the less developed world organized by UNESCO and WHO. Instead of putting them in production, they were freely given to have the broadest and most beneficial effect possible. An example is his work for WHO in Chad, Niger and Cameroon, where prototypes of a village-made clay pipe production machine were made. They were not manufactured, just constructed and demonstrated in villages so that people could produce clay pipes to move water and waste as needed (Roberts, 2017). Consequently, little is known about how they were received by the local communities and whether they were actually manufactured and used. There is no evidence of following up of the projects or evaluation of their impact The Victor J. Papanek Archive 2017).

The approach was in accordance with and a consequence of his ideas of leaving it to the local communities to produce the appliances. However, there is no indication that the communities made use of or developed the prototypes into products. Papanek himself paid no attention to what happened after he had left, he regarded that as something that should be left to the local inhabitants. Consequently, there is reason to believe that his ideas were not implemented in this part of the Third world.

The main outcome was that Papanek had enjoyed these visits and was given the opportunity to learn about the local cultures and thereby develop his ideas and prototypes. He even brought a collection of their objects to his home in the USA (Gowan, 2015). The general outcome of these undertakings in the Third world was that little or nothing was produced or used, and the learning outcome was mainly that of Papanek himself. Consequently, the original problem that the prototypes were designed to improve, remained unsolved. Moreover, his views remained controversial and unpopular among the establishment, which is proved by the fact that by his death, his obituary was refused to be published by The New York Times (Gowan, 2015).

Almost five decades have passed since Papanek's encounter with the Nordic countries. His ideas, infused with the attitudes he met there, have become part of the common conceptual legacy in the international design community. He also updated his ideas by revising his seminal book (Papanek, 2006), and published new titles, particularly *The green Imperative* (Papanek, 1995), but his main attitude remained the same. During the flourishing of the left wing political movement in the late 1960s and early 1970s the Scandinavian design students claimed him for his coice to stay out of politics (Savola, 2015). He stayed true to his original ideology. Designers should be social aware, but remain politically unaffiliated (Smith et al., eds., 2016). In a historic perspective this may be regarded as unrealistic, romantic or arrogant. With his intervention in and presentation of solutions to indigenous people he might also be accused of having Post-colonial views. Nonetheless, hos ideology has achieved status as classical. It that still has impact and makes impression in the design community, in particular design students.

The world we live in today is quite different from that of the 1960s and 1970s. The legacy might seem to be a historic past, with little relevance to our contemporary society. However, there are obvious similarities. One of today's the main challenges is environmental control on a global scale, as well as the acknowledgement of the value and innovative use of various cultural traditions, which was almost exactly what Papanek was occupied by. The paramount issue of the contemporary design discourse is to find ways to meet the challenge of sustainability, both on the physical and cultural level. His ideas are therefore highly relevant. There is reason to ask what we can learn from his way of thinking and working. What were the success factors and what were the failures? How can we utilize the experiences in today's situation?

Papanek represented the first generation of promoters of the environmental movement in design. His role was that of introducing the topic and how designers could or should meet the environmental challenge. At the same time, he had great learning income from his visits and included ideas and attitudes that fit into and strengthened his own ideology. In the less developed world he was able to get more in-depth knowledge of indigenous culture. In the Nordic countries he met a Social democratic tradition that comprised a certain awareness and use of design as a tool to create practical everyday products, supported by official politics and government support. Additionally, a few designers were already acquainted with the environmental movement. This made it easy to create mutual understanding and lasting impact. In this way he also strengthened his own competence and an international authority in the field of human centered and environmental friendly design. His views included what was later called *universal design*, *participatory design* and *green design*. Moreover, he foresaw how designers could contribute to a seamless system of increased consumerism and lack of critical reflection, as later put forward by Hal Foster (Foster, 2002).

The lack of realisation of the ideas in "The third world" constitutes a major shortage of his approach. Thereby the main target group had no immediate improvement of their living conditions. His ideology itself prevented interference with commercial enterprises. Papanek either neglected this fact, or refused to revise his ideology. The next generation of designers were left with the challenge of realizing his ideas, and adapting them to the contemporary society.

As for today's situation, the challenges of climate control are paramount, and rigid ideologies have to be abandoned or adapted to the actual situation. Additionally, it has become obvious that the relation between different cultures and value systems constitutes no idyll. Rather, the meeting between different cultures easily creates social and cultural clashes. In today's multicultural society this is a major problem that needs to be solved. What his ideas has brought forward is a competence and awareness that may be helpful in solving these problems, provided that they are used in a pragmatic way, and in cooperation with politicians, producers and inhabitants.

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5. Conclusions

Papanek's ideas made a tremendous and lasting impact on designers in the Nordic countries including some of their work. Workshops at the design schools and local communities disengaged great creativity and ideas for products. Still, design and production for indigenous people in least developed countries seldom occurred, as he and his followers refused to interfere with stakeholders like politicians and producers. Therefore, they had little impact on the lives of the target groups. One of the few exceptions was the foundation of the Norwegian organization "Design without Borders", which was mainly funded by the government, i.e.by ways of political decisions, and which products were manufactured by private enterprisers, mostly Western. In other words, it was achieved by including the stakeholders that Papanek insisted not to interfere with.

In the Western world it has had great impact in the designer community, in combination with other information about environmental issues. In particular, the Papanek legacy has created empathy and motivation for having an environmental friendly attitude and a global perspective. The Papanek legacy constitutes a mental platform for further development in cooperation with representatives from other parts of the world.

In conclusion: Without contact and cooperation with stakeholders, mainly the political and commercial sector, and users in the local communities on the other hand, it is not possible to realize ideas of this kind in the form of production, implementation and use. Design for the real world has to be created *in* the real world, with all its cultural, social, economic and political contradictions.

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Evaluation of the improvement in thermal comfort with the incorporation of sustainable building materials in the ongoing self-construction processes for housing in the district of Bosa in Bogotá

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Abstract

The use of sustainable materials, incorporates environmental benefits, especially for large cities due to the current high pollution rates (Ferrer, 2015). Currently, cement, brick and steel are the most used materials for construction, unfortunately they are the ones that generate more C02 emissions in their manufacturing process. The objective is to evaluate the process of incorporating sustainable materials in order to improve the thermal comfort of a group of homes with ongoing self-construction processes in the neighborhood of La Libertad de Bosa in Bogotá. The Comfort problem in this project was approached as a fundamental condition of housing, if one takes into account that the thermal conditions of the space affect the human metabolism, from this it is derived that temperatures outside the established ranges imply more energy demand. For its inhabitants, unfortunately in Colombia, thermal comfort has not yet been incorporated as a variable in the processes of self-construction, the houses respond to a need for habitat understood as the need to have a space of its own regardless of the way in which this space respond to climatic variables. The project is carried out in Bosa, an area of Bogotá, which is located on the south-western border of the city. Its total area is 2394 ha, of which 1885 ha are urban land and 508 ha are protected areas. The methodology was considered a chronological experimental quantitative case study. The response provided by them is that: a) co-variation between the independent variable (materials) and the dependent (s), (existing housing) b) the application of the independent must precede the measurement of the Dependent variable and c) other variables, other than the independent one, have to be discarded as possible explanations of the changes observed in the dependent ones. In the second phase the quantitative approach of the project was initiated, with the diagnosis and beginning of the measurements that determined the thermal comfort of the homes that are part of the case study. The methodology of thermal analysis based on ISO 7730 Fanger Method will be used. With the community will begin the incorporation of the sustainable materials in the house object of study. Finally we will proceed to make the measurements that will allow to analyze the thermal comfort of the houses that incorporate the materials. This project is underway and the conclusions can not yet be presented, however for the presentation some results will already be obtained. The theme of the project is of great relevance for the conference for two aspects, the social one due to the geographic context in which a marginal zone of the city of Bogota is developed and the sustainable aspects that analyze when incorporating the project the study of the thermal comfort in Self-built housing as well as the use of non-traditional sustainable materials for the improvement of these dwellings

Keywords: Thermal comfort, sustainable, architecture, housing, design

1. Introduction

The Commission formalized the definition of sustainable development for the Environment in the UN document known as Brundtland report (1987). This definition addresses the needs of environmental resources for present and future generations and defines sustainable

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development as “meeting the needs of the present without compromising the ability of future generations to meet their own needs." (Alvarez, 2010).

This definition has been adapted to the particular needs of each sector in the field of architecture for example; the study Norman Foster + Partners, sustainable architecture defines how "the creation of buildings that are efficient in terms of energy consumption, health, comfort and flexibility in use and are designed to have a long life". (Foster, 2003)

The Building Services Research and Information Association (Association for Information and Research Facility Buildings, BSRIA) have defined sustainable construction as "the creation and management of healthy buildings based on ecological principles and the efficient use of resources". (Kibert, 2009)

The concept of "sustainable development" has numerous variables but a common denominator, which is based on growth and social welfare; it must ensure the conservation of environmental resources by the present generation, for the benefit of future generations.

The materials used in the construction exert environmental impact caused by the extraction, processing, transport, use and disposal. This impact occurs on the global and regional level affecting the climate, biodiversity and health of people.

At the same time, there is no unified methodology that works as a guide for those responsible for choosing the materials to be used in construction. Usually, the concept of "energy incorporated “is linked to the lifetime of a building; the materials used represent 10% of the energy consumed by the use of the building. However, this concept serves to highlight the elevated energy costs associated with the transportation of bulky materials (stone, aggregates, bricks or concrete) and the processing of some very light materials used (aluminium).

2. Meth**ods**

In this project, two methods were used, from the qualitative use of the history of life and for the quantitative method, ISO 7730 was used Fanger Method that is developed following the following elements:

1. Compilation of information about the environment.

1.2 Metabolic rate of the activity developed

1.3 Environmental characteristics of the environment
   1. Air temperature
   2. Radiant temperature
   3. Relative humidity or partial pressure of water vapor
   4. Relative air velocity
2. Estimated Average Voting (PMV)
3. Calculation of estimated percentage of dissatisfied (PPD) from the value of the PMV.
4. Analysis of results
   5. 4.1 Assessment of the situation (satisfactory or not adequate) depending on the value of the PMV and the PPD

4.2 Analysis of the thermal balance corresponding to the evaluated conditions

5. Propose appropriate corrections to improve thermal conditions (if necessary)
6. If corrections have been made, reassess the task with the method to check its effectiveness.

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3. Results

The first measurements showed the following results: the selected dwelling has very low rates of thermal comfort, one of the variables analysed was the thermal inertia of the materials used in its construction. This house used materials such as: reused brass sheets, which have A thermal inertia of 81 (W / (m • K)), very high relative to other materials, brick (0.8 (W / (m • K)) and concrete (1.4 (W /)) . Used traditionally in this typology, housing has uses brass as envelope and as cover, there is no type of material that helps to improve thermal inertia. It is observed that it is necessary to replace these temporary enclosures that affect the thermal comfort of The dwelling analysed See Fig 1.

Figure 1. Housing object of study, view of the main facade.

4. Discussion

Thermal comfort is a totally unknown term for the population of the area where the dwelling is located, the variables and methodology used in this project were designed for projects with a standard that are not fulfilled in the context chosen for this investigation. It is necessary to adapt the existing protocols to a context not contemplated in their wording. (Arenas, 2004)

5. Conclusions

It is necessary to improve the current conditions of the house under study, the main aspect to be improved are the envelopes, facade and roof, the latter was built with brass and zinc plate reused materials which makes the interior temperature of the space analysed is very Below the thermal comfort parameters.

In this improvement process and according to what was proposed, sustainable materials will be incorporated, in order to improve the thermal comfort over the material and the interior space.

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It is necessary to incorporate international standards of thermal comfort in the construction of self-built housing, the dwelling analysed presented very high deficiencies due to the temporary nature of the materials used for its construction.

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Sustainable urban development: the case of São Sebastião, a municipality in São Paulo's coastal region

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Abstract

São Sebastião is one of the municipalities located on the northeast coast of São Paulo, Brazil. The surface relief in this region is formed by the Serra do Mar, a system of mountain ranges. Part of the territory belongs to an environmental protection zone called Serra do Mar State Park, which is the largest continuous reserve of Atlantic rainforest in the country. Within the protection zone, constructions are forbidden by law in order to preserve nature and due to the risk of landslide from the mountains, which is recurrent in summer when heavy rains are more frequent. Informal housing became common in those risk areas. The high real estate prices found closer to the beach made those sites unaffordable to locals, for this reason luxury condominiums were built for vacation homes, where most of the perennial inhabitants carry out their economic activities as service providers. This problematic background demands an urban intervention with sustainable guidelines and social inclusion of residents. São Paulo's state government has been responsible for the program Sustainable Development Project of the São Paulo's Coast since 2007, which intents the development in municipalities along the coast to provide better living conditions for the entire population in a balanced way with the environment. The aim of the present paper is to evaluate the relation between the current urban public interventions in São Sebastião and the actual sustainable development of this municipality. The method used combines the analysis of primary and secondary data. The primary data were collected and observed in visits to the city, including the irregular occupation called Vila Sahy, whose part is within a risk area. The secondary data are publicly provided by official Brazilian institutions, such as the urban diagnosis accomplished by the Pólis Institute, the socioeconomic censuses promoted by the Brazilian Institute of Geography and Statistics (IBGE) and theoretical references on the subject. A Regional Agenda for Sustainable Development was developed by the program. The main guidelines involve resettlement, provision of infrastructure and sanitation as well as recovery, conservation and enforcement actions for environmental protection. Companhia de Desenvolvimento Habitacional e Urbano (CDHU) is the public body responsible for the construction of social housing, where the mixed use should be encouraged to instigate the emergence of new urban centralities. Therefore, the interventions have the potential to leverage the sustainable urban development of São Sebastião.

Keywords: risk areas, social housing, sustainable development

1. Introduction

The development that aims only at economic growth has generated imbalances. While wealth is obtained, poverty, environmental degradation and pollution increase. In view of this, the sustainable development concept came under discussion, seeking to reconcile economic improvement with environmental preservation and social equity. This model of progress has been discussed since the early 1970s. Ignacy Sachs[1] (1973) proposed the term ecodevelopment to define the attempt to conciliate increased production with the preservation of ecosystems to protect the Earth's habitable conditions. The author assumes that the term considers different dimensions of sustainability: social, economic, ecological, spatial and cultural, emphasizing that the social overlaps the others. The ecodevelopment was a precursor of the term sustainable development, introduced a few years later.

Norway's Prime Minister Gro Harlem Brundtland[2], named by the United Nations (UN), led the World Commission on Environment and Development (WCED) to resume the debate on environmental issues. In 1987, the final document of these studies, called Our Common Future or Brundtland Paper, was published by the WCED. The concept of sustainable development was introduced to the world in this paper as:

> "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs." (WCED, 1987)

In 1992, the United Nations Conference on Environment and Development (UNCED) was held in Rio de Janeiro, it is also called Rio-92 or Eco-92. One of the aspirations was to discuss the conclusions and proposals of Brundtland Paper. The document resulting from this meeting is Agenda 21 which establishes the importance of each country to reflect on how the sectors of society could cooperate in the study of solutions to social and environmental problems. Each country develops its Agenda 21. In Brazil, the discussions are coordinated by the Comissão de Políticas de Desenvolvimento Sustentável (CPDS) and the National Agenda 21. In 1997, the Brazilian Agenda 21 was created with the purpose of promoting sustainable consumption and production patterns based on commitments to sustainable development (Ministério do Meio Ambiente, 2002). This is an important instrument with potential to guide society to reinterpret the concept of development since it promotes quality besides the amount of growth.

Other organizations have also contributed to the subject. The definition given by the International Council of Local Environmental Initiatives (ICLEI) explains sustainable development as the one that provides environmental, social and economic services to the entire community without compromising the viability of natural or built conditions (ICLEI, 1995). The concern with the cities is evident in this definition. In urban situations, the sustainable development has directed several public and private intervention actions. In the case of interventions in precarious settlements, the sustainability might be confused with the habitability, which is the pretension of maintaining the quality of life for the inhabitants (Rueda, 1997). The

[1] Ignacy Sachs is a Polish, naturalized French, economist and researcher in the Institute of Advanced Studies in University of São Paulo, Brazil.

[2] Gro Harlem Brundtland is a Norwegian medical doctor, diplomat and international leader in sustainable development and public health.

concept of sustainability is broader because it encompasses other aspects, such as social, economic and environmental. Therefore, the habitability of the urban environment is an essential part in the search for sustainable urban development.

São Paulo's state government has been responsible for the program Sustainable Development Project of the São Paulo's Coast since 2007, which intents the development in municipalities along the coast. São Sebastião is one of the cities included and it presents a problematic background due to the vulnerable population who inhabit risk areas and do not have access to urban infrastructure. In addition, the city contains an environmental preservation region of the Atlantic rainforest. The aim of the present paper is to evaluate the relation between these current urban public interventions in São Sebastião and the possibility of its actual sustainable development.

2. Methods

The present research was initiated in the academic year of August 2015 to June 2016, during a final graduation paper at the Faculty of Architecture and Urbanism of Universidade Presbiteriana Mackenzie, São Paulo. It was completed at the end of 2016, during the first months of the Master's degree at the same school.

The final graduation paper[3] was part of an international program with the École d'architecture de la ville et des territoires à Marne-la-Vallée, which has consisted of a cultural exchange between the students and teachers from both schools, in partnership with the Companhia de Desenvolvimento Habitacional e Urbano (CDHU). The intent was to make a project proposal of social housing with mixed use in Camburi, one of the beaches in São Sebastião. For this reason, it was necessary to understand the situation of the municipality and the public policy that aims at its urban development.

First, a preliminary research of the Serra do Mar region and the Sustainable Development Project of the São Paulo's Coast was carried out. Issues such as legislation, population, economy, historical context, climate and relief were investigated. These secondary data are publicly provided by official Brazilian institutions, such as the urban diagnosis accomplished by the Pólis Institute and the socioeconomic censuses promoted by the Brazilian Institute of Geography and Statistics (IBGE). After this material was studied, the first visit to São Sebastião was made accompanied by CDHU professionals and the teachers from the both schools involved. In this visit to the city, on September 19th, 2015, an analysis was made for another bias, different from that one of the beach users. The first part of the visit was directed to the knowledge of one irregular community, called Vila Sahy, whose part is located in risk areas. It was possible to go through the whole site, make photographic records, talk to the residents and enter one of the houses. In the latter part, a car trek was taken along the highway to the city center, where the relation between the beaches and the urban centralities could have been perceived.

In sequence, meetings were held at the CDHU and at the State Secretariat for the Environment to discuss the subject. At the CDHU, the context of São Sebastião came under the guise as it was a condition for the projects that would be proposed to reallocate the families in danger. At the Secretariat, the main issue was the development of the municipality related to environmental preservation and the removal of people living in risk areas.

On October 14th, 2015, the seminar *Risquer l'habitat* was held at the École d'architecture de la ville et des territoires à Marne-la-Vallée, when several situations of populations living in risk areas over the world were presented, including the Serra

[3] The final graduation paper was teacher-led at the Universidade Presbiteriana Mackenzie by professors Dr. Valter Caldana Jr. and Dr. Maria Augusta Justi Pisani.

do Mar region[4] with focus on São Sebastião's case. The content learned at the event was used to complement the previous research on the subject.

The second visit was on October 20th, 2015, once again accompanied by teachers and professionals from the CDHU. This time, in addition to going to the Vila Sahy community and the center of São Sebastião, a social housing in the municipality of Cubatão was also seen. The visited housing complex is called Conjunto Habitacional Rubens Lara, projected by CDHU in 2009 for families who were removed from preservation and risk of landslide areas.

All secondary data studied in the preliminary survey were reevaluated after what had been observed on the visits and what had been discussed in the meetings. For the final graduation project, a social housing in São Sebastião was elaborated as well as a monograph in which it contained an analysis of the municipality's situation and questions related to the constructive technique used in the architecture project. This work was completed at the end of the graduation in June 2016, however, the interest in continuing the research caused it to be resumed in the Master's degree that was started in August 2016.

During the Master's degree, in the Faculty of Architecture and Urbanism of Universidade Presbiteriana Mackenzie, authors writing about sustainability issues were studied. Those who deal with the theme related to the development of cities and communities were used as theoretical references for this research. The academic basis has allowed a critical analysis of the current urban development policy of São Sebastião, which is the present paper's intention.

3. Results

The concern about the environment is crucial for the implementation of urban policies. The comprehension of the singularities in each geographic, climatic, economic and social context is indispensable to promote sustainable development of cities. Consequently, the present research on the case of São Sebastião involve the analysis of its background.

Serra do Mar is a Brazilian relief formed by a system of mountain ranges with approximately 1500000 meters of extension. It is found from the south of Paraná to the north of Rio de Janeiro, passing through the entire São Paulo's state, including the municipality of São Sebastião (Figure 1). The current vegetation is the Atlantic rainforest, where an endemic ecosystem can be found, such as birds, felines, and primates threatened with extinction. The Conselho de Defesa do Patrimônio Histórico Arqueológico, Artístico e Turístico (CONDEPHAAT), public body whose purpose is to protect, enhance and disseminate cultural heritage in São Paulo, registered and included this region in the Patrimony of the State on June 6th, 1985, due to its geological formation and the abundance of typical fauna and flora (Secretaria da Cultura do Estado de São Paulo, 2013). The climate in this area is characterized by high temperatures and rainfall, especially in summer when heavy rains are more frequent. Part of the territory belongs to an environmental protection zone called Serra do Mar State Park, which is the largest continuous reserve of rainforest in the country. Inside the protection zone, constructions are forbidden by law in order to preserve nature and due to the risk of landslide from the mountains.

[4] The context of Serra do Mar region was presented at this event by the professors Dr. Valter Caldana Jr. and Tito Livio Frascino, from Universidade Presbiteriana Mackenzie, and by the architect and urbanist Bruna Aydar, professional of the Project Management Unit (UGP) of CDHU.

Figure 1. *Location map of São Sebastião and Serra do Mar.*
Note. Elaborated by the author, 2017 (Google, 2017).

São Sebastião is one of the São Paulo's municipalities located on Serra do Mar's region and it is considered an *Estância Balneária*[5], which gives to the city the right to more funds from the state to be used for touristic activities. The mountain range is near the sea and the municipalities are located in a narrow strip of plain between them, including São Sebastião, Figure 2, which has a population of 73942 inhabitants and the total area is 399679 km², resulting in a density of 185 inhabitants per km² (Instituto Brasileiro de Geografia e Estatística, 2010). There are no airports nor rail system that serves the region. The highways giving access to this coastal city are Rodovia Presidente Dutra, connecting to Rio de Janeiro, and Rodovia dos Tamoios, which connects to São José dos Campos and it was recently duplicated to better attend user demand.

[5] *Estânica Balneária* is a title granted by the state government of São Paulo to coastal municipalities that present tourist characteristics and certain requirements such as: leisure conditions, recreation, specific natural and cultural resources.

Figure 2. *Map of the urban situation in the municipality of São Sebastião.*
Note. Elaborated by the author, 2016 (Instituto Pólis, 2012)

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Luxury condominiums for vacation homes were built on sites closer to the beach, 43256 properties are registered in the municipality and 38% of them are for occasional use (Instituto Pólis, 2012). The high real estate prices found there made them unaffordable to locals, therefore informal housing has become common and the protection zone was occupied. This type of occupation, besides compromising the environment, endangers the lives of those people who are living in an area of risk, Figure 3. There are 71 precarious settlements in São Sebastião, where 30% of the perennial inhabitants live, 53 of them occupy buffer zones of the Park, Figure 4. The population density there would range from 100000 to 350000 inhabitants per km², Figure 5 (Instituto Pólis, 2012).

Figure 3. *The irregular occupation Vila Sahy.*
Note. Photograph taken by the author, 2015.

Figure 4. *Vila Sahy and the State Park buffer zone*
Note. Photograph taken by the author, 2015.

Figure 5. *High population density in Vila Sahy.*
Note. Photograph taken by the author, 2015.

São Sebastião is divided into 36 beaches with predominantly residential use. Commercial, services and institutional uses are concentrated in the city center, especially on the beaches Maresias and Boiçucanga, where most of the perennial population lives. This scarcity of urban centralities is one of the reasons that the main economic activity of the locals is the provision of services in vacation homes. Urban infrastructures are a deficiency, for example, the basic sanitation, water supply, garbage collection and electric lighting are not enough to serve the entire population, Figure 6. The fragmentation of the territory and the excess of allotment for luxury condominiums has hampered the inhabitant's social relations and the integration of the municipality (Instituto Pólis, 2012).

Figure 6. *Popular solution to remedy the lack of electric system in Vila Sahy.*
Note. Photograph taken by the author, 2015.

There is a port of shipment in the city center, in the canal between São Sebastião and an island which is a municipality called Ilhabela. In 2013, an expansion project for the port was approved, drastically increasing the number of vessels and the volume of cargo transported. The project was suspended due to environmental impacts, such as the extinction of endangered species. Despite numerous scientific studies claiming that the consequences would be catastrophic and irreversible, the authorization to carry out was reconvened in 2015 (Escobar, 2015). On the other hand, the port’s expansion might increase the supply of formal jobs, which is a lack in the municipality (Instituto Pólis, 2012). Once the project has been resumed, it is imperative that there is a mitigation of its environmental impacts and the professional qualification of the local inhabitants to be employed in these new job vacancies.

The Directing Plans are specified by the Brazilian Constitution as an instrument to direct the development of municipalities in their economic, physical and social aspects. It is required that all municipalities with more than 20000 inhabitants, or within metropolitan areas, or areas of tourist interest must have a Directing Plan. In addition, it is established by law the popular participation in its elaboration, which can be done through the city hall website and public hearings where civilians and nongovernmental organizations are able to attend. Thereby, the Directing Plan becomes a basic instrument to orientate the urban development and expansion. It should contain the guidelines for ecologically balanced economic and social growth (Abiko and Moraes, 2009). The current Directing Plan for São Sebastião was created in 2011, in force until 2031 and a revision is planned for 2018 (Câmara Municipal de São Sebastião, 2014).

São Sebastião’s Integrated Development Directing Plan intents to occupy urban voids to stimulate growth in consolidated areas and to repress disorderly expansion. The guidelines are supposed to integrate urban and environmental improvements, proposing a division into macrozones, such as macrozone of environmental protection and macrozone of urbanization, with different types of use, occupation, vegetation cover and restrictions. Macro zones are subdivided into macro areas (Câmara Municipal de São Sebastião, 2014).

The macrozone of environmental protection is subdivided into two macro areas: Integral Protection and Environmental Conservation. The first one covers the territory of Serra do Mar State Park and presents greater restrictions for use and occupation. The second is a transition between the State Park and the urbanized sites, it concerns a large part of the municipality's territory (Câmara Municipal de São Sebastião, 2014).

The macrozone of urbanization is divided into four macro areas: Urban Qualification, Consolidated Urbanization, Structuring and Conditional Urbanization. The Urban Qualification area is amenable to urbanization and expansion. The Consolidated Urbanization one covers the neighborhood of the city center and coastal stretches in the north. Areas of Social Interest, called AEIS, are part of the Macrozone of Urbanization. They are the transition between Serra do Mar and urbanized sites. The Directing Plan aims to absorb low-income population and create new Zones of Social interest, called ZEIS. The difference between them is that the AEIS are areas where subnormal occupancy nuclei are already identified, whereas the ZEIS correspond to the areas properly regulated as such. According to the proposal, the ZEIS should include urban regularization plans, installation of social and cultural facilities, public spaces, services, and local commerce. The AEIS will be replaced by future ZEIS as they are regulated by specific laws (Câmara Municipal de São Sebastião, 2014).

The guidelines for municipal marine zoning are aimed at regulating the use of waterfront and promoting territorial planning in the Marine Zone, as well as the control of the pollution at the sea (Câmara Municipal de São Sebastião, 2014).

Sustainable Development Project of the São Paulo’s Coast is a public policy of the state government which has been in progress since 2007. The main intention is the sustainable development of the municipalities along the coast as it aims at the at the promotion of better living conditions for the entire population in a balanced way with the environment (Governo do Estado de São Paulo, 2004). The program’s proposals are:

- Attendance of 25000 families in risk areas, reallocating 16000 to new housing units and 9000 to urbanization zones all over the coast;
- Intervention and monitoring of 112 areas, including the implementation of the Environmental Surveillance System in Conservation Units and other areas of pressure due to irregular occupations and risk;
- Structuring of 26 Environmental Operating Rooms to share data of the Environmental Surveillance System;
- Training the prefectures for operation of the monitoring systems;
- Restoration of unoccupied areas in the process of urbanization and removal of risk areas;
- Implantation of the Ecological-Economic Zones in the Directing Plan.

A Regional Agenda for Sustainable Development was developed to the costal municipalities. The fundamental guidelines involve resettlement, provision of infrastructure and sanitation, as well as recovery, conservation and enforcement actions for environmental protection. CDHU is the public body that promotes the construction of social housing at the state level, including this case. Professionals responsible for the CDHU's projects stated that the commercial use will be provided in the new residential buildings, where the inhabitants of the risk areas will be reallocated.

This program works together with another one, called Socio-environmental Recovery of the Serra do Mar and Atlantic Forest Mosaic System, which has been executed in a partnership between the Secretariats of Environment and Housing. The main difference between the two programs is that the Serra do Mar Program operates in the irregular areas within the Park and in the management of conservation units, while the Sustainable Development Project of the São Paulo's Coast works with the irregular occupations in the areas of pressure surrounding the Park and in the integration between state and municipal entities with reinforcement in environmental inspection and reduction of risk areas (Governo do Estado de São Paulo, 2004).

4. Discussion

Despite being created more than 20 years ago, the ICLEI's (1995) definition for sustainable development is coherent in the contemporary world context, once it pointedly embraces the built conditions. Places on Earth that have not undergone human interferences are rare. Most of the planet presents constructed circumstances, regardless of the urban consolidation's degree achieved in each case. São Sebastião is a city where urban and preservation areas must coexist.

The Sustainable Development Project of the São Paulo's Coast has been in force since 2007. Interventions on this scale and scope take a couple of decades to reveal effective results. At the present moment, it is attainable to analyze the program's intentions. The guidelines and proposals presented are applicable in the situation of São Sebastião. which indicates the high probability of their achievement.

The Directing Plan, revised in 2011, is an instrument used in line with the Sustainable Development Project in São Sebastião. The occupation of urban voids was established as a guide to encourage expansion in urbanized areas, demonstrating the interest in control the city's growth so that the areas of risk and preservation will not be occupied. The inhabitants of risk areas will be reallocated to social housing in the ZEIS described by the Directing Plan as areas endowed with urban infrastructures. The popular participation in the Directing Plan's elaboration is a way to instigate popular environmental awareness.

Monitoring systems and the Regional Agenda are the program's proposals used to ensure the conservation of the Serra do Mar State Park. Meanwhile, the removal of families in risk areas, the provision of basic sanitation and urban infrastructures indicate the concern with habitability, which is essential for the promotion of sustainability in the urban environment.

New social housing built by CDHU for the population removed from risk areas may present different uses, such as commercial and service provision. The mixed use stimulates the emergence of new urban centralities and employments, which consequently weakens the fact that the local population depends economically on the summer houses. However, for the consolidation of the new centralities, it is also necessary an arrangement of institutional policies to promote their fomentation.

São Sebastião has the title of *Estância Balneária* which indicates its touristic potential for the realization of tourist activities. Since it is a region where there are areas of preservation, it is fundamental that tourism is carried out in a way that does not endanger nature. The implementation of infrastructure and services would attract tourists with greater intensity during the whole year, not only in the summer. Tourism as a significant economic activity generates more formal jobs for the local population.

According to ICLEI (1995), the proposals meet what is expected of a project that aims at the sustainable development since it seeks to preserve natural resources considering the needs of the vulnerable population. For this reason, the current public policies have the potential to leverage the actual sustainable urban development in São Sebastião.

5. Conclusions

Public and private interventions that use the term sustainable development only as a self-advertising, without considering the various spheres covered by this concept, are frequent. There are several cases in which the focus is the economic growth and environmental issues are added merely to enable the discourse of sustainability, as it is a subject that conveys a positive idea. On the other hand, there are also interventions that seek to reconcile social, ecological, cultural and economic guidelines, promising a real sustainable development

Since all the project's proposals are feasible, the consequences of their implementation will be verified in the long term. Therefore, the present paper's relevance is the critical analysis of a program entitled as a sustainable development of a municipality where the local population is vulnerable and the environmental issues are evident. Regarding the propositions and the São Sebastião's situation, it was ascertained that this project meets what is necessary to promote a sustainable development. The local community needs and the rainforest preservation will not to be subjugated to the economic growth.

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Sustainability of Social Design Laboratories: Infrastructuring of publics and Micro-planning in the development Design Networks

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Abstract

This paper presents the outcomes of the field work of doctoral research in design held at the Faculty of Architecture of the University of Lisbon, which is based on the possibility of expert and non-expert designers acting jointly in co-designing processes, which make the infrastructure of design networks feasible from the engagement of young people living, working or studying in neighborhoods stigmatized by poverty and social vulnerability. From January 2016, participatory design dynamics are being conducted in neighborhoods located in Lisbon, Portugal; and in São Luís do Maranhão, in Northeastern Brazil. Here we present the developments of the field study conducted in the Desterro quarters, the historical centre of São Luis do Maranhão, Brazil, where the "LABDES - Laboratório de Design Social do Desterro" (Social Design Laboratory of Desterro) got started - A platform for collaborative research based on design experimentation was created in there which is intended to search for solutions to complex social problems.

The question that arises in this experiment is how to continue the LABDES platform beyond its initial scope. This involves the responsibility to reflect and to define strategies to ensure that the participatory design initiatives can continue when the expert designers cease to operate in the design network, understanding how they start, operate and not least, how they leave a project behind. In other words, we question the sustainability of the participatory design project when the designers or design researchers no longer have the central role in these initiatives. We understand the ability to establish lasting relationships between various stakeholders to promote continuous appropriation of the problems of a particular design network as project sustainability. At first, reflections are presented from the theoretical framework of participatory design, co-design, micro-planning, infrastructuring and living labs. After this first phase, as the LABDES design network was established, which used the participatory design approach, guided by "bottom-up" decisions and "peer-to-peer" interactions involving designers, members of the Desterro neighbourhood community and other stakeholders. The results presented explain the difficulties for the engagement of young residents. Apathy and resentment caused by the lack of continuity of actions undertaken in the past, hidden agendas, conflicts of power, the need for leadership and the legitimacy of the established leaders, the scarcity of resources, the impact of the use of social networking tools and the influence of the power of drug trafficking are the challenges that are presented to the sustainability of the lab project. In the discussion of the issues, planning, participatory design and low complexity prototyping tools were used as well as Action Research being used for the collection of data for action in the field. We conclude the paper by discussing strategies to support designers and researchers in their practice for training, performance and sustainability of design networks.

Keywords: social design, design labs, infrastructuring, micro-planning, participatory design

1. Introduction

This paper presents the outcomes of field work of the research underway in the PhD in Design program of the Faculty of Architecture of the University of Lisbon, entitled "Social Design Laboratories: infrastructuring of design networks in socially vulnerable neighborhoods" whose objective is to develop a Critical reflection of the action of the expert designers who work on social design initiatives, using the concepts of micro-planning and infrastructuring of publics. This is done through the project of design networks constituted as "Social design laboratories" which seek to encourage actions focused on local participatory processes, analyzing their training dynamics from the performance of youngsters between 15 and 24 years old, in order to seek Solutions to social problems and to the sustainability of the network itself.

Since January 2016 the doctoral candidate has been conducting participatory design dynamics in two socially vulnerable neighborhoods located in Amadora, Lisbon, Portugal; and in São Luís do Maranhão, northeastern Brazil. With this it has been possible to identify issues related to the demands and potentialities, as well as the complexity for the formation of design networks in these territories.

The unfolding generated by the beginning of the fieldwork together with the bibliographical research, presented to the doctoral candidate the importance and complexity of the designer's performance in the formation of project networks in communities in situations of social vulnerability.

This "capacity" or "feature" of design is called “designerly” and is usually exercised when faced with environments, issues and problems that require a solution, and we can change them guided by our wants and needs (Stolterman, 2008; Cross, 2011; Bannon and Ehn, 2013).

This insight has broadened the importance and understanding of design. Manzini (2016) emphasizes this by stating that in the present day the term "design" assumes three different meanings. The first is "diffuse design" which refers to the natural human ability to adopt a design approach, which results from the combination of critical sense, creativity and practical sense. The second is the "specialist design" where we find the designers Professionals who, by definition, must be endowed with specific skills and design culture, and the third is co-design, where we find the total design process resulting from the interaction of a variety of disciplines and stakeholders - end users and design experts Included.

This research is based on the possibility of specialist designers and non-specialists working together with other actors to create project networks that seek solutions to complex problems in neighborhoods that are in a situation of social vulnerability.

The myriad problems faced today require all people to "design" and "redesign" their everyday and lifestyles through a "complex and interwoven system of design processes that involves individuals, enterprises, non-profit organizations, institutions local and global contexts that imagine and put into practice solutions to a variety of social and individual problems” (Tuomi, 2003, von Hippel, 2004 apud Manzini, 2008, p.96).

The complex problems we face are those that are open, without specific formulations, that do not have a restricted number of possible operations and solutions. This concept relates to the idea of "wicked problems" proposed by Horst Rittel in the 1960s, “class of social system problems which are ill-formulated, where the information is confusing, where there are many clients, and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing" (Rittel, 1967, apud Buchanan, 1992, p.15).

Manzini emphasizes that the recognition of a large and complex problem must be faced not by seeking a single, large and complex solution, but by dividing them into "less complex and smaller-scale sub-issues" (Manzini, 2016, p.56). This is possible when we "embrace complexity" as opposed to trying to control it through top-down hierarchical command structures (Green apud Manzini, 2016).

For Josephine Green (2013, p.57 apud Manzini, 2016), "Social innovation shows us how to embrace complexity," and this occurs when local initiatives directly involve the people affected - that is, those who know the problem best and Are directly involved. In this direction, the formation of design networks that use the participatory design approach, driven by bottom-up or peer-to-peer decisions involving designers, community members and other stakeholders can provide an effective way to achieve Solving complex problems.

Bannon and Ehn (2013) argue that there is a renewed interest in understanding innovative bottom-up practices, which seek to examine in detail the vernacular manifestations of "improvisation" and to make use of available resources in areas with scarce resources. They also say that it is necessary to involve users and 'prototypes' in a project and to explore collaboratively potential future use, what they call "design-after-design":

> Designing for a continuous appropriation and redesign where infrastructuring work becomes the main activity. Infrastructure is a central issue, since contemporary design demands extensive collaboration over time and among many stakeholders. (Bannon e Ehn, 2013, p.57).

This infrastructure-building activity is a particular or practical form of participatory design that develops and provides resources and socio-material experiences through linkages with the aim of creating an audience oriented by an issue (Dantec and DiSalvo, 2013).

Infrastructuring is supported by the distinction between participatory design focused on one immediate use and another focused on future use, structured in such a way as to create a fertile ground for sustaining a community of participants, which can bring light to issues related to the maintenance of design networks. In this sense, it works to create "socio-technical resources that intentionally allow adoption and appropriation beyond the initial scope of the project, a process that can often include participants who are not present during the initial design" (Dantec and DiSalvo, 2013, p. 247).

Karasti et al. (2008) complement by stating that infrastructuring has emerged as a way of promoting global community interests. Integrating with ongoing community activities and being incorporated into multiple contexts relevant to communities over extended periods.

Micro-planning is aligned for this purpose because it is a design process where development is based on the experience of communities. It allows the formulation and implementation of programs that promote the common sense in a local, fast and collaborative way. It is a "scaling" process, which is based on instituting the capacity to manage decisions locally, as well as to act from them, as well as to implement the project tasks (Goethert et al., 1992).

In this way, it encourages the organization of actions, providing tools that allow the rapid development of plans in small and medium-sized communities, designed with broad participation. Where it incorporates several quick and simple techniques for the preparation of plans, besides its execution and monitoring, presupposing the necessity of a strategic planning allied to spontaneous local action.

Micro-planning is a learning and training process built to move parallel to its implementation, following the principles of “learning by doing” and then collaborate to boost local development (Gomez et al., 2007).

Goethert et al. (1992) state that the assumptions of their methods are supported by the challenge of addressing four main issues. The first of these is related to implementation, because there is a lack of adequate framework for articulating the problems, definition of solutions, besides building consensus and teamwork.

The second is related to the level of mediation between public and private organizations, donors and implementers, as well as policies and projects. The third points out the lack of sufficient incentives for the production of non-standard local solutions. The last one deals with learning, which is not enough, and most of the time it is not aligned with practical actions, ending with bulky reports that are rarely used.

It was possible to observe in previous experiences of the doctoral candidate acting as a design consultant, that this last question constitutes one of the main reasons for a great feeling of frustration on the part of the inhabitants of communities that have undergone similar initiatives in the past, the lack of knowledge and Articulation capacity needed to implement the projects. And this constitutes a great barrier for the entry of new researchers or consultants in social design in the communities, by generating apathy and discredit for the engagement around new initiatives.

What happens is that some of these processes when put into action, leave out the people who will be affected by their results. The principle of participatory planning and design is important here, therefore, in two ways.

It is important from the technical point of view as a way to increase the efficiency of creation, production, administration and maintenance. And also from the social point of view, because without a great measure of self-determination, ownership, and control, people will generally be expecting a "savior," someone who comes out of nowhere and solves that presented question. And when, as happens most of the time, this person does not appear, they enter into a state of apathy and resentment, deteriorating environments quickly in the physical, political, and social sense (Goethert et al., 1992).

Aiming at understanding these issues, the general objective of this research is to develop a critical reflection of the methodologies used in Social Design initiatives, where micro-planning and the infrastructures of publics to design project networks led by young people who live, study or work in neighborhoods in situation of Social vulnerability, in order to solve demands and potentialize opportunities, observing and analyzing the interaction nature of its actors and processes and how they can achieve a project sustainability.

The territory where the fieldwork has been developed since January 2016 was chosen from an experience of the doctoral candidate in the year 2007, when at the time he acted as design consultant for SEBRAE - Brazilian Service of Support to Micro and Small Enterprises , In a project called "Sustentar" to stimulate sustainable local development through the valorization of cultural diversity in the district of Desterro, located in the region of the Historical Center of São Luís do Maranhão (IPEA, 2006).

This experience has brought the doctoral candidate closer to the region's leaders and residents, which could contribute to a new approach. This option to act in a field where there are "known people" may facilitate access to other residents of the neighborhood. This freedom of choice of the researcher is important because "social closeness and familiarity effectively ensure two of the main conditions of nonviolent communication" (Bourdieu, 1997, p.697).

These conditions allow the investigator to give guarantees so that the investigated person has "freedom to speak without threats and an agreement, even non-verbal, on the content and forms of communication" (Felippe, 2004, p.14).

Desterro is located in the historical center of São Luís, and is a neighborhood that forms part of the initial nucleus of the city. It consists of the urban complex that also includes the neighborhood of Praia Grande, where the second was the large commercial center of São Luís, the first being residential and port support (SÃO LUÍS, 2005 apud Noronha, Oliveira and Rodrigues, 2008) (figure 1).

Figure 1. *Region of Praia Grande and Desterro. Adapted from São Luís (2005) and Ferreira (2012) in Google Earth image.*

While in the eighteenth and nineteenth centuries Praia Grande was a neighborhood of Portuguese merchants, Desterro was inhabited by Brazilians, people with less noble occupations, usually related to work in the port, and other functions such as caulking, locksmiths, carpenters, practitioners, among others (SÃO LUÍS, 2005).

Desterro carries innumerable stigmas since its foundation. From a poor neighborhood that supplied labor to the region of Praia Grande, it was later linked to prostitution, and today it suffers from an image linked to violence and trafficking and drug use.

For many, the neighborhood is considered a dangerous place to avoid, a forbidden area, a "no-go area" where crime, marginality and moral degradation are present, and only members with less value to society (Wacquant, 2007; Gustafson, 2011).

Almost ten years after the investigator's first contact with the Desterro community, stigma persists, encouraged by the public image related to the growing deterioration of many of its historical constructions, caused by the absence of public policies to preserve the memory of the region, Presence of trafficking and drug users.

However, as was seen in 2007 when the “Sustentar project” was developed, it is still possible to identify a great cultural and creative potential in the community of Desterro, expressed through its manifestations and ways of life.

It is important to emphasize that Desterro preserves its traditions through the expression of diverse manifestations, such as: storytellers, folk dances groups, traditional cuisine, the samba school Flor do Samba, founded in 1939; The feasts of the saints in the month of June; And the Orixás procession held every year on September 8, when the foundation of the city of São Luís is celebrated.

The neighborhood also has a network of small services that include graphics, visual communication companies, paint and handicraft workshops, bars and snack bars, theater groups, recording studios, among others.

The perimeter of the neighborhood is the Church of São José do Desterro, the first to be built in the city; Public institutions, educational institutions, as well as the Convento das Mercês, a building of great historical value and with a strong tourist appeal (Figure 2).

Figure 2. *Aerial view of the Convento das Mercês, construction of 1654, in the image decorated for the feasts of the saints in the month of June (Source: Kartagener2, Flickr, 2013).*

Since January 2015, actions have been developed in the areas of social assistance and security, aimed at reducing problems related to drug trafficking and use in the neighborhood. At that time there was a joint action between state and municipal agencies for the removal of residents and drug users from an abandoned house located in Desterro.

The building, according to information of the Military Police of Maranhão, was one of the main points of sale and consumption of drugs in the Historical Center (O Imparcial, 2015). Dozens of people, mostly crack users, used the place as a shelter irregularly, which also housed children and elderly people in an unhealthy situation (Figure 3).

For Manzini, this scenario that combines "demands and opportunities" is very favorable for the consolidation of "creative communities". The demands stem from the problems of everyday life. Opportunities, however, arise from the various combinations of three basic elements:

> The existence (or at least memory) of traditions; The possibility of using (in a suitable way) a series of products, services and infrastructures; The existence of social and political conditions favorable (or at least able to accept) the development of diffuse creativity. Manzini (2008, p.65).

The demands and opportunities presented, together with the proximity of the doctoral candidate to the field, establish a fruitful scenario for initiatives that promote the formation of design networks through design. Collaboration between expert designers and non-specialists are beneficial to enhance capabilities that facilitate the search for solutions to the complex problems that the neighborhood of Desterro faces.

Figure 3. *The vacating action of a house on the corner of the streets of Palma and Health in the Desterro (Source: O Imparcial, 2015).*

2. Methods

In January 2016, the investigator began a process of rapprochement with the residents of the neighborhood of Desterro, aiming at consolidating their research object. At the time, a proposal was made to create a "collective of ideas" a "laboratory of experiences" with the intention of forming a project network that could pick up questions raised at the time of the “Sustentar" project, which took place in 2007.

The initiative was based on a design and collaboration workshop, which should involve young people aged between 14 and 25 years, living, studying or working in the district of Desterro. The workshop was supported by the IFMA - Federal Institute of Education of Maranhão, which gave the space to do it; And the Foundation of the Republican Memory, managing entity of Convento das Mercês.

Despite the efforts made by neighborhood leaders to engage local residents, only two young residents volunteered to participate with a group of IFMA students.

The workshop objective was to provide the favorable environment for the formation of a project network initiated by the youth group and guided by the doctoral candidate. The group should propose viable implementation solutions with resources provided by the project network itself and that did not have the initial support of state bodies and at the same time encourage community sentiment, seeking to generate more lasting links that would allow the network to be sustainable. From the ideas proposed, one would be chosen from the analysis of its complexity.

For Binder (2007a), the workshop is a model that has gained considerable attention, whether users and designers participate collaboratively in project activities, in situations where many stakeholders are involved, in the emphasis as a collaborative vehicle, or in Design research in an academic environment.

The workshop began with a creative exercise, the Egg Drop Project, a project challenge that proposes the construction of a structure that will protect an egg from falling at a certain height, with the goal of keeping it intact. The exercise served as the basis for a discussion of how the designer deals with issues such as time and the scarcity of resources to solve a defined problem.

In order to facilitate the participants' understanding of how the specialist designer works and to explain in a simple and accessible way the possibilities of innovation through design, the workshop explored for five days the "double diamond design process" model proposed by the Design Council UK. The process is divided into four distinct steps that facilitate the understanding of how the design process works (Design Council UK, 2005).

The first one is the "Discover" where the context is explored in depth to understand its level of complexity. The second stage is the "Define" where the issues that arose in the previous stage are discussed so that the points are clarified and the objectives defined. Seven ideas were generated to bring solutions to the issues of public safety, leisure spaces, waste cleaning and treatment, access to medical care, child day care centers and decent housing, preservation of memory, among others.

The next stage, "Develop" includes the elaboration and testing of the proposed solutions, at that stage prototyping tools were used to refine their concepts, evaluating which would be the idea with more feasibility for implementation.The last one "Deliver" the solution was evaluated to verify if its objectives were met, besides being structured for its implementation (Figure 4).

Figure 4. *Application of the model "The double diamond design process" (Source: doctoral candidate, 2016).*

The group worked with the micro-planning perspective, and so chose an idea that could provide the incentive for community participation, making it the starting point for other transformations in the neighborhood. Thus, a proposal for intervention was developed in an area where there used to be a colonial-style house, which, according to residents, fell apart more than 40 years ago. This would require the cleaning of the land, the construction of temporary furniture from recyclable material, a micro-garden, the painting of one of the walls that would provide the projection of films for the community (what they called "cinema -wall"). Working the issues that met the needs of areas of leisure and interaction in the district of Desterro (Figure 5).

Figure 5. *A solution developed by the group. (Source: doctoral candidate, 2016).*

In this sense it would be necessary to present the solution to the residents and the expansion of the project network with the necessary skills for its implementation, in addition to the formation of a decision group that could think the evolution of the action in the space and from the established links, propose New interventions in the neighborhood. Thus, the group invited the leaders who had collaborated in the engagement phase, and these were responsible for taking printed invitations to the other residents for a presentation that was made in the same space that would pass through intervention (Figure 6).

Figure 6. *Presentation of the intervention proposal (Source: doctoral candidate, 2016).*

At the time of the presentation, it was suggested to create communication channels that would help to circulate information to a possible network of stakeholders around the action, and so a group was organized on Facebook and another on WhatsApp, the most used social community. The use of these tools could streamline the participation process by allowing people to engage in activities and share their interests and concerns about the project.

For Bannon and Ehn (2013), tools such as Facebook, Twitter, among others, can be important for the design of Participatory Design, allowing new forms of expression, dissemination and participation. They can bypass the traditional media channels allowing a more fluid disclosure, but with the risks of the lack of editorial curation.

The channels of communication established through social network software were fundamental for the doctoral candidate to observe the unfolding of the process of establishment of the network, since due to the academic calendar of the doctorate it was necessary for the doctoral candidate to return to Portugal. In addition to the individual reports, it was the analysis of the information generated in Facebook and WhastApp that presented the complexity in the construction of people's links with the design network.

In this phase, several questions were raised, where the first one was related to the ownership of the chosen space. Because it is an area listed as Cultural Heritage of Humanity by UNESCO. It was identified that its true owner was the Foundation of the Republican Memory, entity that manages the Convento das Mercês, which already supported the initiative and saw the intervention action with good eyes, provided that the rules of preservation for the region were respected. .

The other issues such as the detailing of the ideas, the cleanliness of the land, the resources needed for the action, and the schedule of action were being defined as the assemblies were held. The doctoral candidate participated using videoconferencing features like Skype or Google Hangouts.

Between the "design and collaboration" workshops held in January and the construction of the furniture in July 2016, twelve assemblies and five actions were carried out, including: public presentation, space cleaning and three "cultural occupations"which consisted of In the projection of films, children's plays and mini-market of products and artisan foods (Figure 7).

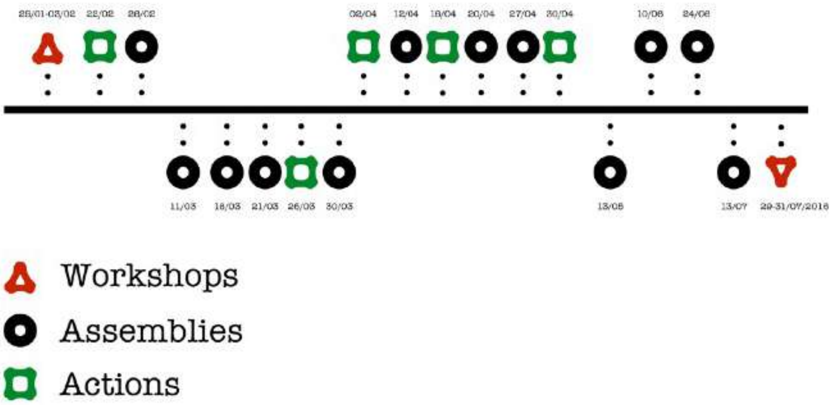

Figure 7. *Activities carried out to establish the project network (Source: doctoral candidate, 2016).*

However, from the cleaning of space, the participation process gradually emptied. That which was formerly considered an abandoned place, in passing, a "non-place", became a motivating element for hidden agendas that deteriorated the capacity of continuity of the project network. A hidden agenda is a personal goal of a member of a particular group that the other participants are unaware of and that can jeopardize collective goals (Zastrow, 2008).

The decision of the continuity of the action and accomplishment of the furniture workshop was shared between some members who still worked in the project network and the doctoral candidate, when it was verified that it would be important to finalize the previously defined schedule so that a "project abandonment" Would make it difficult to re-establish the network (Figure 8).

Figure 8. *Workshop on the construction of recycled material furniture (Source: doctoral candidate, 2016).*

According to information from the neighborhood leaders, only two days after the temporary furniture was placed on the site, part of it disappeared and another was allegedly "sold" by drug users.

Thus, a qualitative methodology was adopted, through a two-stage research, where the entire process (mainly the second stage) was adapted as the needs and questions were presented during the investigation.

The research was exploratory, where its objective was to identify the problems to build criteria and understanding of the research context. The first step was the use of semi-structured interviews to analyze the motivations for participation and the agendas of the actors in the action held in 2016 in the neighborhood of Desterro.

Being the main object of this investigation, the projective networks initiated by young people who live, study or work in neighborhoods in situations of social vulnerability, we use as guide for the interviews four important components for the understanding of the concept of young participation: the context; Motivations; Power relations; And the effects of participation (Rizzini et al, 2008).

Four interest groups were defined for the interviews by the doctoral candidate through the voice dialogues, e-mails and written messages via the Internet: the young people who participated in the action, the leaders who supported the action, the representatives of organizations that participated in the action, and Lastly, what the locals called "The Others There," a group identified as those who hindered action and supposedly destroyed their results.

From the analysis of the elements of motivation for participation and the perception of the experience carried out between January and July 2016, we hope to point out more consistent ways to deepen the questions in the field research.

We will then go to the second stage of field research, where we will use a methodology of interventionist research, action research, which according to Michel Thiollent is:

> An empirically based type of social research that is conceived and carried out in close association with an action or with the resolution of a collective problem and in which researchers and participants representing the situation or problem are involved in a cooperative or participatory manner (Thiollent, 2011, p.20).

The researcher's role in this type of research is active both in the analysis of the problems presented and in the follow-up and evaluation of the unfolding of the actions that were delineated from the problems. Thiollent says that it is not simply a question of collecting data or reports to be archived. In this type of research the researchers must act "in the reality of the facts observed" (Thiollent, 2011, p.22).

The next step was the alignment of action research with design research. In 2016 we worked in Desterro with the use of the workshop as a strategy to structure the research in design.

However, Binder (2007) proposes that design research be conducted as a "laboratory for change." He emphasizes that even if this approach can make extensive use of the workshop format, the notion of a laboratory where stakeholders explore solutions In an open and collaborative way through a transparent and scalable process, can provide a more consistent framework for design research.

In this type of "laboratory" the design process must be conducted in a way where experience is given good use, where projects should be organized as "experiments." The formation of such laboratories is one of the first moves to be made in the formation of infrastructure of a participatory environment, to construct a favorable and productive scenario for social innovation (Manzini, 2015).

We were inspired by the "Living Lab" concept. For Boronowsky et al. (2006 apud Concilio and Riso, 2016) Living Labs are a format of cooperation where resources and opportunities are shared with the focus on finding answers to problems, in order to help each other achieve their goals. They are environments where people (both experts and non-specialists) interact and work in an active way, designing and implementing cooperative experimental activities that result in collective learning and shared understanding.

Bannon and Ehn (2013) complement by stating that Living Labs act with a belief in the right of people to co-determination of their living and working conditions, awareness of how participation can lead to more appropriate and usable systems, the need To use different modalities of experimentation in the development of solutions, besides the value of working with prototyping forms during the design process.

They also emphasize that the main focus of the Living Labs approach is to prioritize the importance of the role of users and real-life contexts in innovation. This precept is aligned with the purposes of micro-planning, the knowledge used in this research.

The Social Design Laboratory will seek to solve problems and respond to social needs or issues related to the communities studied.

Veiga and Almendra (2013) argue that these "social" problems are often not only "social" but also "cultural", "environmental", "economic" and "political". However, since these are inherent aspects of the human condition and all are produced by society or at least are their responsibility - environmental - in a final analysis, all of them can be considered a "social" issue.

The action developed in the first months of 2017, used the foundations of micro-planning and infrastructure as a theoretical basis for the constitution of a "Social Design Laboratory" which in turn was supported in the format of a Living Lab.

3. Results and Discussion

In the period from January to March 2017, fourteen interviews of the eighteen predictions were carried out and they took place parallel to the process of constituting the Laboratory. Of the eighteen planned, fourteen were held.

The main goal of LABDeS was to understand and seek solutions to complex social issues in the Desterro community, through the formation of a project network initiated by young people who live, work or study in the Neighborhood region, seeking the development of a socio-technical infrastructure that enables the construction of links that enable its sustainability.

The four components used for the interview script: the context; Motivations; Power relations; And the effects of participation pointed to issues that were not clear at the time of the 2016 action.

In the contextual issues, the interviews reinforced the stigma faced by the neighborhood. In addition to the current image linked to drug trafficking and violence, the area of prostitution that existed until the end of the 1990s, popularly known as "zona" or "28", because most of the brothels were located on 28th Street July, serves as a symbolic frontier for internal divisions and reinforces the negative image of the neighborhood.

The term "zone," "I am from the zone," "I live in the zone" functions as an instrument of "self-stigmatization" expressed between everyday relationships. The inhabitants of the region "from above" which corresponds to the area where in the past understood the "zone" is stigmatized by the inhabitants of the region "from below" as "place of people of low moral level". The "Desterro from below" is classified by the inhabitants of the region "from above" as "pseudo-elitist" and "pseudo-moralist" (Ferreira, 2012, 36).

These divisions make it difficult to combine efforts around common goals. Just by chance the area chosen for the 2016 action was located on this border between the two regions and although the leaderships on both sides supported and worked for the intervention to take place, other leaderships that did not appear in the forums established in the neighborhood worked from An active form for the non-engagement of the residents and the emptying of the group constituted around the action. They were classified as "the others there" that referred to representatives of an entity that operates on the site; And the "movement personnel," the way residents treat those who are linked to drug trafficking.

Several participants were intimidated not to take action because the land "already owned" and that was to "leave as is" and these adverse facts were not shared with the investigator through the possible means, the leaders only said: When you return, we talk in person"(verbal information, 2016) [1].

For other interviewees who do not live in the neighborhood, the fact that only the leaders participated and the absence of other residents who were personally invited to the assemblies, caused mistrust, discouragement and questioning whether "action was really necessary for the residents"(verbal information, 2017)[2].

[1] Conversation with neighbourhood leadership by WhatsApp chat.

[2] Interview given by the young people who participated in the action 2. [Feb. 2017]. Interviewer: Carlos Delano Rodrigues. São Luís, 2017. 1 file .mp3 (38m45s.)

In the "power relations" component, the dynamics, established leaderships, how they exert influence on the participation of residents in community actions, and other leaderships that do not act openly in the decision-making forums of the Desterro, but were able to impose the demobilization of the group Constituted around the action in the year 2016.

When we deal with the low participation of the young residents of the neighborhood, an apathy was identified related to the lack of opportunities and expectations for the future, low schooling, domestic violence, harassment of drug trafficking by presenting possibilities of access to the consumption of goods and Products, "an easier path" as some report, and the perception that many entities and researchers have promised changes that have never materialized, causing discredit and withdrawal from new initiatives.

When we refer to the effects of participation, most spoke of the disappointment in not being able to demonstrate that the success of the action would be positive for everyone in Desterro, the perception that "people do not want to help and so nothing changes in the neighborhood" (verbal information , 2017)[3]. They said they believed that the design network needed clear leadership and that communication channels could not reach all those interested in the process, that information was fragmented and that it also discouraged many people who left the network during the process.

The interviews presented important questions for the reconstitution of the design network in Desterro, they ran parallel to the engagement of participants to the Laboratory of Social Design between January and March 2017.

With the collaboration of the House of the Neighborhood of the Desterro we present the investigation for a group of young residents of the neighborhoods of Desterro and Praia Grande. The conversation was marked by good interaction between the participants, where questions were asked about the approach, the functioning, the possible personal and collective gains. It was explained that we would function as an "assembly of doing things", because in the Brazilian northeast we use the verb "to thing" in the sense of "action", "solving something" (Figure 9).

Figure 9. *Presentation of the research and the proposal of the Social Design Laboratory of Desterro (Source: doctoral candidate, 2017).*

The process between engagement, viability of a physical space and materials and the first attempt to start the "participatory creative assemblies" occurred in about twenty days. However, only three young people from this initial group remained in the initiative, which required further interviews with the new interest group, "The youths called for LABDES". The intention was to verify the motivations for the permanence, quitting or abandonment of the laboratory.

A second stage of engagement was started with the dissemination of the laboratory through the creation of profiles on Twitter and Instagram, and visits to the homes of young people in the neighborhood. Parallel to this movement were made visits to IFMA - Centro Histórico classrooms. After this process we were able to constitute a group of fifteen participants.

[3] Interview given by the leaders who supported the action 2. [Feb. 2017]. Interviewer: Carlos Delano Rodrigues. São Luís, 2017. 1 file .mp3(47m36s.).

The "participative creative assemblies" began on 11/02/17 with a group of five youth from the neighborhood, seven from the IFMA and three others who demonstrated interest through social media software. At first the group of young people participated in design challenges that were interspersed with thematic discussions on design thinking.

Then they were invited to map the problems and opportunities of Desterro, through the recognition of the territory and interaction with people who live and / or work in the neighborhood. From this mapping the LABDES members sought solutions that could solve the demands and potentiate the opportunities present in the Desterro, generating eight proposals presented by the participants (Figure 10).

Figure 10. *Participatory Creative Assemblies of LABDES (Source: doctoral candidate, 2017).*

Using open access rapid prototyping tools, the participants visualized the complexity level for the execution of the proposed ideas, and so they chose one of them, where the challenge was to be able to implement it in a period of one month. The idea chosen was "Rua da Palma Viva” whose main purpose was to intervene in a street space of the same name, with the presence of colonial houses abandoned and degraded, where the accumulation of garbage is quite significant (Figure 11).

Figure 11. *Colonial houses in abandoned state in Palma street and development of the intervention proposal (Source: doctoral candidate, 2017)*

During the process of developing the idea until its implementation on April 1st and 2nd of this year (2017) (Figure 12), a number of issues were addressed for the infrastructure of the Laboratory, such as: the form of communication of the assemblies, the conflict between the possibility of using tool kits that would collaborate with the organization and planning of ideas, and the willingness and haste to "do it soon" The challenge of equating personal and collective agendas in voluntary work; The difficulty of overcoming the initial bonds of the young residents of the neighborhood, IFMA students and the other participants improving the cohesion of the group; The need for some residents to have personal gains to collaborate with action, among others.

Figure 12. *Day of action "Live Palm Street" (Source: doctoral candidate, 2017)*

5. Conclusions

The problems related to the implementation of the ideas proposed for the neighborhood of the Desterro were diverse and the questions about the role of the designer in a new creative context where there are no "clients" or companies that bank the design works, allied to a dependence of institutions Which finance social projects, presents itself as a challenge (Del Gaudio, Oliveira and Franzato, 2016). In this sense, since the practice requires a complex dynamics of time and funding, would the area of social design be a possibility of sustainable survival for a professional designer?

The process initiated in 2016 at Desterro, which reached its climax in the action "Rua da Palma Viva" (Figure 13), presented other issues.

Figure 13. *Results of the action "Live Palm Street" (Source: doctoral candidate, 2017)*

The first one is related to the possibility of establishing what Manzini (2008) calls "enabling solution", "a system of products, services, communication and what else is necessary to implement the accessibility, effectiveness and replication of a Collaborative organization "(2008, 84). This is not a simple task because it runs counter to the quality of interpersonal relationships because they are fragile and are always at risk for each action, requiring constant mediation.

The second relates to the need to identify the hidden agendas of leaderships and organizations that work in these territories, because in many participatory initiatives, they divert the focus from collective goals, discouraging participation.

The third refers to motivation for participation. How to develop strategies to engage residents of vulnerable neighborhoods to remain in the design network, without first of all, financial gains can be offered, and in most cases these people have more urgent demands for survival.

In the context of the maintenance and replication of these initiatives, it would be possible to explore the collaborative capacity of new online communication technologies as a stimulus for people to act politically in the offline world. (Castells, 2000, Sennett, 2012).

The responsibility of researchers to avoid misconceptions in communities by proposing participatory actions in socially vulnerable neighborhoods should be a moral imperative. In this sense, it is also necessary to evaluate whether ephemeral or "low-cost" interventions, where resources are made available by researchers, universities or through collaboration between collectives and volunteers, could be contributing to a precarious state action in these territories and serving only as a palliative to the most urgent problems.

The difficulties for the engagement of young residents and the apathy and resentment of the adult residents, due to the lack of continuity in actions developed in the past, present themselves as barriers to be transposed. Conflict management, the balancing of individual and collective agendas, and the establishment of leadership in the design network also need to be deepened.

These issues present a great challenge for the sustainability of participatory design, since this depends on the physical presence of the designer in the territory for a long period, requiring a reinforcement of human and financial resources, in addition to using more basic tools than the designers are Accustomed to using. This research intends to continue to deepen the issues inherent in project networks, with the purpose of helping to propose ways for sustainability.

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The role of railway for sustainable mobility in Algarve, Portugal

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Abstract

The railway line of Algarve in southern Portugal was built between the late nineteenth century and early twentieth century. Although the line has driven the development of the region at the time, now it is not adjusted to the needs of the population and the region; the stations are removed from some of the main tourist areas and other major traffic nexus. Public transportation modes are not well linked to each other, so private car is the main transportation means. Car traffic is the largest energy consumer and air polluter, including greenhouse gas emissions. Inter-modal public transport is crucial to fostering more sustainable mobility in urban areas. The goal of this research was to analyze the effects of redevelopment of the Algarve railway and the role it may have in the development model for the region. Three topics of research are reported: an analysis of current shortcomings of the system, based on historical data and a survey to the municipalities; the development of a model to refit the old railway; and an analysis of effects of the proposed model on sustainability indicators in the region. The simulations carried out on various railway-refitting scenarios indicate a qualitative improvement of sustainable development indicators. Better rail service will increase quality, reliability and efficiency in regional mobility, along with an incentive for better land use management. Even modest investments in the railway will cause significant improvements in air quality, road congestion, road safety and accidents, noise and CO_2 emissions. Conservative best-case scenarios suggest reductions of up to 24% in overall transport-related CO_2 emissions in the region, plus interesting results in other environmental and socio-economic indicators. In short, a shift to rail will contribute significantly to a more sustainable development of the region.

Keywords: Algarve Railway Line, railway mobility, Algarve, Sustainable mobility

1. Introduction

Algarve is the southernmost region of Portugal, a major tourist destination. The railway line of the Algarve was built between the late nineteenth century and early twentieth century and has a length of 140 km, passing through the region from east to west, from Vila Real de Santo António to Lagos. Although the line has driven the development of the region at the time, now it is not adjusted to the needs of the population and the region. The railway stations are removed from some of the main tourist areas and other major traffic nexus such as the airport and the University. Public transportation modes (road, rail, air) are not well linked to each other to provide an efficient mobility. Private car is the main transportation means — a particularly inefficient means in a touristic region suffering from chronic congestion in summer.

In the Algarve as in many other places, car traffic is the largest energy consumer and air polluter, including greenhouse gas emissions. Inter-modal public transport is crucial to fostering more sustainable mobility in urban areas.

The current paradigm of transport has become unsustainable. Transportation in Portugal, as in the rest of Europe, remains very dependent on fossil fuels and the major emitter of greenhouse gases (GHG). Many people in academia and in the political arena have defended a paradigm shift, in which increased quality, efficiency and inter-modal public transport is crucial to fostering their use in urban centres.

The goal of this research was to analyze the effects of redevelopment of the Algarve railway and the role it may have in the development model for the region. Figure 1 shows the location of the Algarve Railway Line.

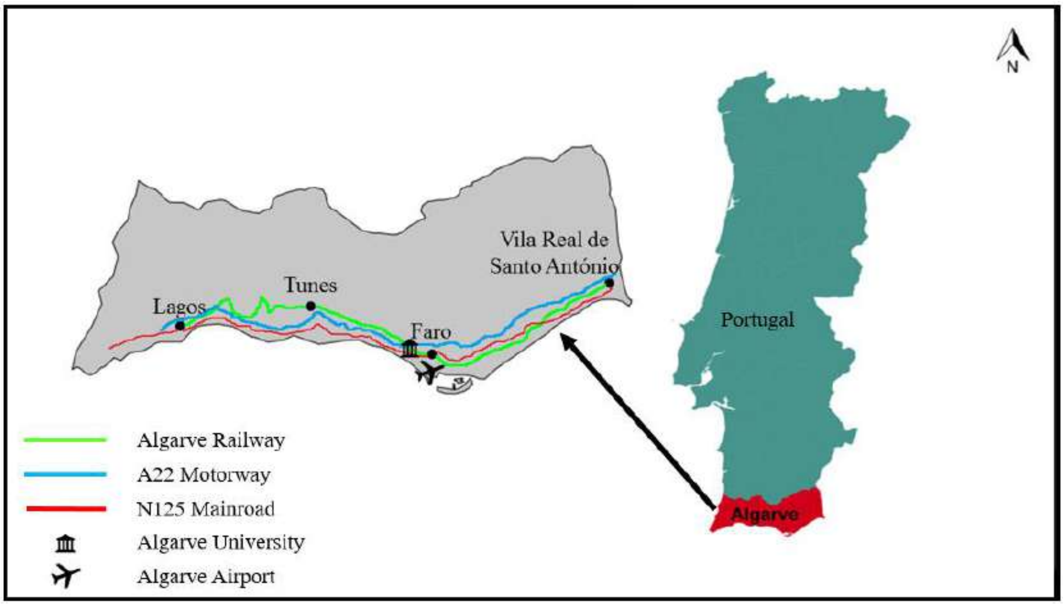

Figure 1 - Location of the Algarve region and the Algarve Railway Line (IP,2015).

2. Methods

The following topics of research are reported in this short paper:

a) An analysis of shortcomings and opportunities, based on historical analysis of travel patterns in the Algarve railway, and a survey to the municipalities and parishes in the region on their expectations regarding the transportation system;

b) The development of a model to refit the Algarve railway line, based on a definition of priorities for previously identified measures;

c) A qualitative analysis of trends in sustainability indicators, comparing the current transportation system with the effects of refitting the railway line; complemented with a quantitative analysis for the indicator “greenhouse gas emissions”

3. Results and Discussion

The volume of passengers registered in the last seven years in the Algarve Line has suffered a marked reduction (Figure 2). This is due to poor schedules, low investment in infrastructure and the overall low inter-modality and quality of the public transport service. The lowest yearly volume of passengers occurred in 2014. However, in 2015 there was a slight rise, and it is premature to say that it is a future trend.

Figure 3 shows responses from municipalities regarding possible improvements of the Algarve Railway. Mayors underscore the relevance of the rail link to Faro Airport, the University of Algarve and Spain. The importance given to the articulation of the Algarve Line with Faro Airport reflects the already identified need of the articulation of the railroad with other transport. The rail link to Spain was considered an advantage for the economic growth of the region. Next in importance comes the articulation of the railroad with the University, for its effect on cultural and technological development of the region.

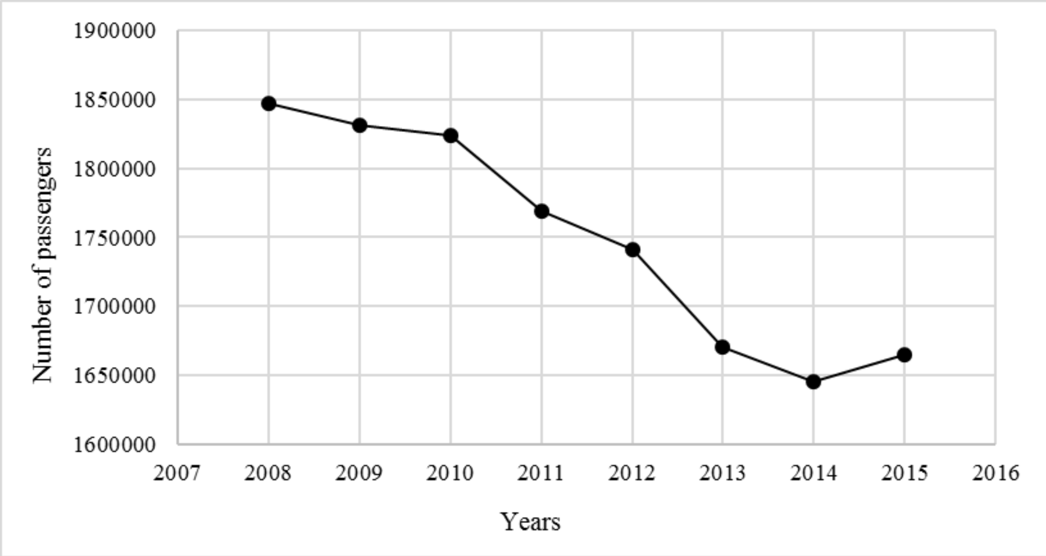

Figure 2 - Evolution of the volume of passengers of the Algarve Railway Line (INE, 2016).

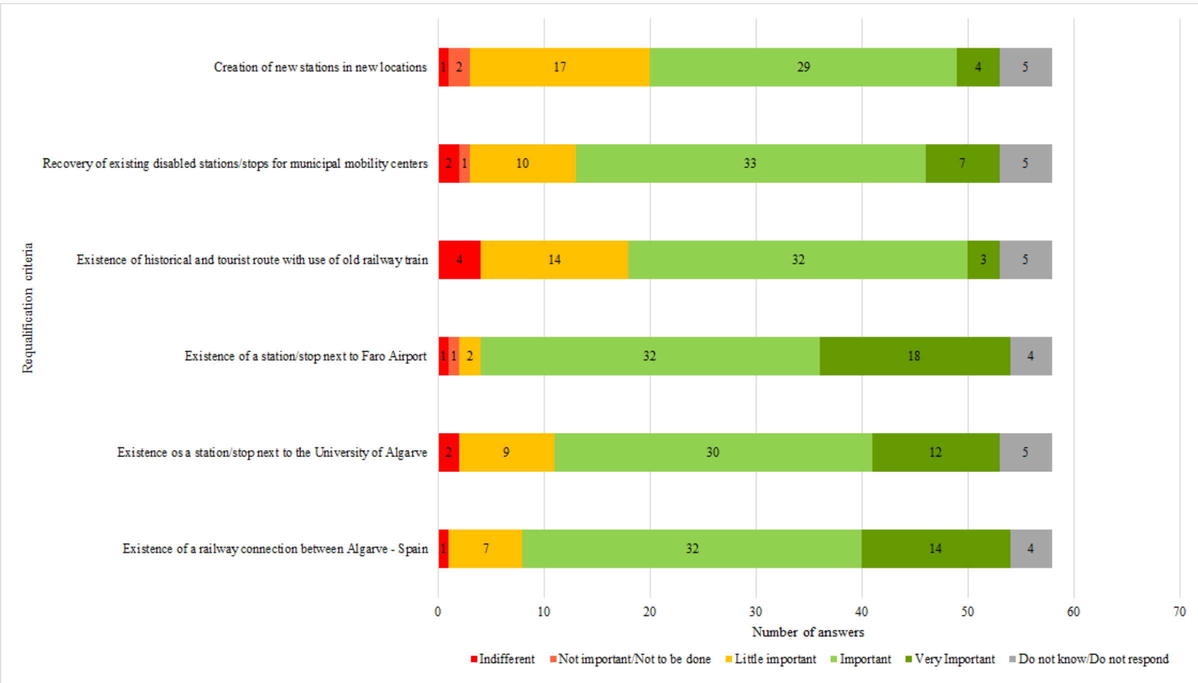

Figure 3 – Responses in the survey to local authorities on the importance of the Algarve Line.

The current model on which rail mobility operations are based does not fulfil the needs of the region and the populations. For decades there has been no modernization of infrastructure or vehicles of the railway. Most of the available funds for transportation having been dedicated to road construction. Public transport service is poorly managed, given the lack of complementarity between the road and the railway, whose articulation is neither stimulated nor promoted.

In order to achieve the new model of rail mobility in the Algarve, the measures to be considered do not require large investments. Articulating existing services through a policy of coordination and cohesion between the different modes of transport will go a long way in promoting public transportation. Adequate, cost-effective investment will foster new business opportunities and overall economic development, benefiting the population from more efficient, less polluting and less costly transport alternatives than individual transport. Figure 4 shows the key differences between the current transport system (Model XX) and the proposed one (Model XXI).

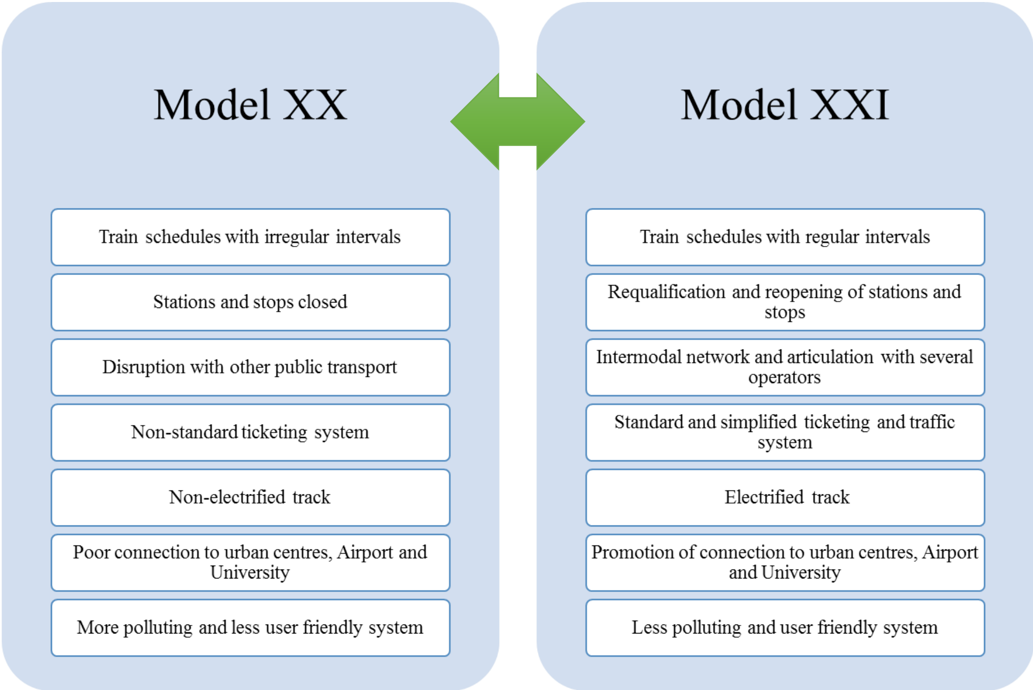

Figure 4 - Comparison between the current transport system and the proposed model.

The complementarity of the road network with the rail network is essential to ensure a sustainable and balanced regional mobility. The articulation of the railroad with other transport was identified in the surveys carried out as one of the most relevant criteria in the measurement of the quality of rail transport service. It is also defended on the premises of the White Paper (CE, 2011) as a measure to combat the current road congestion and the consequent emission of GHG, of which the transport sector is a major contributor.

The objective of this research was to develop an incremental model for the refitting of the Algarve Line, abandoning the idea of an outdated regional service and adopting solutions that allow it to operate as a suburban service. In 2011, the study developed by Silveira et al. (2011) argues that access to railway networks leads to an increase in population concentration in areas with this type of infrastructure, favouring not only the growth of pre-existing urban centres, but also the emergence of new urban centres and new business opportunities.

The preparation of the scenarios and proposals took into account the socio-economic context of the region, the analysis of the current supply of rail passenger services, and the analysis of the survey of local government entities. In view of the present national economic context, and taking into account the national and European mobility strategy (CE, 2014; IMT, 2012), a set of scenarios are presented and defended. The approach was to start with organizational or “software” measures, and later proceed to major investment or “hardware” measures (Figure 5). Each successive scenario (A, B, C and D) is progressively ambitious and includes all measures of the previous scenario. Thus, scenario D encompasses all the proposed measures. A summary description of the measures in shown in Table 1.

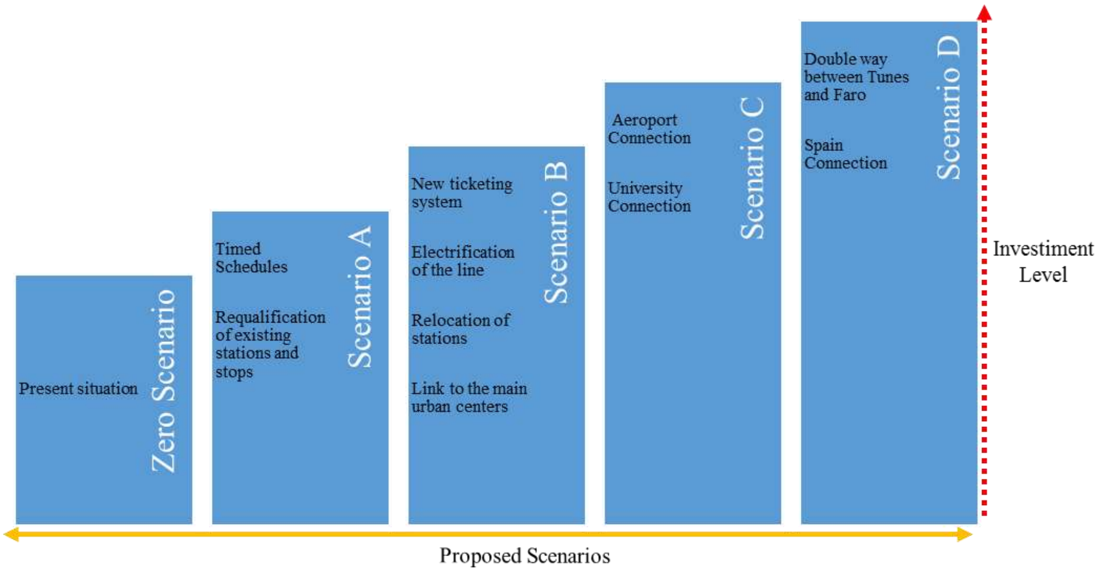

Figure 5 - Scenarios proposed for the refitting of the Algarve Railway Line.

Table 1 - Summary of the proposals of scenarios A, B, C and D.

Typology		Proposed measures	Scenarios
Management of passenger transport services	Schedules	EH1 - Creation of cadence times	A
		EH2 - Creation of intermediate links Lagos - Vila Real de Santo António	A
		EH3 - Creation of direct connections Lisbon - Lagos / Lisbon - Vila Real de Santo António	A, B
	Inter-modality	EI1 – Connection with the main urban centres	A, B
		EI2 - Articulation of the schedules and the routes of the urban roads transport with the stations and stops	A, B
		EI3 - Creation of an entity responsible for the management, coordination and regularization of supply and demand at the municipal and regional level	A, B
	Ticketing	EB1 - Insertion of a standard ticketing system	A, B
		EB2 – Tourist package	A, B
		EB3 – Online information platform	A, B
Infrastructure	Accessibilities	IA1 – Parking near stations	A
		IA2 – Inclusion of platform for smooth mobility	A
	Stations and stops	IE1 – Refitting and modernization of interfaces	A
		IE2 – Relocation of stations and stops	A, B
		IE3 - Promotion of railway stations for inter-modal stations	A, B
	Track	IV1 - Electrification of the Algarve Line	A, B
		IV2 - Creation of crossing deviations	A, B
		IV3 - Airport Connection	A, B, C
		IV4 – University Connection	A, B, C
		IV5 – Doubling the line on the Tunes section – Faro	A, B, C, D
		IV6 - Algarve – Spain Connection	A, B, C, D

After characterizing the scenarios and proposals that make up the Model XXI for rail mobility, it is also relevant to analyze their contribution to the sustainable development of the region. Therefore, a set of sustainable development indicators was identified, reflecting important social, environmental and economic effects of the implementation of this model.

This is a work in progress. Lacking time and resources to quantify all the indicators, a qualitative analysis was performed as a first step (Table 2). With the implementation of Model XXI, the trends that are expected in the future are favourable overall, not resulting in the worsening of the current situation.

Table 2 - Qualitative analysis of sustainable development indicators

Domain	Indicators	Present situation	Scenarios	
			A/B	**C/D**
			Trend	Trend
Air and Climate	Air quality	?	😐	🙂
	GHG emission	?	😐	🙂
	Emission of atmospheric pollutants	?	😐	🙂
Noise	Population exposed to ambient noise	?	🙂	🙂
	Sound sources	?	🙂	🙂
Mobility and Transports	Road congestion	☹	🙂	🙂
	Road accident claims	☹	😐	🙂
	Transport-Cost	?	😐	🙂
Soil and Territory planning	Evolution of the population	?	😐	😐
	Scattered building	☹	😐	😐
Economic development	Public and private investment	?	😐	🙂
	Employment	?	😐	😐
	Tourist Intensity	☹	😐	😐
	Average tourist expenditure	?	😐	🙂
Education	Level of education reached by the young population	?	🙂	🙂
	Level of schooling of the active population	?	🙂	🙂

🙂 Positive trend 😐 Some positive development ☹ Undesirable situation **?** Information unavailable

The simulations carried out by various scenarios indicate a quantitative improvement of sustainable development indicators. The allocation of percentages of passenger pick-up by the Algarve Line was the first step in quantifying the indicators. This percentage is intended to reflect the increase in passenger traffic on each section of the Algarve Line, as a result of the implementation of the proposals in scenarios B and D. It was neither the goal nor within the scope of this paper to outline and elaborate a detailed mobility model. Reported results are not intended to make an accurate and detailed forecast of passenger pick-up by the Algarve Line, but rather a proof of concept. For this purpose it was considered sufficient to use historical figures to establish contrasting scenarios.

The air quality, road congestion, accidents and noise will register an improvement due to the forecast 22% reduction of CO_2 emissions and 24% of the average annual daily traffic, based on the increased quality, reliability and efficiency in regional rail mobility through investments in terms of passenger service and infrastructure.

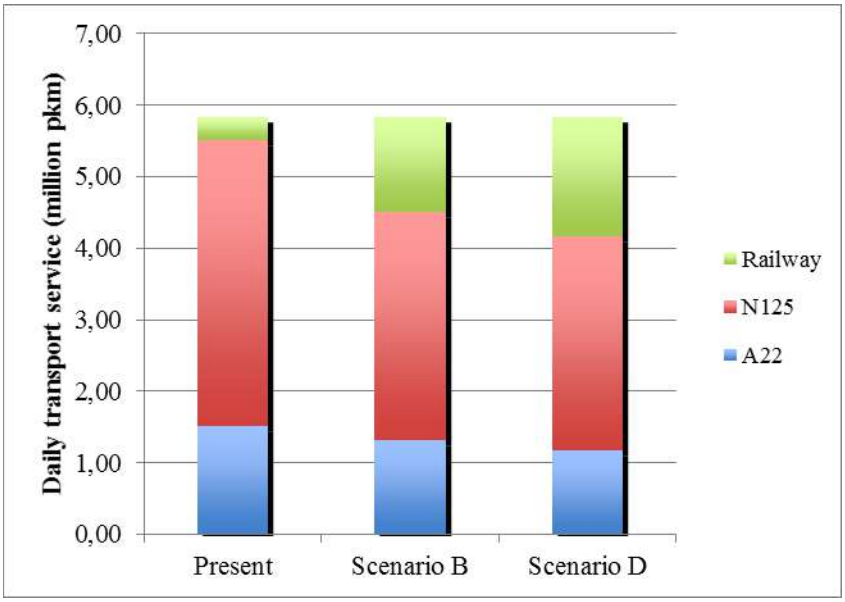

Figure 6 - Traffic estimates for Model XXI

5. Conclusions

The analysis of sustainable development indicators shows that a new transportation model, based on the refitting of the Algarve Railway Line, will have a very positive effect on sustainable development indicators. A 22% decrease in CO_2 emissions is forecast. At the same time, it may reduce average annual traffic by 24%, an improvement to reduce road congestion, and therefore road fatalities and traffic noise. This in turn will improve social and economic indicators such as education, employment, public and private investment and tourism. Transport to the University and the airport will have better quality and individual transport needs will be reduced, for residents and visitors alike.

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Voluntary Environmental Programmes for organisational learning: A Colombian experience

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Abstract

This article discusses voluntary environmental programmes (VEPs) as mechanisms that attempt to encourage better social and environmental performance in companies. The research aims to study why firms, in an emerging market context, join VEPs and what they learn from their participation. The conceptual framework used combines literature on organisational learning and voluntary programmes. The research method is quantitative, using empirical data from 54 facilities that participated in the first 2 editions of an environmental disclosure programme in Colombia (RACES – *Reconocimiento Ambiental CAR a Empresas Sostenibles*). The main findings evidence a mismatch between firms' ex ante motivations to join RACES and their ex post assessment of the benefits obtained from participating. Firms manifest their main driver to join RACES is reputational, however the most valued benefit from participating is capacity-building. In fact, facilities participating in RACES achieve diverse levels of organisational learning regardless of their economic sector. Larger firms tend to achieve higher levels of organisational learning than micro and small companies. The significant organisational learning achieved by RACES firms can also be influenced by the programme's design features and by the fact that the facilities are early entrants in the first two editions of the programme. Academic contributions are made by integrating two bodies of literature to understand the organisational dynamics of companies participating in voluntary disclosure programmes. Recommendations to practitioners involve how to participate in VEPs and the recognition of VEPs as tools for capacity-building in environmental management. Possible implications offered for the design of public policy and voluntary mechanisms that complement command and control and generate organisational learning.

Keywords: *voluntary disclosure programmes, voluntary environmental programmes, organisational learning, sustainability in emerging markets*

1. Introduction

Voluntary environmental programmes (VEPs) are instruments that incentivize firms to voluntarily improve their environmental performance, ideally beyond the regulatory system (Darnall & Carmin, 2005) (Darnall & Sides, 2008). The last three decades have seen a significant increase in VEPs around the world as complementary tools to command and control that allow for greater flexibility and containment of monitoring and enforcement costs (OECD, 1999) (Lyon & Maxwell, 2007) (Borck & Coglianese, 2009). Voluntary approaches have been studied in terms of their design features, effectiveness, sponsorship, and firms' motivations to participate. Scholarly focus has been placed on understanding VEPs effectiveness in terms of improving environmental performance (Khanna & Damon, 1999) (Darnall & Sides, 2008) (Borck & Coglianese, 2009) and compliance with environmental regulation (Potoski & Prakash, 2005) (Blackman, 2012).

Although most studies have focused on VEPs in industrialised countries, namely USA, more recently literature has studied voluntary programmes in emerging markets like Indonesia, India, Costa Rica, Colombia and Mexico to understand differential operationalisation and performance. Authors have studied diverse aspects of VEPs, including how they work, why firms participate, the effect of VEPs on environmental improvement and on regulatory compliance, and the benefits obtained by firms that participate (Afsah, Blackman, & Ratunanda, 2000) (Rivera, 2002) (Powers, Blackman, Lyon, & Narain, 2011) (Blackman, 2012) (Franco-García, Sosa, & Bressers, 2012).

However, few studies have analysed the capacity-building effect of VEPs. Blackman et al (2013) have suggested that voluntary agreements in developing countries can create environmental management capacity both among firms and regulators. Nonetheless, there is still a lack of understanding about the dynamics of emerging markets firms participating in voluntary approaches or Voluntary Environmental Programmes (VEPs) and their perception of benefits obtained (Blackman, 2012). Almost no links have been explored between VEPs and organisational learning, despite the broad acceptance of the importance of organisational learning as a means to achieve environmental performance and sustainability (van Hoof, 2013) (Feng, Zhao, & Su, 2014).

This article aims to address the literature gap regarding the lack of understanding about motivations, benefits and organisational learning achieved by firms in developing countries that participate in voluntary programmes. This gap is addressed by linking VEPs and organisational learning in order to understand the impact of voluntary mechanisms in terms of capacity-building in firms in the context of emerging markets.

This paper addresses two main research questions: 1. Why do firms in emerging markets participate in VEPs? and 2. What do firms in emerging markets learn from participating in a VEP? We suggest the usage of a model adapted from the works of Argyris and Schön (1996) and van Hoof (2013) to gauge the levels of organisational learning attained by firms that participate in VEPs.

The case selected to study these questions is a voluntary disclosure programme called RACES launched in 2014 by the Cundinamarca regional environmental authority in Colombia (*CAR*) to complement command and control strategies and to improve its relation with the private sector. The experience of RACES was selected as a case of analysis as data was available for 54 facilities that participated in the programme's first 2 editions. Moreover, after Chile, Colombia is the second country in Latin America with most proliferation of voluntary regulation (Blackman, Uribe, van Hoof, & Lyon, 2013). However, disclosure programmes in Colombia have not been specifically studied and less so as a vehicle to generate organisational learning.

By answering the research questions, through the analysis of the RACES case, this study contributes to a deeper understanding of why firms in emerging markets join VEPs and what they gain from their participation. The study unveils a mismatch between firms' ex ante motivations to join and their ex post assessment of benefits from VEP participation. Although reputation seems to be a key driver for joining RACES, firms consider the most important benefit to be organisational learning and capacity-building. This suggests a lack of full understanding of VEPs as instruments for environmental management. Moreover it highlights VEPs' ability to catalyse organisational learning in terms of how to participate in voluntary mechanisms and environmental improvement opportunities for firms.

The present article is structured as follows: the second section consists of the conceptual framework on voluntary environmental programmes and organisational learning. The third section describes the method used to analyse the data from the programme in Colombia. The fourth section analyses the case of RACES and presents the results to understand firms' motivations and perceived benefits from participating in the programme and the levels of organisational learning attained. Section 5 discusses the findings of the case of RACES vis-à-vis the conceptual framework to understand who participates, why they do so, and what they learn. Suggestions on VEP design features are given to foster organisational learning. The last section concludes with the recognition of the articles' limitations and requirements for further research.

2. Voluntary environmental programmes and organisational learning

This section aims to understand VEPs and disclosure programmes and how they differ when implemented in emerging markets versus industrialised countries. Literature linking voluntary agreements with organisational learning is discussed to find models through which learning can be assessed and measured.

2.1. Voluntary Environmental Programmes

"VEPs are defined as programmes, codes, agreements, and commitments that encourage organisations to voluntarily reduce their environmental impacts beyond the requirements established by the environmental regulatory system" (Darnall & Sides, 2008, p. 96). Voluntary programmes have been conceptualized as "club goods" that provide non-rival but potentially excludable benefits to members (Potoski & Prakash, 2005). For firms, the value of joining a "green club" over taking the same actions individually is to take advantage of the club's positive brand reputation and cost reduction (Potoski & Prakash, 2005, p. 235). In other words, VEPs serve as mechanisms that signal consumers, government agencies, civil society, and private sector about the environmental performance of participants (Darnall & Carmin, 2005); however, it is too costly for a single firm to achieve this "signalling", thus it makes more sense to be part of a VEP or "green club" which effectively informs key stakeholders about participating firms' environmental improvement.

VEP Typology and design features

Numerous authors have suggested VEP typologies to differentiate their sponsorship, purposes, and design features. Most have focused on differentiating VEPs according to their sponsor (private sector – "unilateral initiatives", government – "public voluntary programmes" or "negotiated agreements") (OECD, 1999) (Rivera, 2002) (Borck & Coglianese, 2009). Darnall and Carmin (2005) suggest a useful model with four VEP typologies with varying degrees of signalling accuracy about firms' environmental performance depending on the presence or absence of four criteria: internal commitments, self-reporting vs. external monitoring, and sanctions for non-compliance. This model links together typology, design features and VEPs' ability to signal participants' environmental improvement.

The four VEP types are:

i. *Information assistance and awareness*: technical assistance or education programmes to familiarize firms with environmental regulations; they don't include any internal commitments, reporting, monitoring or sanctioning mechanisms;
ii. *Environmental pledge*: consists of internal commitments for improvement without any reporting, monitoring or sanctioning mechanisms;
iii. *Voluntary reporting*: includes internal commitments and self-reporting;
iv. *Performance monitoring*: internal commitments are made and monitored by an independent third-party.

The last two types may or may not include sanctions for non-conformance. *Performance monitoring* with sanctions has proven to be the most accurate VEP in signalling firms' environmental performance and improvement, whereas *information, assistance and awareness* displays the least accuracy of all programme types. This is consistent with other authors' findings suggesting that third-party monitoring decreases firms' tendency to free-ride in voluntary mechanisms by benefitting from an improved reputation without truly displaying improved environmental performance (Rivera, 2002).

Motivations for VEP participation

Why firms participate in VEPs has been a broadly discussed question, particularly in voluntary programmes implemented in industrialised countries. Fewer authors have focused on why firms participate in developing countries. The main reasons why firms seem to join voluntary agreements can be grouped into three main drivers: i. To reduce compliance costs, ii. Increase sales or obtain price premiums, iii. Improve reputation (Rivera, 2002) (Blackman, Uribe, van Hoof, & Lyon, 2013).

Authors have argued that firms aim to reduce costs of complying with mandatory regulation by pre-empting it or reducing its stringency (Rivera, 2002) (Blackman, Uribe, van Hoof, & Lyon, 2013). Compliance costs can also be reduced by accessing regulatory relief and subsidies, as well as by improving efficiency and reducing production costs (Blackman, Uribe, van Hoof, & Lyon, 2013).

Firms aim to increase sales or obtain price premiums by participating in VEPs, especially those companies that target "green" consumers (Rivera, 2002). This expected benefit is only achieved under certain conditions that minimize free-riding and reward firms with superior environmental performance targeting industries with a significant segment of environmentally-conscious consumers (Rivera, 2002).

Reputation is also a key driver for firm participation in VEPs. Firms aim to legitimate their environmental initiatives vis-à-vis their different stakeholders in order to reduce not only government attention, but also community or civil society pressures (Blackman, Uribe, van Hoof, & Lyon, 2013).

Criticism of Voluntary Mechanisms

There is a debate regarding VEP's ability to improve environmental performance in participating firms. Some studies have found that VEPs can be effective in improving firms' environmental performance by helping them set goals and achieve them through innovative ways that command and control wouldn't allow for (Khanna & Damon, 1999) (Fiorino, 2002) (Ribeiro & Kruglianskas, 2013). Other studies question VEPs impact on firms' environmental performance by pointing out that companies tend to free-ride on previous accomplishments that had already been reached before joining the voluntary programme. Free-riding is also present in firms that join "green clubs" without displaying any true commitments to environmental improvement. In fact, some studies evidence that nonparticipants actually perform better than VEP participants in terms of environmental accomplishments (Darnall & Sides, 2008). There are also mixed views on whether VEPs improve compliance, with some studies arguing that participant firms can even display greater incidence of environmental sanctions than nonparticipants (Blackman, 2012).

Authors have also pointed out that some firms participate in voluntary initiatives in order to conceal their inferior environmental performance while taking advantage of a positive reputation and a reduced pressure from government and other stakeholders (Rivera, 2002). In fact many studies have found that early joiners tend to display better environmental performance than late joiners. Delmas and Montes Sancho (2010) argue that early joiners are subject to higher levels of institutional pressure from regulatory agencies, trade associations and public in general, and thus tend to display better environmental performance when joining VEPs; late entrants, on the other hand, tend to only symbolically participate. This has also been referred to as isomorphic pressure where firms participate in voluntary initiatives as an imitation of other leading firms (Blackman, Uribe, van Hoof, & Lyon, 2013), but not due to specific pressures that require a tangible environmental improvement.

More nuanced views argue that VEP effectiveness depends on the programme design. Darnall and Sides (2008) find that under self-reporting mechanisms, nonparticipants have greater improvement in environmental performance than participants (24% more improvement), whereas under third-party verification schemes (ISO 14001), participants have 2.5% more improvement than nonparticipants. This is consistent with other findings that assure VEPs have greater impact on environmental improvement and compliance when they have strong monitoring and enforcement mechanisms rather than self-reporting practices (Darnall & Carmin, 2005) (Prakash & Potoski, 2006).

2.2. Disclosure Programmes in Emerging Markets

Disclosure programmes are VEPs where information is collected about firms' environmental performance or improvement and is used to rate plants and to publicly disclose the information in order to address market and community pressures (Powers, Blackman, Lyon, & Narain, 2011). Government, civil society and market pressures tend to be intense in industrialised countries where active NGOs monitor firms and demand certain levels of environmental accountability even beyond government enforcement. Also, industrialised countries have a high proportion of large-scale firms, which are wary of reputational risks and make significant investments in environmental improvement.

However, VEPs, and specifically disclosure programmes in emerging markets, don't perform exactly as they do in industrialised countries. When looking at the Mexican case, Franco-García, Sosa & Bressers (2012) found that the first generation of voluntary agreements failed due to four main reasons: i. programme characteristics which lacked benefits such as pollution abatement subsidies, ii. weak government pressure, iii. weak non-governmental pressure and predominance of small firms, which are more likely to free-ride on larger ones, and iv. distrust between government and industry. These findings relate to Blackman et al (2013) who found that VAs served as a mechanism to build trust and exchange between industry and government; there was a need to “establish dialogues with industry representatives, gather technical information, and build the capacity needed to implement the new law” (Blackman, Uribe, van Hoof, & Lyon, 2013, p. 361).

Moreover, several studies have found that firms operating in wealthier and better-educated communities tend to display greater environmental performance when participating in VEPs given the importance of community and civil society pressure (Rivera, 2002) (Powers, Blackman, Lyon, & Narain, 2011). This was the case of studies performed in Costa Rica and India, given that wealthier communities are more educated, have better access to media and have the resources to exert greater pressure. Thus, in developing countries, VEPs run the risk of displacing polluting firms towards poorer communities where civil society and community pressure is weaker.

Another common finding in the analysis of VEPs in developing countries is that most improvement is seen among dirtier facilities and those with poor compliance records. This occurred both in PROPER, Indonesia and in India’s Green Rating programme (Afsah, Blackman, & Ratunanda, 2000) (Powers, Blackman, Lyon, & Narain, 2011).

Blackman et al (2013) have pointed out that in developing countries, voluntary agreements serve the purpose of creating environmental management capacity among firms and regulators. This was also the case of PROPER in Indonesia, which spurred improvement by informing plant managers about their opportunities for pollution abatement and environmental management strategies (Afsah, Blackman, & Ratunanda, 2000).

Cases of Voluntary disclosure programmes in Emerging Markets

The previous findings confirm the need to recognise that VEPs and disclosure programmes don’t perform equally in industrialised countries and in emerging markets. This section briefly analyses 4 disclosure programmes in emerging markets to understand their typologies, sponsors, design features, and key achievements (see Table 1).

The typologies of the programmes are defined using the categorisation by Darnall & Carmin (2005) according to the four performance criteria discussed earlier: internal commitments, self-reporting vs. external monitoring, and sanctions for non-conformance. The sponsors of the VEPs are defined as agents who financed, developed and administered the voluntary programme (Carmin, Darnall, & Mil-Homens, 2003). Most of the voluntary disclosure programmes that were analysed in emerging markets were sponsored by governments (some national, other regional) with the exception of Green Rating in India, which was sponsored by a non-governmental organisation.

The design features relate to the main characteristics of the disclosure programme including its functioning (rating system, certification, award system, etc.), the evaluation process (self-reporting vs. external monitoring), and the benefits offered to firms (reputational, decreased government monitoring, subsidies or economic benefits). The key achievements analysed in 4 disclosure programmes in emerging markets discuss the effectiveness of the mechanism in terms of reaching the sponsors' objectives (e.g. environmental improvement, increase in regulatory compliance, pollution reduction).

Programme and Type	Country	Sponsor	Design features	Key achievements
PROPER Type: Voluntary reporting/ Performance Monitoring	Indonesia	BAPEDAL - National Government	-Color-coded rating system for publicly grading facilities performance -Self-reporting and some firms receive external monitoring -Main benefits for firms are reputational and decreased government monitoring.	-Most improvement among facilities with non-compliance records (rated "Black") -Environmental improvement due to managers' increased information about plants' emissions and abatement opportunities
Clean Industry Type: Performance Monitoring with sanction	Mexico	PROFEPA - National Government	-Voluntary programme with 2 year certification -Facilities pay for audit and negotiate action plan for improvement -External monitoring -Main benefits are reputational. Decreased government monitoring and tax exemptions.	-Limited effectiveness due to: weak government and non-government pressure; lack of pollution abatement subsidies, predominance of small-scale firms -Contributed to generating trust between government and industry

Programme and Type	Country	Sponsor	Design features	Key achievements
Green Rating Type: Voluntary Reporting	India	Centre Science & Environment (CSE) – NGO	-Rating of plants' environmental performance -Evaluation based on life-cycle impacts -Self-reported information compared to secondary data -Programme supervision by panel of industry, government, judiciary, academia and NGOs	-Pollution reduction in dirty plants, but not in clean ones. -Plants located in wealthier communities were more responsive to GRP ratings, as well as single-plant firms
PREAD Type: External monitoring	Colombia	SDA – City Government	-Programme to reward firm's environmental performance -Firms have to make part of the environmental management programme -Sectorial targets -External monitoring -Benefits include reputational improvement and tax exemptions.	-The same group of firms tends to be rewarded continuously under PREAD -Lack of improvement once firms achieve sectorial targets -Capacity-building in environmental management

Table 1. Voluntary Disclosure Programmes in developing countries. Source: Authors based on (Afsah, Blackman, & Ratunanda, 2000). (García, Afsah, & Sterner, 2009) (Blackman, Lahiri, Pizer, Rivera, & Muñoz, 2010) (Powers, Blackman, Lyon, & Narain, 2011) (Franco-García, Sosa, & Bressers, 2012)

VEPs and disclosure programmes in developing countries seem to foster trust between governments and private sector (Blackman, Lahiri, Pizer, Rivera, & Muñoz, 2010) (Franco-García, Sosa, & Bressers, 2012). Moreover, they evidence capacity-building for environmental management through a greater knowledge of mandatory regulation and opportunities for pollution reduction and environmental improvement. In Indonesia, firms declare that PROPER spurred environmental improvement by "providing information to plant managers and owners about their own plants' emissions and abatement opportunities" (Afsah, Blackman, & Ratunanda, 2000, p. 12). Similarly, in Colombia, voluntary agreements have served the purpose of building capacity for environmental management both among firms and regulators, particularly at a time when environmental institutions were incipient (Blackman, Uribe, van Hoof, & Lyon, 2013). This leads to the need to further understand the role of VEPs on engendering organisational learning.

Certain design features of voluntary disclosure programmes in developing countries can enhance organisational learning. In particular, external monitoring systems that give feedback to firms about their environmental records help managers and owners become more aware of their improvement opportunities and their performance in comparison to other similar facilities

(Afsah, Blackman, & Ratunanda, 2000) (Blackman, Lahiri, Pizer, Rivera, & Muñoz, 2010). This was the case of PROPER in Indonesia, Clean Industry in Mexico, and PREAD in Colombia.

2.3. Organisational learning in VEPs

Few links have been made between organisational learning and VEPs given that studies have focused on assessing its effectiveness in improving environmental performance or increasing regulatory compliance.

Importance of organisational learning for sustainability

Organisational learning is key to firms' survival, growth and sustainability. It is defined as a process of change that an organisation undergoes in order to fit a changed environment (Kloot, 1997). Learning involves generating knowledge and using it to cause behavioural changes and to influence organisational practices (Ebrahim, 2005). Learning is a complex process considered to be interactive, accumulative and auto-generative (Senge et al, 1999 in van Hoof 2013).

In order for firms to become more sustainable and to improve their environmental performance they need to change the way they operate: their procedures, incentives, and culture. Thus, to achieve environmental improvement and sustainability, firms require organisational learning. In fact, difficulties in implementing cleaner production (CP), environmental management systems (EMS), and other environmental voluntary approaches arises due to an overestimation of technical aspects disregarding organisations' capacity to learn (van Hoof, 2013) (Feng, Zhao, & Su, 2014). Thus, when aiming to assess VEPs effectiveness, one must understand VEPs' ability to generate organisational learning.

Assessing organisational learning for sustainability

Organisational learning has become widely important as a means for companies to adapt to a changing environment, to enhance competitive advantages, to implement voluntary environmental initiatives, and to become more sustainable (Feng, Zhao, & Su, 2014). Thus, growing importance has been placed on understanding how organisational learning is achieved and in which ways it can be enhanced.

Argyris and Schön (1996) have made a key contribution to organisational learning theory by conceptualising the way learning occurs. According to them, learning in organisations occurs at two basic levels: single loop or double loop learning (Argyris & Schön, 1996) (Ebrahim, 2005).

Building on Argyris and Schön's model, van Hoof (2013) proposes four systemic levels of organisational learning applied to firms participating in the Mexican Sustainable Supply Chain Programme (MSSP). The four organisational learning levels are: zero learning, single-loop, double-loop, and triple-loop. Zero learning occurs when companies are invited to participate in a programme or undergo an initiative, but no organisational action is taken. Single-loop learning consists of achieving goals and objectives maintaining existing values and norms within the organisation (Argyris & Schön, 1996). This learning occurs when theoretical knowledge is acquired, but real-life application is not achieved (van Hoof, 2013). Double-loop learning implies the modification of organisational values and norms (Ebrahim, 2005). Under this level of learning, new ways of operating become part of organisational processes; staff adopts preventive views and modify their attitudes (van Hoof, 2013). Triple-loop learning involves the creation of new knowledge to solve more complex sustainability issues as part of the firm's business strategy; the firm "learns how to learn" through the establishment of new methodologies, processes and routines (van Hoof, 2013, p. 3).

This organisational learning model will be adapted to suggest a way in which organisational learning derived from voluntary approaches, such as RACES, can be measured. Assessing the diverse levels of organisational learning that can be achieved through VEPs in emerging markets seems particularly relevant given the prevalence of capacity-building among the voluntary programmes analysed in developing countries. In emerging markets, voluntary agreements don't display additionality in environmental improvement because it is not what those mechanisms are designed for; "they aim to build capacity, not boost environmental performance per se" (Blackman, Uribe, van Hoof, & Lyon, 2013, p. 365).

3. Method

As the purpose of this study is to learn why firms participated in a VEP and assess the organisational learning obtained through their participation in the programme, a quantitative research strategy was chosen to address the formulated research questions. The experience of

RACES, a VEP in an emerging market context such as Colombia, provided empirical data to address the research questions.

3.1. The programme

RACES (acronym for Reconocimiento Ambiental CAR a Empresas Sostenibles) is a voluntary disclosure programme led by the regional environmental authority of Cundinamarca in Colombia (CAR – Corporación Autónoma Regional de Cundinamarca). It was launched in 2014 with the objective of recognising and rewarding facilities that evidence environmental responsibility beyond regulatory compliance through the application of cleaner production (CP) initiatives that evidence tangible environmental improvements (CAR - Uniandes, 2014).

The programme's design features include: a) three levels of recognition to incentivise upgrading, b) facilities internal commitments and evidence of environmental improvement, c) self-reported information through the online application form, d) external monitoring by an independent evaluation committee and verification visits to facilities, e) feedback to firms about their performance in RACES and their improvement opportunities, and f) sanctions in the form of disqualification of firms or removal of the firm from the web site if non-compliance is presented after recognition.

The three levels of recognition include: i. Facilities with potential recognises plants that are beginning to design and/or implement CP or environmental improvement projects with economic and environmental benefits; ii. Proactive facilities recognises plants that have implemented CP projects and also display the usage of eco-efficiency indicators as a tool for decision-making; iii. Strategic facilities recognises firms that have implemented CP projects, eco-efficiency indicators, and additionally have carried out collaborative projects with other stakeholders of their value chain in order to extend environmental improvement beyond the plant's boundaries (CAR - Uniandes, 2014).

The case of RACES in Colombia was chosen given the availability of data on 54 facilities that joined the programme during its two editions and 20 additional ones that registered but dropped out before submitting the application. Moreover, the case was deemed relevant for analysis given its implementation in Colombia, the second country in Latin America with the most proliferation of voluntary regulations after Chile.

3.2 Operationalisation

The mechanism that will be used to measure the effect of RACES on facilities' organisational learning is adapted from the model by Argyris and Schön (1996) and van Hoof (2013) in his study of the Mexican Sustainable Supply Chain Programme (MSSP). The operationalization of the model for the case of RACES is presented below:

- **Zero learning:** Firms that are considered to fall under this learning level are those that registered to participate in the RACES voluntary disclosure programme but didn't submit their application according to the specified deadline. These firms were invited by the regional environmental authority (CAR) or by another stakeholder to participate in the programme, they initially displayed interest by registering, but at the end took no action to fill out and submit the application form. Thus they didn't learn how to participate in a VEP or about environmental improvement opportunities through RACES.
- **Single-loop learning:** Firms that stay under this level of learning are those that successfully submit their application to RACES but are not recognised by the regional environmental authority given that they fail to approve the verification and assessment process. However, these firms do go through the process of acquiring initial knowledge given that they are exposed to filling out the form and presenting their formulated and implemented cleaner production projects. They get feedback from third-party evaluators as to why they didn't achieve recognition, thus learning how to participate in VEPs. However, they don't deepen their knowledge on environmental improvement strategies.
- **Double-loop learning:** Firms that achieve this level of learning are those that successfully submit their application to RACES, undergo the verification and assessment process, and are recognised by the regional environmental authority, CAR, as a firm that can evidence environmental improvement beyond mandatory regulation. To achieve this level of learning, firms have acquired knowledge on how to participate in a VEP and have put into practice the tools and methodologies that allow them to implement cleaner production projects and environmental initiatives that go beyond minimum legal requirements.
- **Triple-loop learning:** Firms that are categorised under this level of learning are those that have successfully applied to more than one version of RACES achieving recognition by the CAR in repeated occasions due to their remarkable environmental improvement. The

evolution achieved by these firms is not only vis-à-vis environmental regulation, but regarding their own past performance, given that RACES incentivizes firms to evidence new cleaner production projects or a clear evolution of the ones presented under previous versions of the programme. Companies under this level of learning have embarked in a continuous improvement process and have institutionalized within their business strategy methodologies, routines and procedures that allow them to continue solving complex sustainability issues setting goals that grow in complexity (van Hoof, 2013).

Organisational learning levels	Description	Registration	Application submission	Recognition	Double recognition
Zero learning	Firms invited to participate in disclosure programme that show initial interest by registering, but then take no action to apply and don't join the VEP	X			
Single-loop learning	Firms that register and submit application form, thus learning how to present CP projects and indicators. However they don't evidence sufficient application of improvement projects with environmental and economic benefits.	X	X		
Double-loop learning	Firms that are recognised due to their evidence of environmental improvement through CP projects and the application of eco-efficiency indicators. Some also evidence collaborative projects with their value chains.	X	X	X	
Triple-loop learning	Firms that are recognised more than once by the disclosure programme given their significant improvement beyond regulation and vis-à-vis their own past environmental performance. They create new knowledge for solving complex sustainability issues. They "learn how to learn".	X	X	X	X

Table 2. Organisational learning levels in RACES. Source: authors.

3.3 Data collection and analysis

Data was gathered from a variety of sources including: i. The programme's data base where information is collected on facilities that register to RACES website, those that submit their online applications, and facilities that have been recognised during the 1st and/or 2nd edition of the programme, ii. Facilities' application forms with information about firm size (by number of employees), location, and economic activity; iii. Results of first survey in which firms answer about their motivations to join, the decision-making process within the company, their previous participation in other programmes promoted by CAR, and their feedback to the programme's website, online application form, and handbooks, iv. Results of the second survey where firms assess the benefits they obtained from participating and give feedback to the regional authority on alternative mechanisms to continue strengthening environmental improvement among firms.

The research method for this article is quantitative analysis. In order to analyse the data, statistical analysis was used to establish percentages and frequencies. The dependent variable used is the level of organisational learning achieved. The independent variables analysed are firm size and economic activity.

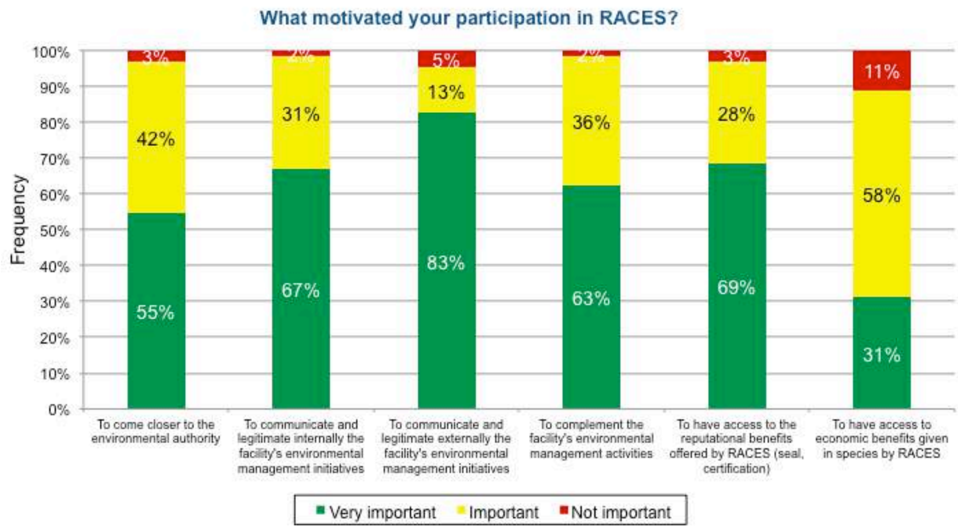
4. Results

This section will present the results of the analysis of RACES in Colombia in terms of why firms decide to participate and how they achieve different levels of organisational learning through the disclosure programme. In total, 74 facilities have had contact with RACES, 54 have successfully submitted their applications to enter the programme and 20 have initially registered but decided not to finalise the application process. 13 facilities have participated in both editions, some being recognised twice, others only succeeding once.

4.1. Why do firms participate in RACES?

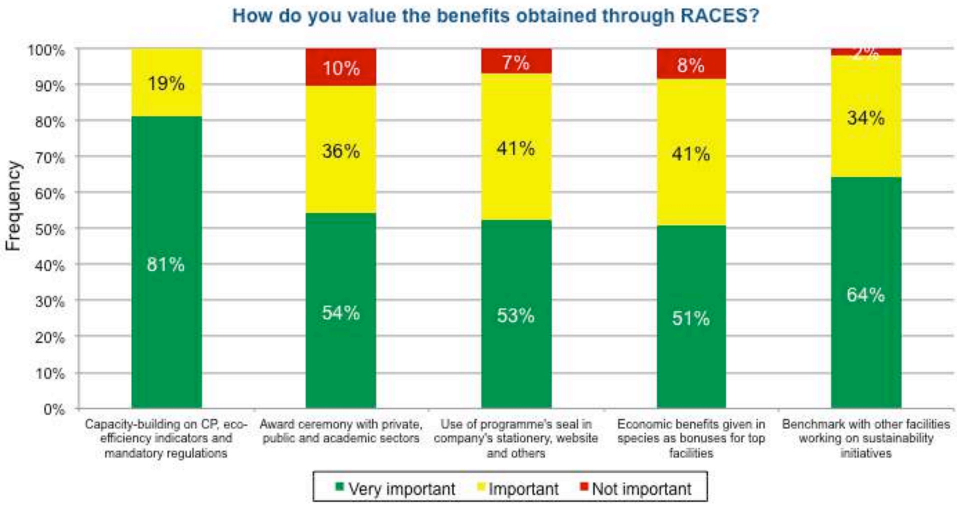
Online surveys applied to RACES facilities aim to understand the drivers and motivations behind participation in the programme. The results from the two editions display that the main driver for firms to participate was to "communicate and legitimate *externally* the facility's environmental management initiatives"; 83% of respondents ranked this issue as a "very important" determinant for their participation. Another key motivation seems to be "to have access to the reputational benefits offered by RACES in terms of the stamp and the certification"; 69% of respondents considered this aspect to be "very important" in influencing their decision to join. The importance of communicating and legitimating environmental initiatives *within* the firm and complementing internal initiatives also seemed to be important motivations for firm participation.

When looking at the drivers to join RACES, reputation seems to override economic incentives. In fact the motivation ranked as least important for the decision to join the programme was the "access to economic benefits given in species". 11% of respondents considered it was "not important” for their decision to join. Of course, 31% of respondents did classify it as “very important” and 58% as “important”.



Graph 1. Motivations to join RACES. Source: RACES Programme

A second survey was applied to participating firms to gauge how they valued the benefits obtained through RACES; the results were compared to the initial motivations to see whether the programme was satisfying the firms’ objectives. The most valued benefit was “capacity-building on cleaner production, eco-efficiency indicators and mandatory regulations”; in fact 81% of respondents graded that benefit as “very important” and 19% as “important”. The next most valued benefit was the “benchmark with other facilities that are also working on sustainability initiatives”; 64% of respondents graded it as “very important” and 34% as “important”. Again, the economic benefits seemed to be the least valued together with the award ceremony, as can be seen in graph 2.



Graph 2. Benefits obtained through RACES. Source: RACES Programme

The previous results indicate that facilities are particularly valuing the capacity-building offered by RACES. This suggests that firms are not only being recognised and rewarded for their environmental improvement, but they are actually learning through their participation in RACES. This matches the findings by Blackman et al (2013) about voluntary agreements in emerging markets serving as tools to create environmental management capacity.

4.2. Organisational learning in RACES

The organisational learning model derived from van Hoof (2013) was applied to the 74 facilities (54 of them actually submitted the application, 20 registered but did not finalise the process) that had contact with RACES during any of its two editions. The objective is to determine the different accumulative levels of organisational learning achieved and to understand differential performance between firms' ability to learn.

The following table displays the distribution of firms among the different organisational learning levels. Given that some facilities that participated in both editions of RACES did not achieve the same level of learning in both occasions, this table depicts the final level of organisational learning achieved, even if it was not the highest one, recognising that learning is accumulative and iterative. As illustrated in the table below, 27% of the 74 initial facilities achieved zero learning given that they registered in RACES but did not submit the application, thus not achieving any knowledge about how to participate in a VEP or practical knowledge about environmental improvement opportunities through the programme. 73% of facilities achieved single-loop learning, which means they successfully applied thus possibly gaining knowledge through the application process about VEP participation and about RACES. Those that stayed in single-loop learning (9 facilities) did not evidence sufficient environmental progress to achieve recognition by the regional environmental authority. 61% of facilities attained double-loop learning given that they successfully applied and were recognised for evidencing results in terms of CP projects and initiatives that lead to tangible environmental benefits. 9% of facilities were able to achieve the highest level of learning, triple-loop, by being recognised twice in a row by the environmental authority. These facilities learned how to participate in a VEP, gained knowledge about environmental improvement strategies, and put it into practice to evidence tangible results and continuous improvement compared to their own past performance.

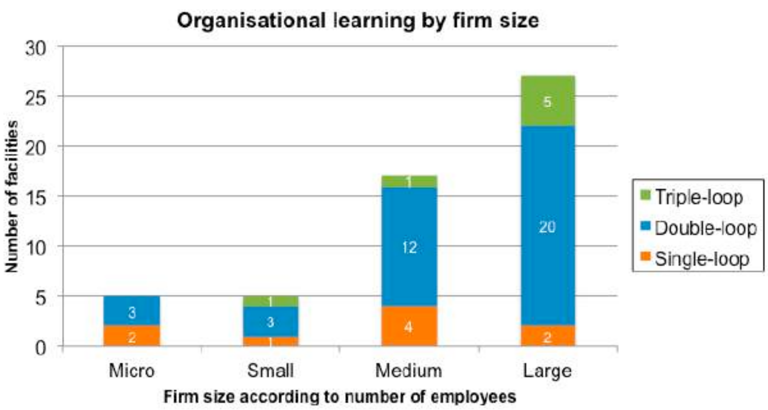
Organisational learning levels	Number of facilities	% of facilities
Zero learning	20	27%
Single-loop	54	73%
Double-loop	45	61%
Triple-loop	7	9%

Table 3: Organisational learning levels achieved by facilities in RACES. Source: authors

Of the 13 facilities that successfully submitted their application for both editions of RACES, results evidence that all of them increased their level of organisational learning during the second edition except for one plant which was disqualified (during the second edition) given the fact that it was temporarily not operating and thus its environmental initiatives were not currently functioning. 5 out of the 13 facilities that participated in both editions leaped from single-loop learning (applying but being disqualified) to double-loop learning (being recognised), which suggests that during the second edition they were able to amend the problems that impeded their recognition during the first edition. This suggests learning on how to participate in a VEP. 7 out of the 13 facilities went from double-loop learning (being recognised once) to triple-loop learning by being recognised twice by CAR for their environmental improvement in less than a 1-year period. This evidences not only learning on how to participate in VEPs, but also knowledge about environmental improvement opportunities. As mentioned, only one facility was downgraded from double-loop to single-loop given its activity cessation during the second edition.

RACES differs from other similar programmes by attracting a significant amount of facilities owned by micro, small and medium enterprises. Traditionally disclosure programmes appeal to large firms that have already invested resources in environmental improvement (Powers, Blackman, Lyon, & Narain, 2011). Out of 54 facilities that submitted their application to RACES during its 2 editions, 50% are owned by micro and SMEs, the other 50% are facilities owned by large firms[1]. When analysing the learning levels achieved by facilities according to firm size, we found that diverse types of firms achieve different levels of organisational learning. 40% of micro firms displayed single-loop learning and 60% double-loop learning; no micro firms display triple-loop learning. 20% of small enterprises displayed single-loop learning, 60% double-loop and 20% triple-loop learning. Large firms displayed mainly double-loop learning (74%). Moreover, large firms tend to own most of the facilities that achieved triple-loop learning (5 out of 7).

As explained in the model, for a facility to achieve triple-loop learning it must have participated in more than one edition of RACES. It is worth highlighting that RACES' second edition was opened less than a year after the first one and the programme's rules demand that facilities evidence environmental improvement through new CP projects or through a clear evolution of the previous ones presented under the first application. Thus for micro and even small firms it was probably too soon to display new projects and environmental improvement, whereas medium and large firms could more easily present other projects as an evidence for continuous improvement.



Graph 3. Organisational learning by firm size

[1] Firm size was calculated according to the Ministry of Commerce scale by number of employees: Less than 10, micro; 11 to 50, small; 51 to 200, medium; over 200, large enterprise.

The economic activities of the facilities that participated in RACES were analysed to understand whether they appeared to influence the level of organisational learning achieved. As can be seen in table 4, this does not seem to be the case. Under each level of learning there appear to be facilities from diverse economic activities. The most predominant economic sectors in RACES are agro-industry (26%), construction (17%), chemical products (15%), and services (13%). All of these economic activities are present in the different levels of organisational learning as displayed in table 4 (except for construction in single-loop).

Economic activity	Single-loop	Double-loop	Triple-loop	Total
Agro-industry	1	12	1	26%
Construction		8	1	17%
Chemical products	1	4	3	15%
Services	3	3	1	13%
Food products	1	3		7%
Agriculture	1	2		6%
Industry	1	1	1	6%
Manufacturing		2		4%
Transportation	1	1		4%
Poultry		1		2%
Consumer goods		1		2%
Total	**9**	**38**	**7**	**54**

Table 4. Organisational learning by economic activity. Source: authors

In brief, the results of the analysis on RACES convey that firms participating in the programme were able to achieve diverse levels of organisational learning. This learning is mainly focused on knowledge on how to participate in VEPs and increased environmental management capacity. Although firms of all sizes and economic activities seem to be able to achieve different learning levels, large firms do tend to achieve higher levels of learning in RACES given the resources they have already invested in environmental performance that allow them to evidence continuous improvement.

5. Discussion

The results of the analysis of RACES in Colombia allow us to shed light on the two research questions that have guided this paper: i. Why do firms in emerging markets participate in VEPs? ii. What do firms in developing countries learn from participating in VEPs?

Why do firms participate in VEPs?

Previous studies of VEPs in developing countries have argued that firms participate in voluntary mechanisms mainly to reduce compliance costs, increase sales or profit, and to improve reputation (Rivera, 2002) (Blackman, Uribe, van Hoof, & Lyon, 2013). However, ex ante motivations have not been compared to the ex post benefits of participating. The case study of RACES in Colombia reveals a mismatch between firms' ex ante drivers and ex post assessment of benefits.

According to the results obtained, firms' main driver to join seems to be reputational, given the importance of using the VEP to legitimate – towards external and internal stakeholders – the environmental initiatives that they are implementing. Firms conveyed that the use of the programme's stamp and the certification obtained by the facility were important motivations to join the programme. However, when firms evaluated the benefits they obtained from participating in RACES, 81% of them favoured capacity-building in environmental management and improvement strategies as the main benefit they had obtained from the programme. This aspect was valued significantly higher than the public award ceremony and the use of the programme's stamp, which are benefits associated with reputational improvement.

This mismatch can be explained through previous findings in literature. On the one hand, reputational pressures in emerging market contexts seem to be weaker than in industrialised countries. Authors have manifested that in developing countries weak governmental and non-governmental pressures have led to the failure of VEPs (Franco-García, Sosa, & Bressers, 2012). Unlike in industrialised economies, in emerging markets, government, civil society and communities are less active in exerting pressure to demand social and environmental accountability from firms. This might explain why firms a priori enter voluntary programmes thinking that their most important gain will be reputational but then realise that, given the lack of stakeholder pressure, they actually benefit more from organisational learning and capacity-building. This finding leads us to discuss the second research question.

What do firms learn from VEP participation?

The study of RACES evidences that firms can achieve organisational learning through their participation in VEPs. On one hand they learn how to participate in voluntary programmes (single-loop learning) and on the other hand they learn about environmental improvement strategies and opportunities (double-loop and triple-loop learning). This goes in line with previous findings that have identified capacity-building in environmental management as a key outcome of VEPs in developing countries (Afsah, Blackman, & Ratunanda, 2000) (Blackman, Uribe, van Hoof, & Lyon, 2013).

Under RACES, facilities owned by companies of all sizes and economic sectors achieved diverse levels of learning. However, micro enterprises did not attain triple-loop learning, probably because they lack sufficient resources to evidence new environmental initiatives in short time periods. In order to recognise a firm more than once, RACES demands evidence of environmental improvement through new CP projects or the significant evolution of formerly presented ones. On the other hand, large firms displayed the highest levels of learning with a significant percentage of triple-loop and double-loop learning. This is consistent with findings that point out that large firms perform better in VEPs than small firms (Rivera, 2002). Some authors even argue that small firms tend to free-ride on the activities of larger participants of voluntary agreements (Franco-García, Sosa, & Bressers, 2012). Although this is not the case in RACES, there is a clear tendency for larger firms to achieve higher organisational learning levels.

The positive results of RACES' firms of all sizes and economic activities in attaining organisational learning is probably influenced by the fact that these 54 facilities are early entrants and pioneers in the first two editions of the programme. Delmas and Montes-Sancho (2010) have identified that early joiners are subject to higher levels of political pressure, they tend to be better connected to trade associations, and are usually more visible. This forces them to improve their environmental performance and to display "substantive cooperation" in voluntary agreements. Late entrants, on the other hand, tend to act as followers and evidence symbolic cooperation that is not represented by tangible improvements in environmental records (Delmas & Montes-Sancho, 2010). Other authors also recognise that early joiners in VEPs tend to improve first and more significantly than late joiners (Lyon & Maxwell, 2007). This is an important caveat for the present article given that the analysis of RACES includes a sample of early entrants. It would be interesting to observe how results vary as the disclosure programme evolves throughout the years.

Another important aspect is how VEP design features can facilitate organisational learning among participants. This article suggests that RACES design features allow participant firms to achieve organisational learning. The link between voluntary programmes and organisational learning has not been explored explicitly by previous literature, and thus the question about which VEP design features enable learning remains largely unexplored.

Nonetheless, authors have discussed which design features increase VEP effectiveness in terms of improving environmental results. There seems to be a broad acceptance of the importance of external monitoring for increasing the accuracy of VEPs in signalling firms' environmental improvement (Rivera, 2002) (Darnall & Carmin, 2005). This article builds on Darnall and Carmin's (2005) VEP categorisation to suggest that programmes that include internal commitments by firms, external monitoring and some type of sanction also tend to facilitate organisational learning.

RACES design has a focus on capacity-building. The programme offers diverse tools such as a handbook, access to virtual and face-to-face sessions, and feedback at each step of the process. All firms receive a report assessing their performance on RACES and with feedback on how to improve in future editions.

Moreover, RACES has an independent evaluation committee as mentioned earlier. Representatives of the evaluation committee grade the online application form submitted by firms using self-reported information. Firms that pass this filter then receive a verification visit to guarantee that their self-reported application truly displays the reality of what is happening in the facility.

The programme contemplates sanctions in the form of exclusion of firms from the programme's website if they incur in a violation of mandatory regulation. In order to avoid firms from using the RACES stamp as if they had been continuously recognised by CAR, they are only allowed to use the stamp with the year of their recognition and the location of the rewarded facility. This avoids free-riding by other facilities owned by the same firms and also guarantees that stakeholders know in which year the facility was recognised for its environmental responsibility. This also incentivises firms to continuously update their commitments for improvement.

Thus, following Darnall & Carmin's (2005) VEP typology, one could argue that "performance monitoring" programmes with sanctions are those that better signal environmental improvement by firms, but also appear to foment organisational learning. Of course, the VEP must also have a focus on building-capacity in terms of handing key information to firms about their current situation and opportunities for further environmental improvement, as is the case of RACES.

These findings contribute to the understanding of VEPs in developing countries. We have conveyed that it is imprecise to establish that voluntary agreements are not effective in emerging markets because they cannot evidence environmental improvement or additionality. Actually, VEPs can be an important tool to complement command and control strategies and to increase firms' environmental management capacity. Organisational learning is a pre-requisite for sustainability and VEPs can contribute in the construction of the capacities needed for firms and regulators to achieve better environmental performance.

6. Conclusion

Voluntary environmental programmes can be effective tools in developing countries where institutional capacity is weak and stakeholder pressures are limited. However, the main value of VEPs in emerging markets is not necessarily to improve firms' environmental performance or to drive them towards compliance. In contrast, VEPs can act as capacity-building mechanisms, which allow both firms and regulators to improve environmental management skills (Blackman, Uribe, van Hoof, & Lyon, 2013). This article draws an explicit link between VEPs and organisational learning, arguing that although firms declare that the main driver to join voluntary agreements is reputation improvement, in reality their most valued benefit from participating is capacity-building and organisational learning. This mismatch between ex ante motivations and ex post perceived benefits from VEP participation, suggests that there is a lack of full understanding of voluntary programmes as instruments for environmental management.

The findings from this paper convey that firms participating in VEPs can achieve diverse levels of organisational learning. Highest levels of learning seem to be achieved by large firms that have more resources to invest in environmental improvement projects such as cleaner production initiatives and also tend to be more visible and subject to stronger stakeholder pressures. However, small and micro enterprises can also learn through VEPs, especially about how to participate in voluntary programmes and how to design and implement strategies to improve environmental performance while also generating economic benefits for the business. Economic activity does not seem to have an impact on the levels of organisational learning attained through VEP participation.

Further research should be conducted in other VEPs in emerging markets to assess organisational learning of participants versus non-participants in order to determine causality. This study has several limitations including a possible bias due to the proximity to the programme, a lack of information on firms that achieved zero learning, and a limited generalizability of results given the particularities of RACES' design and functioning.

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Innovative business models: sustainable or not?

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Abstract

Sustainability practices characteristic of most contemporary business organizations foster incremental change by product, process and management innovation. While this is very important, incremental improvements neglect a number of larger opportunities associated with new forms of doing business and 'the underserved markets at the bottom of the economic pyramid' (Hart and Milstein, 2003, p. 65). A growing number of experts recognise this and emphasize the role of more radical change to be brought about by innovative business models. According to Schaltegger et al. 'the business model perspective is particularly interesting in the context of sustainability because it highlights the value creation logic of an organization and its effects and potentially allows (and calls) for new governance forms such as cooperatives, public private partnerships, or social businesses, thus helping transcend narrow for-profit and profit-maximizing models' (Schaltegger et al., 2015).

However, research on business models and their various impacts on sustainable development is still in its infancy and the majority of existing documents dealing with business models takes a pragmatic approach describing the basic characteristics of product-service systems, the sharing economy, the collaborative enterprise, innovative financing solutions, etc. from a practitioner's point of view. Apart from a lack of deeper understanding of these innovative business models their environmental and social impacts have not been uncovered yet. For this reason, research efforts at the Budapest University of Technology and Economics concentrate on the collection of empirical evidence relating to the fast spread of the sharing economy. Which social groups are affected by sharing economy businesses and how? How do lifestyles change as a result of their fast growth? What are their negative and positive environmental impacts and what is their net effect on natural ecosystems?

The aim of the empirical research is to provide answers to these questions through the practical experiences of a regional sharing economy business, which has been operating in the transportation sector for several years. Data gathered as a result of the operations of the net based company reveal tendencies during its growth and its actual and potential effects on society and the environment.

Early findings of the research suggest that the fast growth of the sector require the attention of policy makers who do not have the necessary data and understanding yet to make informed decisions (Zilahy, 2016). Research findings may also contribute to the development of an assessment framework of new business solutions and as a result, to policy recommendations with regard to their development and support.

Keywords: sustainable business practices, radical change, sustainable business models, sharing economy, sustainability performance

1. Introduction

Sustainability practices characteristic of most contemporary business organizations foster incremental change by product, process and management innovation. While this is very important, incremental improvements neglect a number of larger opportunities associated with new forms of doing business and 'the underserved markets at the bottom of the economic pyramid' (Hart and Milstein, 2003, p. 65). A growing number of experts recognise this and emphasize the role of more radical change to be brought about by innovative business models. According to Schaltegger et al. 'the business model perspective is particularly interesting in the context of sustainability because it highlights the value creation logic of an organization and its effects and potentially allows (and calls) for new governance forms such as cooperatives, public private partnerships, or social businesses, thus helping transcend narrow for-profit and profit-maximizing models' (Schaltegger et al., 2015).

However, research on business models is still in its infancy and the majority of existing documents dealing with the topic takes a pragmatic approach describing the basic characteristics of product-service systems, the sharing economy, the collaborative enterprise, innovative financing solutions, etc. from a practitioner's point of view. Apart from a lack of deeper understanding of these innovative business models, their environmental and social impacts have not been uncovered yet. For this reason, our research concentrates on the collection of empirical evidence relating to the fast spread of the sharing economy. Which social groups are affected by sharing economy businesses and how? How do lifestyles change as a result of their fast growth? What are their negative and positive environmental impacts and what is their net effect on natural ecosystems?

The aim of our empirical research is to provide at least some partial insight into these issues through the practical experiences of a regional sharing economy business, which has been successfully operating in the transportation sector for several years. First, we will introduce the notion of sustainable business models followed by a discussion of the sharing economy in general. We then identify a list of potential impacts of the sharing economy on the economy, environment and society.

Next, we introduce the ride share company and analyse data collected by the platform they use and the feedback of users on the company web page. Finally, we draw some conclusions regarding the sustainability of the business venture.

2. Sustainable development and the sharing economy

2.1 Sustainable business models

The importance of the topic of innovative business models has grown considerably over the last few years, especially after the publication of a practical handbook describing the process of business model development by Osterwalder and Pigneur (2010).

Various definitions of business models have emerged over this short period of time. Most of them emphasize the descriptive nature of the notion and that business models reflect the underlying logic of an organisations operations. Magretta interprets business models as "stories that explain how enterprises work" (Magretta, 2002, p. 4), while Amit and Zott explains business models as "a bundle of specific activities — an activity system — conducted to satisfy the perceived needs of the market, along with the specification of which parties (a company or its partners) conduct which activities, and how these activities are linked to each other" (Amit and Zott, 2012). This latter definition of business models focuses the attention on the linkages between activities and stakeholders carrying them out and thus highlight the reason why the topic of business models is especially suitable for the analysis of the sustainability performance of corporations. This potential has already been recognised by some authors. Schaltegger et al., for example, stress that the notion of business models can provide a useful framework to analyse disruptive change in business operations from a sustainable development point of view since it illuminates the value creation logic of an organization, its effects and allows for new forms of governance (Schaltegger et al., 2015).

Utilising the business model framework, Boons and Lüdeke-Freund (2013) developed a normative framework, which defines the requirements of sustainable business models. The authors identify the following four factors:

- the value proposition should provide measurable ecological and/or social value;

- suppliers should take responsibility for their own and their suppliers' stakeholders;

- customers should be motivated to take responsibility for their consumption and for the stakeholders of the companies involved in the supply chain;

- economic costs and benefits should be distributed appropriately among actors and should account for the company's ecological and social impacts (Boons and Lüdeke-Freund, 2013).

Sustainable business models may take many different forms, but they should all contribute to the implementation of some wider objectives over narrow profit interests. Among others, sustainable business models include product-service systems, the circular economy, production on demand, inclusive sourcing, social enterprises, the sharing economy, etc.

The emergence and success of organisations following sustainable business models may be explained by diverse factors. Zilahy (2017) demonstrated the explanatory power of two popular management theories, namely the resource based view of the firm (RBV) and transaction cost economics (TCE) using the examples of industrial symbiosis and the sharing economy. He concludes that technological change (namely the spread of the internet and connected devices) facilitates the reduction of transaction costs, which results in new resources entering the market and providing competitive advantage to new business ventures and incumbents eager to innovate.

2.2 Impacts of the sharing economy

The sharing economy has long been promoted for its supposedly positive impact on both society and the environment. Early experiments already focused on the system wide changes resulting from sharing, instead of owning resources.

The rapid development of the sharing economy is facilitated by technological developments, an increasing scarcity of resources, rapid urbanisation, and demographic and social changes (PWC, 2015a). Looking at the different manifestations of the sharing economy, Benkler suggests that "the highly distributed capital structure of the contemporary communications and computation systems is largely responsible for the increased salience of social sharing as a modality of economic production in those environments" (Benkler, 2004: 278.).

While sharing economy businesses spread rapidly all over the world, practical experiences have already generated some criticism as well. The sharing economy poses important questions for established businesses trying to avoid disruption, new entrants who wish to lure away clients and policy makers who try to regulate and manage the market. One example of the latter is that participants in the sharing economy often exhibit tax-avoiding behaviour, which is hard to uncover for tax authorities. Furthermore, the sharing economy is a broad concept, which can cover businesses with – at least partially – different business models.

By taking a resource-based view with regard to the sharing economy, the sustainability debate mainly concentrates on the physical aspects of these new types of businesses (expecting a significant decrease in resource use), but often neglects their impacts on social relationships. However, the sharing economy does not only build on previously underutilised resources such as empty seats in a car, spare apartment space, additional workforce and available time, which are invested in the provision of such services, but also on the trust relationships facilitated by innovative service providers.

Owners and users of resources such as apartment space, empty car seats and underutilised equipment also invest time and effort in transactions, as well as bear a risk inherent in the activities they engage in. Those taking advantage of the services offered also have to trust the providers of services and spend time on engaging with them and the platform providers, e.g. registration, filling in surveys, etc. Time and effort invested in such activities is in excess of that required by traditional operators, e.g. registration is not needed to flag down a cab on the street. Both parties also provide information to platform operators during the course of the transaction and afterwards, which is utilised as a key resource by them later on.

Since physical resources traded in the sharing economy are not owned by platform providers, however valuable they might be, they alone cannot provide a sustained competitive advantage. On the other hand, by constructing scoring schemes and making them available to their customers, sharing economy platforms capitalise on a resource created by the community and provided for the platform free of charge 'to assist other users in their decisions'. As a result, this 'trust bank' turns into private capital – a very effective source of sustained competitive advantage. Practical experience seems to support this logic as the main differences between platform operators are founded in the number of network members and the 'trust bank' built on these and not in their underlying business models or IT solutions they use. As a result, early movers in an industry – assuming that they do not make significant management mistakes – can develop their businesses rather fast and achieve a strong, safe position, which is hard to challenge later.

Thus, by considering the perspective of the resource-based view of the firm, providers of sharing economy solutions, which charge a market-based fee for their services, i.e. the provision of a platform for the actors to locate each other and network, are just like other, more traditional businesses, capitalising on a valuable, rare and hard to imitate/substitute resource: the 'trust bank' they created with the free contribution of their users. (This is not to say that other resources are not important for these businesses: apart from the database they build up and can utilize in many ways, their continuously developing applications, which show the characteristics of artificial intelligence, the organizational capital working behind the scenes and lawyers and lobbyist also play important roles in the success of these businesses.) From the point of view of these platform providers, resources actually shared are of less importance as long as they are abundant and users are willing to share them; their quality, price and other attributes play a secondary role. The better utilisation of resources – as expected from these solutions from a sustainability point of view – is also only a by-product – a by-product, which generates goodwill and is often used for marketing purposes.

The role of trust in the sharing economy has recently generated some interest in the literature. An article by Yang et al. (2016) examines Airbnb, the prime accommodation sharing business and the trust built up between its customers and the company, as well as the hosts offering accommodation through its internet based application. Taking and integrated perspective of attachment theory and the trust building model (TBM) they seek to provide a research model that describes trust gaining on-line. The authors argue that Airbnb deals with both informative and social interaction through its website, which thus has cognitive features (e.g. relating to quality and security) and affective characteristics (e.g. direct communication and real-time responses) and propose a research agenda to show – among others – that cognitive factors influence customer-Airbnb trust, while affect-based factors have a positive influence on customer-host relationships (Yang et al., 2016).

Henten and Windekilde (2016) analyze the sharing economy from the point of view of transaction cost theory and claim that new digital platforms change the substitutability of traditional services, e.g. offered by a hotel or car rental company, by offering alternative private rooms and car seats. While traditionally these latter goods are more difficult to find and are less standardized thus involving more uncertainty, the use of internet-based services can mitigate many of these shortcomings and the degree of substitution will increase (Henten and Windekilde, 2016).

Using the classification of transaction costs by Coase, the sharing economy benefits from developed internet platforms that help partners discover each other (by using sophisticated search engines, often based on location), communicate with each other and finalize a contract (e.g. a rental agreement). Further, the payment for the provided service is also often made very simple by organizing financial transactions over the internet (sometime even automated, like in the case of Uber).

A closer look at various sharing economy businesses illustrates that both RBV and TCE can explain some of their important aspects even though other factors also play a role in their success.

3. Methodology of the research

In order to demonstrate the wider impacts of sharing economy businesses, we analysed a regional peer-to-peer drive sharing business called Oszkár based in Budapest, the capital city of Hungary. In drive sharing systems car owners drive their own cars and contrary to car sharing companies transactions happen between the driver and the passenger (without the involvement of the platform owner).

Oszkár is one of the best known Hungarian start-ups, which started operations in 2007. The company uses a web site and mobile applications to provide its services to users. The platform helps drivers offer their empty seats to potential passengers, while riders can make seat reservations through the system. Typical trips are long distance routes between two settlements within the country, but foreign trips are getting more and more popular. The main benefits of using the system include its lower cost and faster speed compared to traditional forms of transportation, (trains, buses and airplanes) and a higher level of flexibility and comfort offered by private vehicles. Oszkár also helps to reach places where public transportation options do not exist or are far away and/or operate sparsely.

By early 2017 almost half a million users have signed up to the system (out of approximately ten million citizens), although their activity level varies widely. Apart from casual drivers, professional service providers have also started to offer their trips through the system of Oszkár.

In order to analyze the wider impacts of the company, first we identified a long list of potential impacts in the economic, environmental and social domains. Tables 1-3 list all potential impacts as identified.

Table 1. *General features and economic impacts of car sharing operations*

Aspect	Related impact
Users, diffusion of the service	Demographic characteristics of users; patterns of spread
Patterns of usage	Changes in the length and frequency of trips, destinations, means of transportation substituted; timing of trips
Development of the application, platforms, versions and functions	Impact on the number/type of users
Competitors	Impact on incumbent service providers: transportation and other (e.g. postal service) Impact on new entrants, type of market
Impact on driver's route	Destination, direction, time and date, weather, driving style, etc.
Regulatory/institutional barriers: national and international	Rigidity of the regulatory environment Missing, constraining regulations Country differences – problems caused
Motivations	Lower cost; higher comfort; flexibility (time, destination); environmental concerns, other personal motivations, etc.
Benefits of the regional nature of business	Competitive advantage – key resources Local/regional vs. global players
Technological constraints of development	Internet, mobile penetration; server capacity, software issues

Table 2. *Environmental impacts of car sharing operations*

Aspect	Related impacts
Vehicles used	Number of vehicles (e.g. in family) Size, comfort, performance, age and other characteristics of vehicles Changes in maintenance patterns
Resources used	Changes in mileage covered; fuel consumption (type, quantity)
Infrastructure	Choice of routes/roads, auxiliary infrastructure (e.g. parking)

Table 3. *Social impacts of car sharing operations*

Aspect	Related impacts
Demographic characteristics of users	Domestic and international trips: gender, age, educations, etc.
Social injustice, spatial inequalities	Access to transportation Access to employment opportunities
Accidents/injuries	Rate of accidents and injuries (number and severity) for example as a result of a change in driving style; impact of the evaluation system on driving habits
Safety/criminal events	Number and type compared to other means of transportation Perceptions regarding safety
Peer-to-peer evaluation system	Tendencies in evaluations Traditional vs. new forms of exclusion
Employment opportunities provided by the system	Part time vs. full time service providers Acceptance by passengers Sharing vs. access economy
Virtual security	Handling of user data

4. Discussion

In order to gather as much information as possible, we analysed data collected during the operation of the platform between 2008 and 2016 and conducted a number of interviews with the founder. Additionally, we studied the more than 3,000 comments made by users on the web site of the company to learn about their motivations. Platform generated data can reveal the basic characteristics of users (e.g. gender and age), vehicles (e.g. brand and type) and trips (e.g. destination, date and time, number of passengers, etc.). However, some of the data requires heavy processing (e.g. car types and their characteristics), while other data is not available (e.g. Oszkár does not collect information about the means of transportation substituted by a ride share trip).

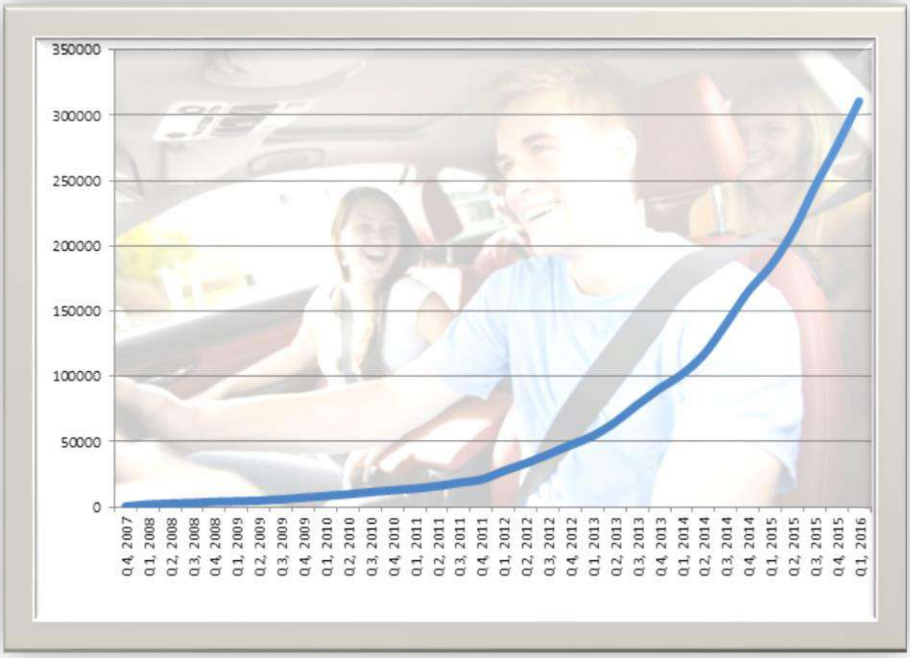
In the following paragraphs we will introduce a number of interesting phenomena, but more data collection will be needed in order to characterise the company's impacts as described in Tables 1-3.

Since the first day of operations, Oszkár has grown to become the market leader among ride share providers in the region. Figure 1. demonstrates that after an initial period of slow growth, the number of trips has started to increase sharply around the end of 2011. This period is also characterised by the decision of the founders to fully concentrate on the business leaving their other commitments behind. Fast growth continues to day and the number of registered users has reached almost half a million by early 2017.

According to the founder of the company a few other businesses have also tried to set up similar schemes during this period, but their number was low and they faded away fast. At the moment the only other significant ride share company active in the region is an international business. Competition exists between the two companies, but according to the company representative the understanding of local circumstances (e.g. consumer needs and habits) help Oszkár successfully compete with its rival.

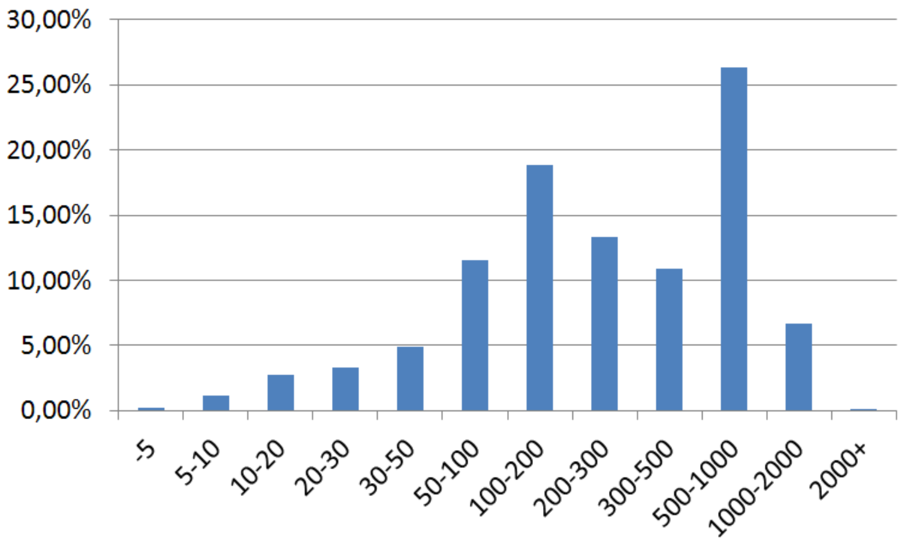
Data regarding the impact of Oszkár on other transportation service providers (e.g. train and bus services) is not available yet, but numbers suggest that the ride share company has started to have a perceptible impact on its competitors, at least during popular dates and times. During long weekends, when many people travel home to visit their families, several tens of thousands of trips are conducted by Oszkár. During these busy periods, ride sharing is especially appealing since trains and buses run at close to full capacity.

Figure 1. *Number of registered users by year (Source: Oszkár)*



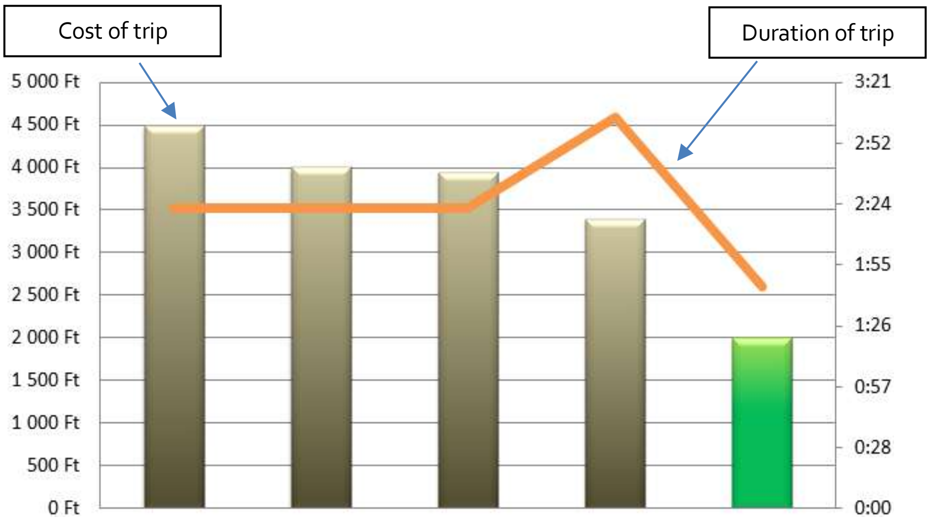
As mentioned earlier, the services of Oszkár are usually used to travel from one settlement to another within the country. Figure 2. shows the distribution of trips according to their lengths. According to the data, almost 20% of the trips are between 100 and 200 kilometres (typical trips in this range are trips between the capital city and other major towns), while more than 25% of the trips are much longer: between 500-1000 kilometres. These longer trips are used by those working abroad and visiting home for the holidays and weekends (typical destinations are Austria and Germany). A thorough analysis of data describing the locations of departure and arrival may reveal more detailed information, for example whether small, remote settlements benefit from the system or not.

Figure 2. *Share of trips by length, % (Source: Oszkár)*



Motivation factors behind the use of the platform are numerous. Figure 3 shows the two most obvious factors, namely cost and duration of trip in case of a popular long distance trip within the country. As demonstrated by the figure, taking an Oszkár ride may reduce cost by as much as 60% and shorten duration by about 50%. While cost and duration are important factors, a content analysis of comments made by users (both drivers and passengers) regarding their experiences with Oszkár on the company's web site reveal a number of other motivation factors. Users often mention the comfort offered by traveling by private cars compared to public buses and trains; the flexibility of trips (e.g. regarding timing and destination) and many mention the importance of personal relationships (e.g. being able to discuss with people with different backgrounds). Other motivations may also play a part: for example Oszkár drivers may deliver packages or carry animals and large baggage, which would be hard to transport otherwise.

Figure 3. *Price (left) and duration (right) of trip with Oszkár (green) vs. other means of transportation (Source: Oszkár)*



Basic demographic information about Oszkár users can be obtained from the database. According to this, most users (male and female) are in their twenties, but other age groups are represented as well (see Figure 4.). Users in their sixties and seventies are also present, although their trips may be arranged by their children, because of a lack of computer skills and equipment (e.g. smart phone).

Another interesting aspect is the question, whether there are differences between men and women regarding the use of the platform and if so, who would use it more often? An assumed aversion from the service exhibited by women was only evident in the early years of operations and by 2015 and 2016 half of the users are women (see Figure 5.).

Figure 4. *Age distribution of Oszkár users (Source: Oszkár)*

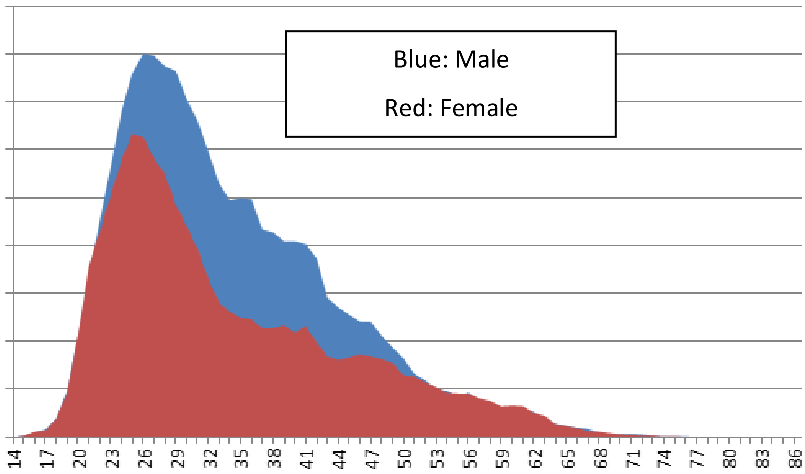
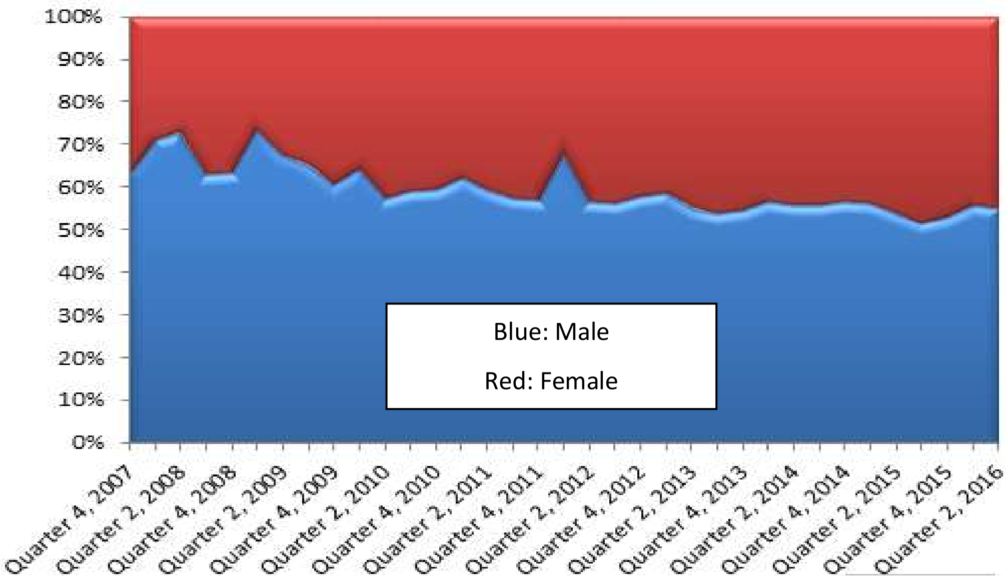


Figure 5. *Share of men and women users (Source: Oszkár)*



It is also of interest, whether there were any accidents during the trip and whether it is safe to take Oszkár compared to other means of transportation. While the database does not contain information regarding these issues, we asked the representative of the business, who said that no major accidents or crime events happened over the years of operations and people trust Oszkár to be safe and reliable.

5. Conclusions

Businesses operating in the sharing economy have a considerable growth potential, but also have to face a number of challenges. To survive in the long run, they should be able to offer clear benefits to their customers over traditional forms of service providers. They should also be able to cope with an inadequate regulatory system and competitors (both incumbent and new) on the market.

Our findings regarding the Hungarian drive share company demonstrated a number of benefits associated with the operation of the platform, as well as some issues the company has to deal with in the future.

Regarding social consideration, we did not find any evidence of traditional forms of exclusion, such as exclusion based on gender, age or ethnic group. To the contrary, women use the service as much as men do (at least for taking a ride) and elderly people can also benefit from the system (although their number is still rather low). Moreover, many people enjoy meeting travel companions with different educational and professional backgrounds.

The evaluation system used by the company can generate a new form of exclusion by motivating to avoid drivers/passengers with low scores. The application itself reminds users to check the reflections about a driver if his or her point score goes below a certain level. Since registering with different names and cars is not possible, low scores can actually result in the exclusion of some users.

Another social benefit of the platform is that it helps those with limited language skills, but working abroad. While it may take longer to take an Oszkár ride than flying, far away foreign destinations are still popular, because they provide (almost) door-to-door services, while flying requires getting to and from the airport and finding the address, which all require language skills.

Data obtained so far is not enough to draw a clear picture of the environmental benefits of Oszkár (e.g. the detailed analysis of registered cars vs. the average Hungarian fleet is needed). However, users commenting on the service on the company's web page often refer to savings in fuel and thus project positive results.

The founders also recognized some limitations of the regulatory environment. In Hungary no specific regulation exists regarding the tax consequences of charging a fee to the passengers. For this reason the company obtained a statement from the tax authority, which states that irregular, small scale income should not be reported and taxed. Still, in a few cases drivers were held responsible for not reporting their incomes originating from their participation in Oszkár.

This is not the case for professional drivers, who should arrange all their administrative tasks themselves, including the payment of taxes. Oszkár, when realising that professional drivers started to offer services on their platform, decided to mark their profiles and make sure that passengers understand the circumstances of the trip. By now most passengers accept the presence of professional drivers even though by stopping too often they may take more time to reach a certain destination than casual drivers. Thus Oszkár facilitates employment within its system.

Our investigation revealed a successful business model characterised by clear ecological and social benefits. While the precise quantification of these benefits will only be possible with further research (e.g. by identifying the means of transportation substituted by ride sharing and the changes of transportation habits), our efforts already yielded some interesting results. For example fears related to the use of the service (e.g. crime, higher accident rate, etc.) were swept away according to the experiences of the company (most likely as a result of the scoring system and related change in driving behaviour). On the other hand, expectations regarding the core benefits of the system (cost and time savings) were confirmed by analysing user comments and the importance of other types of benefits (i.e. personal relationships) could also be demonstrated.

Taking our results as a first step, further research will aim at the collection of data from other sources (such as mass transportation companies and a survey designed for the drivers and passengers of Oszkár) in order to provide a comprehensive picture of the sharing economy.

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Interview

Prácser, A., founder and managing director, Oszkár – serveral interviews between February-April, 2017

The growing acceptance of eco labelling: an empirical analysis in Spain

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Abstract

An ecolabel is the visible manifestation of a voluntary eco-innovation process. In this process, consumers' environmental expectations are met; firms increase their created and captured value and enhance their sustainability, and governments and institutions foster sustainable production and consumption. The European Ecolabel, also known as EU Flower, has the mission to regulate and propose common standards in the region and it has been considered one of the ways to promote the Europe's transition to a circular economy in Europe. Even though, the European Commission communicates the evolution of EU Label in the whole region, little is known about the EU Ecolabel evolution in Spain and it is not clear what are the drivers that encourage its implementation. Thus, the aim of this study is to assess the EU Label growing acceptance in the European Union and, more specifically in Spain by product categories and by geographical regions. The analysis shows that the major part of EU Label awarded products, in Spain, belong to the following categories: do it yourself (paints and varnishes), paper products, cleaning up, and electronic equipment. Interestingly, this study also shows that there are clear indications that the regions with higher incomes and exports in the country tend to register more products with eco-labels. Moreover, the regions with higher rates of ecolabelling have implemented and promoted sustainable public procurement criteria. Finally, this study may contribute as an important guidance for policy makers and firms to trigger ecolabelling practices and the transition to a circular economy in Spain and other regions with cultural proximity, like Ibero-America.

Keywords: Environmental certificates, EU Flower, eco-innovation, Spain, Circular Economy indicator, eco labeling.

1. Introduction

An ecolabel is the visible manifestation of a voluntary eco-innovation process (Prieto-Sandoval et al., 2016). In this process, consumers' environmental expectations are met; firms increase their created and captured value and enhance their sustainability, and governments and institutions foster cleaner production and consumption (Prieto-Sandoval et al., 2016). In this way, it simplifies the decision making process of consumers and it may involve to them with a "green" good or service (Thøgersen et al., 2012). Additionally, the eco labelling is a way to bridge the distance between the industry and the ecologist mind, because it stimulates the development of best practices. Hence, the increase of consumer involvement and information about the green products stimulates the demand and moves the companies to change the way they produce according to the current environmental perception. For this reason, the European Commission (2016a) has recognized its importance to support the Circular Economy implementation in the region.

Ecolabels have a recent history (Figure 1). The first milestone took place in 1977 when the Federal Republic of Germany launched the Blue Angel like the first environmental label scheme (Reisch, 2001; Villot et al., 2007). This green initiative was clearly reinforced by the (WCED, 1987) with the publication of "Our common future" or "The Brundtland report" which defined by the first time the concepts of sustainable development and the institutional challenges that it was going to imply. The report suggested different ways to use labels to encourage more responsible production and consumption, especially in the energy sector.

Ecolabelling milestones: A time line

The Blue Angel (1977)	Germany
"Our Common future" (1987)	United Nations
Green Seal (1989)	United States
The EcoMark (1989)	Japan
The White Swan (1989)	Nordic Countries
Rio Conference (1992)	United Nations
The EU Ecolabel (1998)	European Union
Agenda 21 Implementation (2002)	United Nations

***Figure 1**. Ecolabelling milestones.*

According to these facts in the international panorama, the labelling initiative was followed by other countries such as USA, Japan, and France (Hemmelskamp and Brockmann, 1997; Salzhauer, 1991; Salzman, 1991). Another milestone is the Nordic Ecolabel Scheme, named the White Swan, which was adopted in 1989 by the Nordic Council of Ministers and its purpose is to promote the sustainable production and consumption (Dietz et al., 2002). It is very important for ecolabel history because it was the first initiative made by a community of countries. Moreover, the marketing job made to introduce the green culture in decision making has had tangible returns in environmental conservation (The Swedish Society for Nature Conservation, 1999). Additionally, the United Nations Conference in Rio and the Agenda 21 program encourage the implementation of environmental labels to inform consumers (United Nations, 2002, 1993). As a final point, one other milestone is the EU ecolabel program launched by the European Union in 1998 to regulate and propose common standards in the region (Loureiro, McCluskey, & Mittelhammer, 2001). Nowadays, the ecolabelling is a growing eco-innovative practice, with a wide variety of seals which represent different criteria.

As follows, there are multiple factors that may encourage ecolabels implementation by firms such as: to inform customers of products' new green features in a visual way (Thøgersen et al., 2010), to trigger eco-innovation processes (Dangelico and Pujari, 2010; Prieto-Sandoval et al., 2016; Rubik et al., 2008), to be perceived as high quality products (Zanoli and Naspetti, 2002), to open markets where they could be technical trade barriers (Melser and Robertson, 2005), to conquer new segments of the market such as customers who are willing to pay premium prices (Delmas and Grant, 2014; Loureiro et al., 2002; Testa et al., 2015) or governments and institutions that promote the green public procurement (European Commission, 2015; Witjes and Lozano, 2016; Yong, 2007), among others.

This is focused on the EU ecolabel, also known as the EU Flower, because it is supported by the biggest common market and it has been continually updated to become a key tool for circular economy achievement (European Commission, 2016a). However, little is known about the EU Ecolabel evolution in Mediterranean countries like Spain, and it is not clear what are the specific drivers that encourage its implementation there. Thus, the aim of this study is to assess the EU Label growing acceptance in the European Union and especially in Spain by product categories and by Spanish autonomous regions. Moreover, this study may contribute as an important guidance for policy makers and firms to trigger ecolabelling practices and the transition to a circular economy in Spain and other regions with cultural proximity like Ibero-America.

The paper is structured as follows. After this introduction, the second section describes the methods used to develop this empirical analysis. In section 3, we present the results and discussion of the empirical analysis to understand the EU Flower diffusion in one European country; in Spain by region and economic sectors, according to the information provided by the European Union. Finally, the conclusions are defined.

2. Methods

This empirical analysis was carried out through the triangulation method that refers to the use of two or more data sources, researchers' perspectives, methodologic approaches, theoretical perspectives (Denzin, 1989; Kimchi et al., 1991), or analytical methods (Kimchi et al., 1991), within one study to build and objective analysis (Saunders et al., 2009). The source used by this study was an EU Label database, semi structure interviews to EU label delegates from every autonomous region and the academic literature (Figure 2).

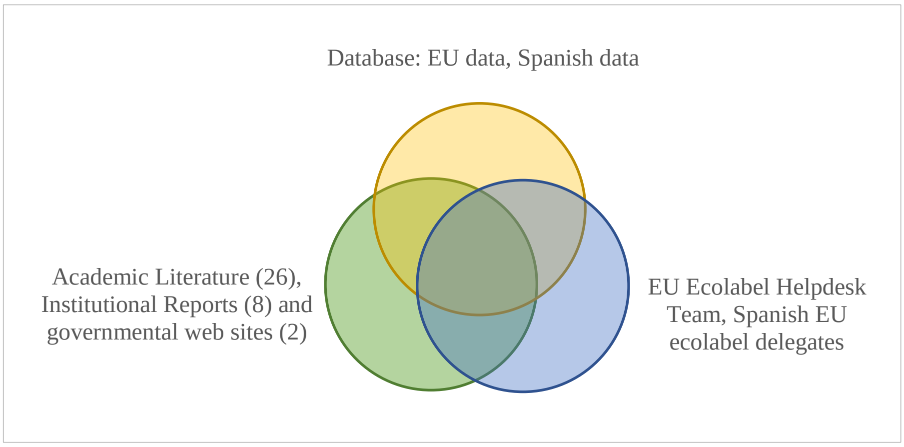

Figure 2. *Triangulation sources.*

First, the main data source was provided by The EU Ecolabel Helpdesk Team and The Ministry of Agriculture, Food, and Environment of Spain. The database allowed us to count the total number of licenses issued since 2002 to 2015. However, the information is only strengthened by sectors and autonomous regions in Spain, from 2013 to 2015. In addition, we made a geographic analysis of the licenses assigned in 2015, in the ArcGis Software. This tool gave us the opportunity to visually understand the current situation of EU Flower diffusion in Spain. Secondly, qualitative information was gathered through semi structure interviews to the EU label delegates from every autonomous region to identified the drivers that encourage the EU Flower certificate in the regions. In parallel, we review the literature in an iterative way, to understand the EU Flower evolution in all product categories analyzed in Spain.

3.Results and Discussion

3.1. European Situation of EU Flower

After the implementation of Council Regulation (EEC) N° 1980/2000 related to the environmental label, the expedition of the firsts EU ecolabel licenses was in 2002, and nowadays the number of licenses has been multiplied by 15. Then, the number of certified products is distributed according to the categories established by the EU Ecolabel manual, excluding food to avoid confusion for consumers and medical products that are regulated by the European Chemicals Agency (ECHA).

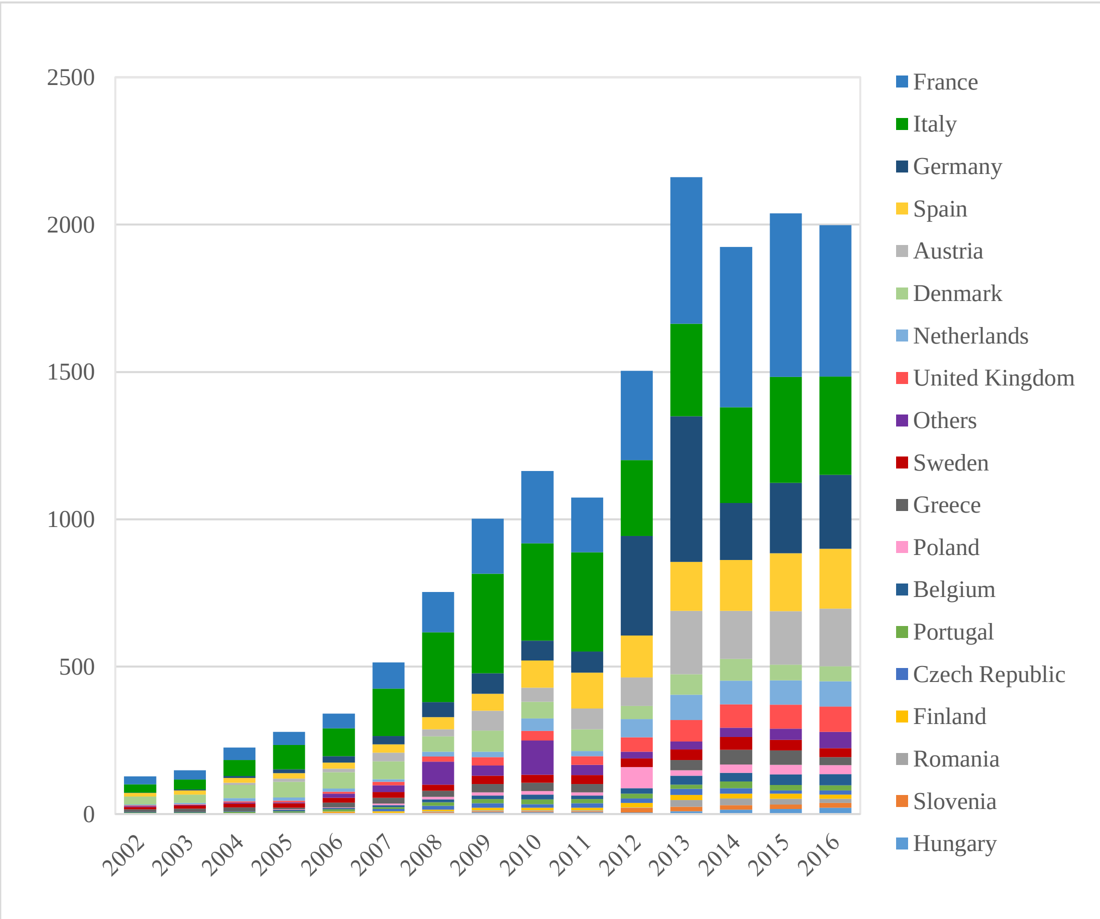

Figure 3. EU Ecolabel Licenses evolution from 2002. Own elaboration based on data provided by The EU Ecolabel Helpdesk Team(2017) and The Ministry of Agriculture, Food, and Environment of Spain.

France, Italy, German and Spain have been the most significant participants during this implementation process based in the fact that they have more than 60% of the licenses. There are countries like Hungary and United Kingdom which are increasing their participation while Portugal, the Spanish neighbor, is very low in the statistics (Figure 3). Unexpectedly, Nordic countries which has been pioneers in ecolabels developing, have a low participation in the EU ecolabel scheme, probably because the competition between their well-known White Swan and the EU Flower. Even though, the official web site of The Nordic Swan Ecolabel explains that it is equivalent to the EU scheme and often synchronized (Ecolabelling Sweden, n.d.). Based in the fact that the success of ecolabel schemes depends on their recognition and trajectory in the market (Johnson and Turner, 2006), the development of multiple environmental labels in the region, suggests that EU Flower has important obstacles to its diffusion.

In addition, the statistics of 2016 showed that the major part of licenses of France and Italy belongs to the Tourist Accommodation category, 287 and 186 correspondently. The success of this category in those countries could be attributed to their high importance in the top 10 world tourist destinations (UNWTO, 2016) and the multiple the economic benefits based on the eco-efficiency improvements and cost savings achieved by the EU Flower certification process (Dziuba, 2016). In Germany, the licenses are more distributed in different kind of products, unless an important part belong to All-purpose & sanitary cleaners (47), Lubricants (48) and Tissue paper (40). In Spain, the majority of licenses are in the category of All-purpose & sanitary cleaners (55), then Tourist accommodation services (45) and Hand dishwashing detergents (32). This is coherent with the total EU Ecolabel licenses categories that has mainly awarded Tourist Accommodation, Tourist Accommodation and Tissue paper (European Commission, 2016b).

3.2. EU Flower implementation in Spain

The Figure 4 represents the behavior of EU Ecolabel in Spain from 2002 to 2016 with an annual increase of 23% in average. This is very similar to Blue Angel graphic in its early stage of implementation according to Hemmelskamp & Brockmann (1997), although that graphic was made with the number of products with the Blue Angel from 1979 to 1993.

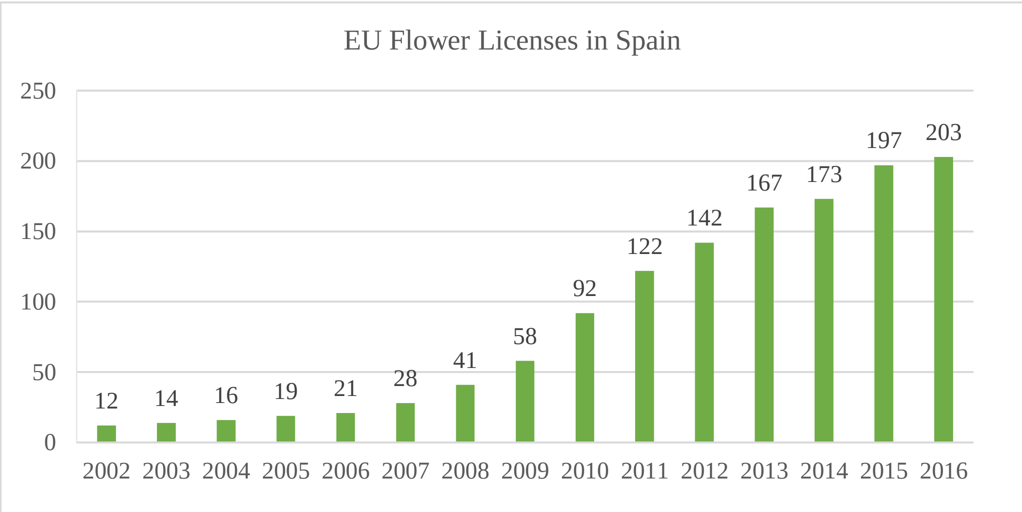

Figure 4. *EU Flower licenses evolution in Spain from 2002 to 2016. Own elaboration.*

The geographic analysis of the database according to the licenses assigned in 2015 facilitated the understanding of EU ecolabel diffusion in Spain and it also showed that twelve out of sixteen Autonomous communities of Spain have at least one license of EU Flower registered. The Figure 5 shows in the darkest color the Autonomous communities which have more products ecolabeled with EU Flower; the boards inside describe the Autonomous community, the number of licenses and the products covered by those licenses. The east region of the country is clearly the region more integrated to the "green" culture promoted with the EU ecolabel scheme. Cataluña is the leader with 1984 products, covered by 84 licenses while zones with a superior GDP per capita like Madrid and Basque Country (Table 1), just has 76 products, covered by 11 licenses, but they are geographically smaller regions. Nevertheless, big communities such as Andalucía, Castilla y León and Extremadura have less than 2 licenses or none. Even though in the Figure 5 Cataluña seem to be a leader, the EU Flower has to compete with the development of regional environmental labels like the “Distintiu de garantia de Qualitat Ambientar” in Cataluña (i Canals et al., 2002), as it has to do it with other European ecolabels reviewed before.

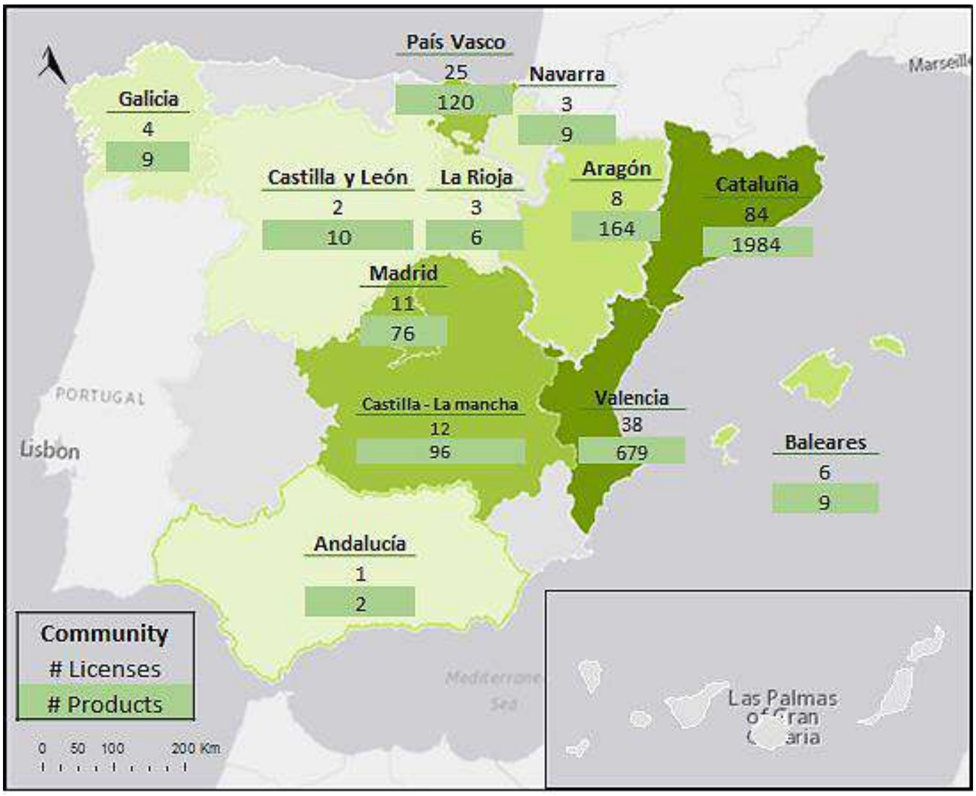

Figure 5. *EU Ecolabel licenses and ecolabeled products in Spain in 2015 by Autonomous communities. Own elaboration in ArcGis.*

In 2015, Spain registered 3164 products awarded with the EU Flower and the 96% of them belong to four categories: 1) Do it yourself, 2) Paper products 3) Cleaning up and 4) Electric equipment. The remaining percentage of ecolabeled products are distributed in seven categories (Figure 6). It is evident that the major effort has been done in the improvement of products related with paints and varnishes in the category named “Do it yourself”, where Cataluña has 1088 products out of 3164 in Spain. In Paper Products category, Cataluña with Valencia have 304 and 299 certified products respectively from a total of 778 in Spain. In third place, the Cleaning up category is dominated by Cataluña and Valencia too, with 283 and 213 products respectively, even though it is a growing category in Aragón (45). Fourthly, the Electronic Equipment products (266) are totally located in Cataluña, by just one multinational company named Sharp Electrónica España S.A. with an environmental management strategy according to their web site www.sharp.es.

In the case of EU Flower the most ecolabeled products are *Do it yourself* (paints and varnishes), *Paper products*, *Cleaning up* products and *Electric equipment*; categories which are closely related to chemical and pollutant products, water use and energy efficiency. Those results are coherent with the total licenses in the whole European Community, except the *Tourist accommodation* category, where paints and varnishes represent almost the 11% of products, Paper products are the 31,1% and *Cleaning up* products make up the 12,94%. However, the most notable absence is the EU Flower in the Tourist Accommodation category of Spain, based in the fact that Spain held on to 3th place in international tourist receipts (US$ 57 billion) and in arrivals (68 million) (UNWTO, 2016). This result shows the low level of reception of this environmental management tool in this sector.

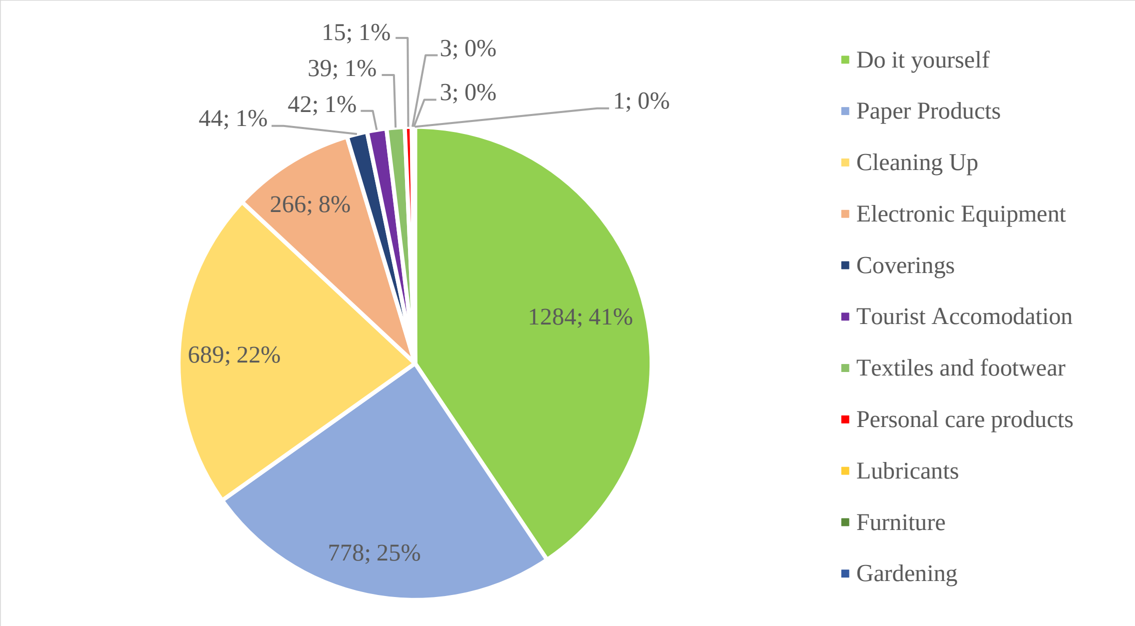

Figure 6. *EU Ecolabel products per product category in 2015. Own elaboration.*

We consider that the contrasting accumulation of licenses exposed in the Figure 5, may have three factors: 1) Sustainable public procurement criteria, 2) Local income and 3) International trade incentives.

Firstly, according to Witjes and Lozano (2016), the sustainable public procurement may motivate suppliers to develop new or more sustainable products and business models that lead to reductions in raw material utilization and waste generation. In this way, the dissimilar amount of licenses among the Spanish regions (Figure 5), conducted this study to inquire among EU Ecolabel delegates if they have financial or political incentives for EU Flower implementation. The Cataluña delegate confirmed that there is not any tax incentive but in the past, there were a call for subsidies for the achievement of eco-labeled products licenses. Another useful mechanism that encourages the ecolabelling is the inclusion of environmental criteria in the public procurement documents, especially for cleaning services that is the most remarkable category for Cataluña licenses (Annex 1). Moreover, other regional leaders in this aspect such as Valencia, Basque Country, Madrid and Castilla-La Mancha have included sustainable procurement guides and criteria in their budding process since 2008, when the council of ministers approved the Green Public Procurement Plan of the General State Administration and its public bodies, and competent organizations of the Social Security (Ministerio de la Presidencia, 2008). This result shows that ecolabel market penetration varies between product category and competition strategies among companies (Horne, 2009).

Secondly, there are important clues that suggest the influence of the local income to boost the ecolabelling. According to the Table 1, the 90% of licenses assigned in Spain are located in the region with the highest income per capita, it means Cataluña, Madrid, Basque Country, Aragón and Valencia. Moreover, there was a significant correlation ($p < 0.01$) between the number of licenses and the GDP per capita in each Autonomic community. This result makes us infer that companies of the most prosperous regions are more willing to implement environmental measures and produce goods which are less harmful to the environment. Even though the cultural engagement with the environment may be a reason (Rametsteiner, 1999), a high income also facilitate that consumer are willing to pay premium prices for sustainable products (Loureiro and Lotade, 2005) and individuals with higher levels of income would be less sensitive to price changes (Aguilar and Cai, 2010).

Third, if consumer from other countries value the cleaner production it may work as an international trade incentive to open new markets, consequently foreign exporters can try to adopt an ecolabel to increase their credibly commit to a less emission intensive production process (Greaker, 2006). For example, Germany, France, Italy and UK residents that preferred sustainable forest products (Rametsteiner, 1999) and that culture influences the penetration of any ecolabel. This is consistent with the fact that, communities with the 86% of licenses produce the 66% of exports in Spain (Table 1) and paper products are the second category with the major amount of licenses. Besides, a significant correlation ($p < 0.01$) was found between the number of licenses and the exports by Autonomic community.

Table 1. *Distribution of licenses, Regional GDP per capita and Exports (Millions) in Spain in 2015. Own elaboration based on EU Ecolabel Helpdesk Team* (2017)*, Ministry of Economy, Industry, and Competitiveness of Spain* (2015)*, and Statistics National Institute of Spain* (2015)

Autonomic community	Licenses	% Licenses	Regional GDP per capita	Exports (Millions)	% Exports
Cataluña	84	43%	26.585 €	140.063 €	26,9%
Comunitat Valenciana	38	19%	19.656 €	51.902 €	10,0%
Basque country	25	13%	29.514 €	38.684 €	7,4%
Castilla - La mancha	12	6%	17.266 €	27.360 €	5,3%
Madrid	11	6%	30.637 €	85.496 €	16,4%
Aragón	8	4%	24.646 €	20.842 €	4,0%
Baleares	6	3%	23.439 €	2.726 €	0,5%
Galicia	4	2%	19.663 €	34.033 €	6,5%
Navarra	3	2%	28.039 €	13.118 €	2,5%
La Rioja	3	2%	24.311 €	2.913 €	0,6%
Castilla y León	2	1%	20.877 €	12.647 €	2,4%
Andalucía	1	1%	16.522 €	51.465 €	9,9%
Murcia	0	0%	18.156 €	18.344 €	3,5%
Asturias	0	0%	19.506 €	7.017 €	1,3%
Canarias	0	0%	18.758 €	5.444 €	1,0%
Cantabria	0	0%	20.361 €	4.322 €	0,8%
Extremadura	0	0%	15.224 €	2.776 €	0,5%
Ceuta	0	0%	18.277 €	327 €	0,1%
Melilla	0	0%	16.674 €	324 €	0,1%
Total	197	100%	408.111 €	519.804 €	100%

4. Conclusions

At the beginning of the analysis we could stablish that the number of licenses of EU Flower are increasing, however this label has important obstacles to its diffusion such as the competition with environmental labels launched before in Europe and others which have been promoted in Spanish regions. This competition dilutes the efforts made by the European Union to encourage their ecolabel implementation and its recognition by consumers and producers. However, the EU Flower has achieved a significant penetration in the Tourist Accommodation category, All-purpose & sanitary cleaners, Lubricants and Tissue paper in Europe.

Spain is positioned as the fourth country in the region with the highest number of licenses which are mainly located in Cataluña, Valencia, Basque Country, Castilla-La Mancha and Madrid. According to this study we identified three factors that may encourage the EU Flower implementation in the most remarkable Spanish regions: 1) Sustainable public procurement criteria, 2) Local income and 3) International trade incentives. In this way, we consider that another country or region from a similar context, that want to trigger the ecolabels implementation should start by develop policies to develop a “green” or sustainable public procurement to encourage the supply side to develop sustainable products and business models. Regarding those three factors, we could establish that there are clear indications that the areas with higher incomes in a country tend to register more products with eco-labels. This finding is coherent with the presence and performance of ecolabel around the world, considering that the most influential countries such as Germany, Japan, the US, the Nordic countries, among others, which have been pioneers in developing environmental tools. Hence, this study recommends that the introduction of ecolabel schemes in other countries would be more effective starting by the most developed and prosperous regions based in the fact that consumers (demand side) can pay a premium price for green products. As a final point, we suggest to identify the foreign target market with an environmental culture that appreciate sustainable products because an ecolabel can work as an influential green marketing tool to open those markets.

In addition, we want to enhance that Spain and Ibero-American countries can still make the most in the Tourism Accommodation sector which has not been still conquered by the EU Flower because they have not realized the economic, environmental and social benefits that ecolabelling has.

More broadly, research is also needed to examine the firms' perception about the benefit they have perceived from the ecolabelling process and the main reasons which move them to get the EU Flower license. Thus, we recommend to EU Ecolabel authorities to gather additional information about the amount of EU Ecolabelled products exported and their influence in the European economy in other to assess and boost its implementation in the market.

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Appendices

EU Flower Category	Cataluña	Valencia	País Vasco	Castilla - La mancha	Madrid	Aragón	Baleares	Galicia	Castilla y León	La Rioja	Navarra	Andalucía	Grand Total
2013	**77**	**33**	**18**	**13**	**12**	**6**	**4**	**3**	**1**				**167**
Cleaning Up	32	20	10	8	8	5			1				84
Tourist Accommodation	21	3	1				4	1					30
Do it yourself	10	2	4	3	1			2					22
Paper Products	6	3	3	2	1	1							16
Personal care products	2	2											4
Textiles and footwear	1	2			1								4
Coverings	1	1											2
Electronic Equipment	2												2
Gardening	2												2
Lubricants					1								1
Other Household items													
Furniture													
Household Appliance													
2014	**77**	**31**	**19**	**15**	**12**	**7**	**6**	**3**	**2**	**1**			**173**
Cleaning Up	34	18	10	10	8	5	2		2				89
Tourist Accommodation	19	3	1				4	1					28
Do it yourself	11	2	4	3	1			2		1			24
Paper Products	6	3	3	2	1	2							17
Personal care products	2	2	1										5
Textiles and footwear	1	2			1								4
Electronic Equipment	2												2
Coverings	1	1											2
Lubricants					1								1
Gardening	1												1
Furniture													
Other Household items													
Household Appliance													

2015	84	38	25	12	11	8	6	4	2	3	3	1	197
Cleaning Up	34	26	9	10	8	5	2	1	2			1	98
Tourist Accommodation	25	3	8				4	1			1		42
Do it yourself	12	1	4		1	1		2		1			22
Paper Products	6	4	3	2	1	2					1		19
Textiles and footwear	1	2								1	1		5
Personal care products	2	1	1										4
Coverings	1	1											2
Electronic Equipment	2												2
Lubricants					1								1
Furniture										1			1
Gardening	1												1
Other Household items													
Household Appliance													

Exploring the relationship between green hotel attributes, guest satisfaction and loyalty

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Abstract

Sustainability in tourism emerged as a critical issue for a long-term strategy of industry's growth. The accommodation sector is responsible for roughly one-quarter of tourism GHG emission and, since decades, eco-friendly practices have been applied on a voluntary basis. The implementation of these practices is partly a consequence of consumers' growing awareness toward environmental sustainability. Examining the results of a survey addressed to guests of an Italian hotel awarded with Legambiente Turismo Eco-label, the paper investigates the relationship between guest's perceptions of hotel green attributes and their satisfaction and loyalty. Variance-based Structural Equation Modelling (SEM) has been employed to test hypothesis. Findings suggest that the environmental practices implemented by the hotel have a positive impact on guest overall satisfaction and loyalty. Moreover, results indicate that the staying at green hotels lead guests to develop a specific loyalty toward the whole range of hotels implementing green practices.

Keywords: green hotel attributes; hotel eco-label; guest satisfaction; guest loyalty; PLS-SEM

1. Introduction

Tourism is a relevant industry worldwide, contributing to 5% of GDP (World Travel & Tourism Council, 2015). On the other hand, the industry is also a significant contributor to environment degradation and, particularly, to greenhouse gases emissions (Pang et al., 2013). Concurrently, tourism is one of the most vulnerable industries to environmental degradation and climate change (Gossling and Peeters, 2015; Smith, 1990).Therefore, the success of tourism industry in the long-term is strictly linked to its capacity to manage environmental sustainability issues (Bramwell and Lane, 2008). The hospitality industry is responsible for roughly the 20% of tourism emissions and, since decades, has been applying green practices (Erdogan and Baris, 2007; Mensah, 2006). Kim et al. (2017) define green practices in the hospitality context as "a value-added business strategy that benefits a hospitality operation that engages in environmental protection initiatives" (Kim et al., 2017). Considering the hospitality industry, going green is becoming an effective strategy to gain competitiveness (Han et al., 2009). The implementation of eco-friendly practices is mainly a consequence of a growing attention of consumers toward sustainability (Cronin et al., 2011; Dodds and Holmes, 2016). Research has established a positive relationship between guest perceptions of hotel green attributes and behavioral intensions (Gao et al., 2016). Specifically, several studies have highlighted that green hotel practices are significant determinants of guest's satisfaction (Berezan et al., 2013; Gao and Mattila, 2014; Xu and Gursoy, 2015), loyalty and willingness to pay a premium price (Lee et al., 2010; Manaktola and Jauhari, 2007; Teng et al., 2012).

The main objectives of this study are to evaluate (1) how hotel guests perceive green hotel practices; to verify if green practices have a positive influence on (2) guest overall satisfaction, (3) loyalty, and (4) loyalty toward green hotels. The study presents findings of a survey delivered to guests staying in an Italian hotel awarded with "Legambiente Turismo" eco-label, which is the most diffused Italian green lodging program, accounting for 200 certified hotels. A PLS-SEM analysis has been conducted to test hypothesis (Legambiente, 2017).

The paper is structured as follows. After this introduction, Section 2 presents the relevant theoretical background and develops research hypothesis. Next, Section 3 describes the survey design and measure development, data collection and data analysis method. Section 4 presents the study results. Finally, Section 5 provides discussion of results and implications.

2. Literature and hypotheses development

Scholars have widely debated on the relationship between service attributes and customer satisfaction in lodging industries (Albayrak and Caber, 2015; Anderson and Mittal, 2000). Hotel green attributes were identified as facilitating attributes and influential in the formation of guests' satisfaction (Gao and Mattila, 2014; Kassinis and Soteriou, 2015; Slevitch et al., 2013). In this paper, it is tested whether the use of environmental good practices lead to higher levels of customer satisfaction in hotels. The subsequent hypothesis are tested:

H1: Hotel environmental practices positively influence guests' satisfaction.

As for customer satisfaction, environmental practices in hospitality industries are a mean to improve customer loyalty (Gao et al., 2016). Some scholars identified that guests are more likely to patronize when hotels adopt environmentally responsible practices, suggesting a positive relationship between green hotels and customer loyalty (Berezan et al., 2013; Choi et al., 2009; Lee et al., 2010; Xu and Gursoy, 2015). Thus, the paper tests the following hypothesis:

H2a: Hotel environmental practices positively influence guest loyalty.

Scholars' investigations have shown consistent findings supporting the positive relationship between environmental practices and guest loyalty. Scholars found that the firms' level of responsibility toward the environment significantly boost hotel guests' intentions to visit a green hotel, to engage word of mouth (Han et al., 2011; Han and Kim, 2010). In this paper is tested weather hotels with a higher rate of commitment toward green practices will lead guests to experience greater loyalty toward this type of hotels. Thus, following hypothesis is formulated:

H2b: Hotel environmental practices positively influence guest loyalty toward green hotels.

There exists a general consensus that customer satisfaction is an antecedent of customer loyalty (Boulding et al., 1993; Lee, 2009; Martínez and Rodríguez del Bosque, 2013). In relation to sustainable practices in the hospitality industry, recently studies have shown a connection between satisfaction for green hotels and guests' loyalty (Gallarza and Saura, 2006; Gao et al., 2016; Prud and Raymond, 2013; Xu and Gursoy, 2015). This evidence provided by previous literature is thus tested with the following hypothesis:

H3a: Customer satisfaction is a significant antecedent of guests' loyalty.

As suggested by Han and Kim (2010), efforts to increase customer satisfaction would enhance guests' predisposition to repurchase a green hotel product (Han and Kim, 2010). Therefore, in this study it is tested wherever customer satisfaction influence guest to develop loyalty toward a green hotel:

H3b: Customer satisfaction is a significant antecedent of guest loyalty toward green hotels.

3. Research methods

3.1 Measures and questionnaire

The questionnaire was built through a three-step procedure. In the first one, measurement scales were identified after an in-depth literature review. Next, the list of obtained items was skimmed with a semi-structured interview with hotel managers. Finally, the questionnaire was pre-tested on a sample of hotel guests (Castellanos-Verdugo et al., 2015).

The questionnaire consisted of three sections. The first section aimed at measuring guest perceptions on hotel environmental practices. The environmental attributes were identified with specific requirements that the hotel must satisfy to obtain the Legambiente Turismo eco-label and with attributes retrieved from previous studies. Guests' evaluation of hotel environmental attributes was measured on a scale ranging from 1 (poor performance) to 7 (excellent performance). The second section consisted of six items to measure overall satisfaction loyalty and loyalty toward green hotels. Both satisfaction and loyalty were measured on a Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The final section included guests' general information (age, gender, duration of the stay, type of trip). Table 2 lists all item employed in the measurement scales (constructs), means and standard deviation (scale 1 to 7).

3.2 Data collection and data analysis

The survey was conducted between July and August 2016. Eventually, 235 questionnaires were usable and employed for subsequent analysis. PLS-SEM modeling was chosen to estimate the structural equation models and to test hypothesis (Wold, 1982). SmartPLS (V.3.2.6) software was employed to build models and assess their validity (Ringle et al., 2015).

4. Results

Profile of respondents per type of traveler, purpose of stay and guest information on the eco-label are provided (Section 4.1). Next, validity and reliability analysis of the measurement model is tested (Section 4.2). Then, the hypothesis developed in Section 2 are tested through the structural models (Section 4.3).

4.1 Profile of respondents

Table 1 provides the main characteristics of respondents. Roughly 70% of respondents were males, while females were 30.7%. Most respondents in the age range 18-29 (34.8%) and 30-39 (35.7%), and only 6.2% aged over 60. Almost half of the respondents were travelling with family (46.5%), 23% with friends, 18% as single and 11% in couple. The large majority was staying at the hotel for leisure (72.7%), while 23.3% for business purposes. Considering the nights of stay, the majority stayed at the hotel 1-2 nights (35.1%), 17.2% 3-5 nights, 34.2% 6-10 nights, and 13.5% over 10 nights.

Table 1. *Characteristics of respondents, type of traveler and purpose of stay.*

Variable	Range	Percentage	Variable	Range	Percentage
Gender	Female	30.7%	**Purpose of stay**	Leisure	72.7%
	Male	69.3%		Business	23.3%
Age	18-29	34.8%	**Nights of stay**	1-2	35.1%
	30-39	35.7%		3-5	17.2%
	40-49	22.4%		6-10	34.2%
	50-59	5.0%		over 10	13.5%
	over 60	1.2%			
Type of traveler	Single	18.9%			
	Couple	11.6%			
	Family	46.5%			
	Friends	23.0%			

4.2 Assessment of the measurement model

Before proceeding with the measurement model evaluation, the relationship between constructs and indicators has been analyzed in order to evaluate if the construct in the measurement model should be reflective or formative (Diamantopoulos and Siguaw, 2006; J F Hair et al., 2014; Stacie et al., 2007). In this study, we followed the guidelines of Hair et al.(2014) as well as Jarvis et al. (2003), suggesting the choice of reflective constructs. The PLS-SEM evaluation consists of a two-step procedure: the measurement model assessment followed by the structural model assessment. The measurement model assesses that all constructs are correctly measured through the indicators (Klarner et al., 2013). The measurement model must be assessed for its reliability and validity. Table 2 shows indicators outer loadings for the reflective constructs. Internal consistency reliability for all constructs is satisfactory, well above the suggested threshold of 0.7 for both Composite Reliability (CR) and Cronbach's Alpha. For all constructs, the Average Variance Extracted (AVE) exceeds the threshold value of 0.5, suggesting adequate convergent validity.

Table 2. *Items, constructs, and measurement model evaluation results.*

Constructs/Indicators	Mean	St. dev.	Loading
Hotel environmental practices (Env_prat)			
α= 0.895; CR= 0.905; AVE= 0.526			
Organic or seasonal food are available for breakfast (E_food)	6.01	0.99	0.672
The hotel implement water and energy saving practices (e.g. new linen only when necessary)	6.02	0.88	0.578
The hotel tries to avoid disposable or single-dose products (E_disp)	5.87	0.95	0.662
In the hotel separated waste collection is available (E_waste)	6.10	0.93	0.487
The hotel informs the guests about the good environmental practices implemented (E_info)	5.86	1.08	0.843
The hotel provides its guests with information on how they can contribute to reduce the hotel's environmental impact E_g_info)	5.79	1.19	0.819
The hotel provides its guests with information on the environmental and cultural activities available in the area (E_g_area)	5.96	1.17	0.863
The hotel provides information on public transportation (E_trasp)	5.87	1.18	0.807
The hotel provides its guests bicycles for free or for rent	6.34	1.02	0.644
The hotel uses environmental certified or green labeled products (toiletry products, paper)	5.90	0.96	0.779
Overall satisfaction (Sat)			
α= 0.921 ; CR= 0.962; AVE= 0.926			
I am satisfied with my experience in this hotel (Sat_1)	6.06	0.80	0.959
My expectations have been satisfied (Sat_2)	6.03	0.79	0.966
Loyalty (Loy)			
α= 0.893; CR= 0.949; AVE= 0.903			
I would come back again in this hotel (Loy_revisit)	5.90	1.04	0.948
I would recommend this hotel in the future (Loy_wom)	5.91	0.95	0.953
Loyalty toward green hotel (Loy_env)			
α= 0.903; CR= 0.954; AVE= 0.911			
I would come back in a hotel that implements good environmental practices (Loy_E_revisit)	5.86	0.93	0.955

I would recommend a hotel that implements good environmental practices (Loy_E_wom)	5.90	0.88	0.954
α= Cronbach's Alpha; CR= Composite reliability; AVE= Average Variance Extracted.			

Discriminant validity was assessed with heterotrait–monotrait ratio (HTMT). All values of the HTMT are below the suggested 0.9 threshold (Table 3), suggesting a relevant relationship between indicators and constructs (Henseler et al., 2015).

Table 3. *HTMT discriminant validity criteria.*

	Loy_env	Loy	Env_perf	Sat
Loy_env				
Loy	0,660			
Env_perf	0,490	0,563		
Sat	0,639	0,808	0,578	

The measurement model assessment showed the reliability and validity of constructs measures. Thus, next section aims to test the hypothesis developed in Section 2 through the structural model's evaluation.

4.3 Assessment of the structural model

The structural model examines the relationships in terms of weights and magnitudes between the endogenous and exogenous latent variables in the model (Hair et al., 2011). Figure 1 provides a graphical description of the model tested. The core criteria to evaluate the structural model are the path coefficient significance level (β), the coefficient of determination (R2), and cross-validated redundancy (Q2) (J F. Hair et al., 2014). A t-statistic was obtained through a bootstrapping procedure with 5000 resamples, to evaluate the significance of path coefficients and estimate the standard error in the proposed models. The p-values generated by the bootstrapping allow to accept or reject the hypothesis, testing the significance of the relationship among constructs. R2 represent the effect of the exogenous constructs on endogenous construct, and measures the predictive accuracy of the model. PLS-SEM objective is to maximize the R2 value that ranges between 0 and 1. Values below 0.25 indicate a weak accuracy, 0.50 moderate accuracy, and 0.75 substantial predictive accuracy. The Stone-Geisser's Q^2 values are obtained through a blindfolding procedure to evaluate the predictive relevance of the exogenous constructs on endogenous constructs. Values below 0 ensure the model predictive relevance. The bootstrapping procedure indicates that all path coefficients are significant with a confidence interval of 95%, thus all hypothesis H1, H2a, H2b, H3a, and H3b are accepted. The predictive accuracy of the model is confirmed by the Q2 and R2 values. The model explains 55.7% of Loy variance, 36.5% of Loy_env variance and 27.4% of Sat variance (Table 4).

Table 4. *Model hypothesis statistics (bootstrapping) and endogenous constructs assessment (R2 and Q2).*

Path coefficients and bootstrapping				
Hypothesis		**Original Sample**	**T Statistics**	**P Values**
H1a	Env_prat → Sat	0,524	9,003	0,000
H2a	Env_prat → Loy	0,168	2,239	0,025
H2b	Env_prat → Loy_env	0,188	2,137	0,033
H3a	Sat → Loy	0,644	10,958	0,000
H3b	Sat → Loy_env	0,484	6,174	0,000
Endogenous constructs assessment				
	R2	**R2 Adjusted**	**Q²**	
Loy	0,557	0,555	0,479	

Loy_env	0,365	0,361	0,304	
Sat	0,274	0,272	0,238	

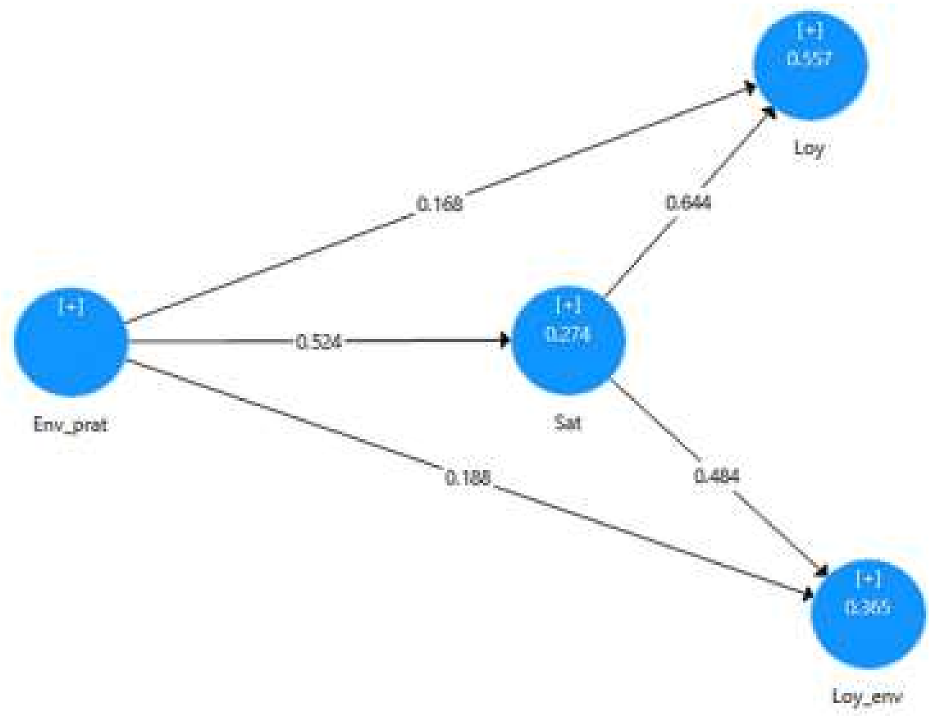

Figure 1. *Model 4 direct effects: β for path coefficients and R2 for the exogenous construct.*

5. Discussion, Implications and limitations

The study investigates the impact of hotel green attributes on guests' perceptions. The research reveals:

(1) a significant relation between hotel environmental practices and guest overall satisfaction (H1), confirming previous studies findings that environmental friendly actions enhance visitor satisfaction (Berezan et al., 2013; Gao and Mattila, 2014; Kassinis and Soteriou, 2003; Lee and Heo, 2009; Xu and Gursoy, 2015);

(2) that hotel environmental practices have a significant influence on guest revisit intention and on positive word of mouth (H2a). This result is consistent with previous scholars' findings (Berezan et al., 2013; Choi et al., 2009; Gao and Mattila, 2014; Gao et al., 2016; Han and Kim, 2010; Kassinis and Soteriou, 2003; Lee et al., 2010; Xu and Gursoy, 2015);

furthermore, in accordance with Han et al. (2011) and Han and Kim (2010), results show that (3) guests staying in a green hotel develop a favorable loyalty toward this type of hotels (H2b).

Secondly, the study investigates the role of customer satisfaction as an antecedent of loyalty (e.g. see (Boulding et al., 1993; Lee, 2009; Martínez and Rodríguez del Bosque, 2013). In line with other studies in the field of green hotels (Gallarza and Saura, 2006; Gao et al., 2016; Prud and Raymond, 2013; Xu and Gursoy, 2015), findings show that (4) overall satisfaction is a determinant factor for guest loyalty to hotel (H3a); moreover, results suggest that (5) guest loyalty toward green hotels is significantly influenced by the level of visitor satisfaction (H3b), confirming Han and Kim (2010) conclusions.

6. Conclusions

This study investigates how consumers perceive actions implemented by hotels for environmental sustainability. It is hypothesized that hotel environmental practices positively influence guest overall satisfaction and loyalty. The PLS-SEM analysis allows to accept all the hypothesis tested. Moreover, findings suggest that the staying at a green hotel lead guests to develop a specific loyalty toward the whole range of hotels implementing green practices. The research thus offers interesting findings both to hospitality research and industry practitioners. First, it enriches the literature dealing with sustainability practices in the hospitality industry and guest perceptions. Next, to our knowledge, this is the first study investigating the role of hotel environmental practices in stimulating consumers to develop not only a generic sense of loyalty, but also a specific loyalty for green hotels. Findings may also assist hospitality practitioners. Managers, when choosing among available strategies to enhance service quality, might invest on sustainability practices, since these enhance guest satisfaction and behavioral intentions. Despite the positive contribution to the field of sustainability in hospitality industry, this study is not free of limitation that reveal opportunities for future investigations. The study does not address the way through which environmental practices influence customer satisfaction and loyalty. In this way, further investigation on guest eco-friendly attitudes and demographic characteristics seems to be necessary in order to fully understand this link. Finally, as service quality in hotels is conceived as a multi-criteria construct, it would be compelling to evaluate the simultaneous effect of environmental attributes together with the other service attributes, that in literature have been identified as crucial in the hotel industry.

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Corporate sustainability: From anthropocentric to ecospheric approach

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Abstract

Due to the challenges met by companies when facing problems like population growth, climate change and lack of resources, among others, while responding to the economic and market demands, now days, one of the issues required in global sustainability agendas is *Corporate Sustainability*. As a framework, this document is based on a research project that carried out a systematic search of specific concepts as key words to find the existing relationships and proposals that could associate *sustainability aspects* with *human aspects*. The results of the search showed that a conceptual development has taken place from two disciplines: economy and ergonomics. From this approach we refined the search using three concepts: eco-efficiency, eco-productivity and eco-effectiveness obtaining 15 documents which were read and analysed carefully and comparatively. It was found out the three concepts used are tightly related to Corporate Sustainability development. In this context, and considering the Ergoecology approach (G. García-Acosta, Romero, & Saravia, 1997) (Gabriel García-Acosta, Pinilla, Larrahondo, & Morales, 2014) we may say that Corporate Sustainability needs to reorient its traditionally anthropocentric and economic-based view towards a holistic, integral, and ecospheric approach. To structure this paper we introduce the model proposed by the economists Dyllick and Hockerts (2002). It is based on six criteria for the management of Corporate Sustainability and their work from the concept of Triple Bottom Line (TBL). From there, it is presented the anthropocentric vision of the ergonomists Zink, Steimle, and Fischer (2008) . Based on Dyllick and Hockers proposal, these authors involve on a determinant way the Human Factors and Ergonomics (HFE) approach in the development of Social Sustainability. Then, going back to the economics point of view presenting the Mauerhofer´s approach (2008), which proposes "3D Sustainability" to understand the concepts of *three capitals*, in order to achieve equity and environmental sufficiency. Finally, with the literature review it was confirmed that there is a different manner to approach forward and understand Sustainability. This new manner is exposed first, in the Ergoecology proposal by G. García-Acosta et al. (1997), and then in Green Ergonomics proposed by Thatcher, Garcia-Acosta, and Lange Morales (2013). The starting point comes from the systemic approach of ergonomics towards the ecology aspects to become aware of the interdependence between natural systems and human systems, seeking a dynamic balance. Parallel to the development of the research project, other perspectives are recognized from the approach of the economists who move from the classic view of the Financial Economy (R. M. Solow, 1991), through holistic proposals such as the Ecological Economy

(Costanza, 1989; Daily & Ellison, 2012; Georgescu-Roegen, 1975) and Economic Degrowth (Latouche, 2009; Martinez-Alier, 2010), among others, but are not directly related to the human aspects and therefore are not included in the theoretical framework. Concluding, it may be said that under Sustainable Development, the eco-efficiency criterion has become the main objective of organizations, which misrepresent the notion of *economic growth* and neglect environmental and social aspects. Likewise, it is needed to develop other criteria to address issues such as *ecological equity* with a view to achieving *social sustainability*. In order to achieve this transition, *from Ergoecology approach*, routes and strategies are raised allowing to identify actions that organizations should make to achieve true *Corporate Sustainability with an ecospheric approach*.

Keywords: Ergoecology, corporate sustainability, ecospheric approach, transition strategies

1. Introduction

From the development of the research project "Ergoecology Foundations: eco-efficiency, eco-productivity and eco-effectiveness", developed in an academic network between the *Mimapro research group* of the Universidad Nacional de Colombia and the *Design, ergonomics and innovation research group* of the Pontificia Universidad Javeriana, it was concluded that there is a clear opportunity to integrate the visions that currently address the social, environmental and economic aspects in pursuit of Sustainability. In particular, we found out that from this integrated perspective, both, ergonomics (HFE) and ecology can contribute to promote many aspects of what now days it is understood as "Corporate Sustainability".

However, there is still a great deal of ignorance about the wide and varied approximations that have been developed by academics and professionals of different areas of knowledge with methodological rigor and analytical depth. Without being exhaustive but with the certainty of having done a wide documentary review at the research project carried out, the main tendencies and interests of those whom have worked together the two perspectives mentioned above were identified and classified.

With this document in particular, we seek to address the issue of Corporate Sustainability as one of the topics of great impact that, within the global problems of planetary sustainability, is very important and attracts the attention of various business sectors. To develop our vision –at the theoretical framework section that we added– we outline, in chronological order, only some significant proposals (from diverse disciplines focus) that have been unfolded about Corporate Sustainability. This in order to show both, the theoretical evolution and the more concrete way to establish the relevance of ergonomics into general sustainability as well as into Corporate Sustainability specifically.

Despite these findings about the theoretical approach, the work around Corporate Sustainability in practice fails to internalize, in a concrete way, how to assume the limit of natural capital expressed, for example, in the loss of non-renewable resources. From this perspective, our literature-review also confirmed the urgent need for the transition from the anthropocentric principle to an ecospheric approach.

As a main conclusion of this work we can point out the need to develop new criteria to address issues such as ecological equity with a view to achieving social sustainability within Corporate Sustainability. In order to achieve this transition –from Ergoecology approach– at the results and discussion section, some routes and strategies are raised to identify those actions that organizations should make to achieve true Corporate Sustainability with ecospheric approach.

2. Framework

The most recognized and still been used definition of Sustainable Development was written in the Brundtland Report (WCED, 1987). Nevertheless, experience has demonstrated that Sustainable Development assumes exclusively an anthropocentric approach, being (to increase) the economic capital its main goal. This position restricts the majority of the approaches and sustainable models that are proposed (based on Triple Bottom Line) falling into the Jevons paradox (which embraces the rebound effect, eco-efficiency and doing more with less) and having as a consequence conflicts between the concept and the practice when is try to achieve real sustainability (Alcott, 2005). This conflict happens when thinking and talking from the view of Sustainable Development expecting to generate growth. Thus economic and social capitals are privileged over the natural capital making the financial economy valid and predominant, which is oriented to produce and consume without effective solutions for limitations –more evident every day– of natural capital.

Many efforts have been made in order to validate and maintain the Sustainable Development scheme. However, is impossible to deny the catastrophic effects of natural resources exploitation and inefficiency of this anthropocentric posture which is trying to be shown as successful. Never the less, as examples of real and current problems linked to global warming (generated within the Sustainable Development practices) we can mention: the vulnerability of river and coast towns; the rising droughts that produces irreversible desertification, reduction of food production and distribution; and increasing infectious and epidemic diseases, among others.

Corporative Sustainability

One of the proposal that pursuits the improvement of Sustainable Development is Corporative Sustainability, particularly the one created by the economists Dyllick and Hockerts (2002). Based on the definition of Sustainable Development from the Brundtland Commission, Dyllick and Hockerts conceive their own Corporative Sustainability concept as "the satisfaction of the direct or indirect business stakeholders without compromising the capability to satisfy future stakeholders". In favour of this goal companies should keep and build their economic, social and environmental progress as their capital baseline, while they actively contribute to politics sustainability.
From previous definition there are three key elements of corporative sustainability that are identified:

1. *Integration of economic, environmental and social aspects in a 'triple balance' (triple-bottom line).* Is relevant to point out that the most important principle of orthodox sustainability theory is to recognize that business sustainability is not enough to achieve global corporation sustainability. Satisfaction of the three dimensions is required.

2. *Integration of short and long-term aspects.* The Influence of stock market forces to think about short-term utilities. This is opposite to sustainability spirit because it cuts off the power to satisfy future needs of their stakeholders.
3. *Consume the incomes and not the capital.* Keeping the capital base is common in business as a condition to get success and responsible management. But, companies should manage environmental and social capital not just economic capital, in pursuance of long-term sustainability.

On this basis, the authors show the need to understand each aspect of the triple balance as an organizational capital: economic capital, environmental capital and social capital. An *economically* sustainable company should guarantee its liquidity with constant production. Meanwhile, an *environmentally* sustainable company only uses natural resources under its regeneration rate or alternative materials under its development rate; it does not cause emissions trespassing the natural absorption capacity rate of the natural system and does not participate of activities that imply eco-systemic services degradation. Finally, a *socially* sustainable company adds value to communities where it works increasing human capital of individuals and also social capital of those communities.

In order to complete the conceptual basis of their model the authors emphasize in three topics that are related to social and environmental capitals: the *irreversibility*, the *non-linearity* and the *non-substitutability*. Reaching irreversibility means the impact is irreversible once the threshold is forecasted, the point of no return. The non-linearity can be less evident. The environmental and social capitals do not reveal any effect until a determined threshold is reached. Finally, the *non-substitutability* of resources expresses that the resources of social and natural capital cannot be replaced by others, contrary to the orthodox economic theory, in which all the supplies of a process can be quantified and valued in monetary units, as well as replaced by another equal or comparable at the time that is needed.

From this expanded perspective and based on their own interpretation of *eco-efficiency* –concept that has been widely disseminated by the models that promote Sustainable Development– Dillick & Hockerts elaborate their central proposal in which they include six criteria for the management of Corporate Sustainability. On the scheme of the sustainability triangle and its three basic aspects (Triple bottom line), they construct a model that covers the three 'cases' already explained –business, societal and natural– emphasizing the need to contemplate them in an integrated and interconnected way. The intention of the authors is that those six criteria will allow such integration and promote balance in terms of achieving true sustainability and therefore what they have defined as Corporate Sustainability (Figure 1).

Figure 1. *General description of the six criteria of Corporative Sustainability. Retrieved from Dyllick and Hockerts (2002).*

Dyllick and Hockerts (2002) close their approach affirming that to achieve true social sustainability a solution must be found yet that guarantees the equitable distribution of natural capital. Unfortunately, they note, that there are still no clear indicators to guide companies in this criterion of sustainability.

Ergonomics and Sustainable Development

The concerns of the relationship between Ergonomics-Human Factors (henceforth EFH) and Corporate Sustainability have their beginnings in Europe with the studies of a group of ergonomists directed by Professor Karl Zink (Zink et al., 2008) whom in studying Dyllick and Hockerts (2002), recognize that it is just as important to talk about *economic sustainability* as about *social sustainability*. Zink and his colleagues understand that HFE is a key factor in the development of the concept of Corporate Social Responsibility, opening up a series of challenges and opportunities for the work of ergonomists in the field of organizational ergonomics (macroergonomics). In this context, their proposal is oriented beyond health and safety at work (prevention of injuries and accidents), reaching the welfare of the worker in its widest sense. In other words, to make the worker feel at ease with what he does, motivated, integrated and participant in the decision making according to his role. However, although they make Corporate Sustainability more robust it still maintains an anthropocentric approach promoted only from social responsibility.

The work of Zink and his colleagues, establishes differences in terms of scope and times of action, between the approaches that seek Business Excellence/Total Quality (TQM) and those of EFH. The authors state that while the approaches to business excellence pursue economic sustainability for present generations, EFH seeks social sustainability for the present and future generations as well.

In order to harmonize these objectives, they propose that Corporate Sustainability should consider economic, social and environmental sustainability, taking into account not only present but also future generations. Finally, they locate the principles, tools and methods alluding to the two approaches mentioned, on the Dyllick and Hockers' triangle (Figure 2).

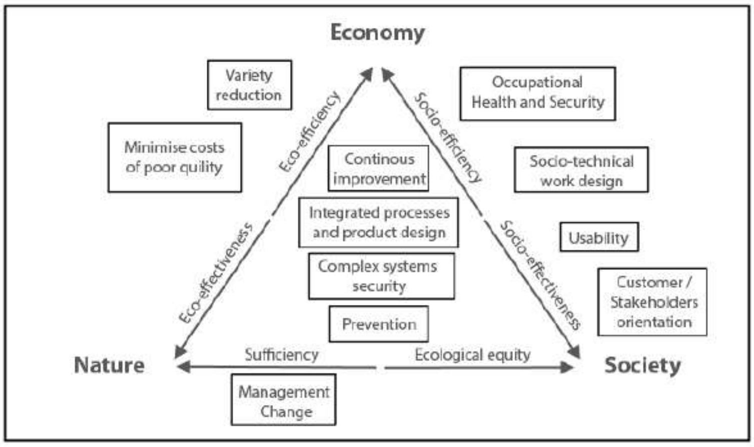

Figure 2. *Principles, methods and tools for business excellence and human factors in Corporative Sustainability. Retrieved from Zink et.al. (2008).*

3D-Sustainability

Within the evolution of sustainability models, the one proposed by economist Volker Mauerhofer (2008), is also based on the sustainability triangle proposed by Dyllick and Hockerts (2002). It develops a three-dimensional cone-shaped representation called "3D-Sustainability" which shows how, contrary to traditional models, the "carrying capacity" of natural capital (understood as the population size that a species or an ecosystem can withstand indefinitely or sustainably), conditions the growth and development of economic and social capitals.

The author argues that literature reviews on the three dimensions of sustainability have traditionally been done just through a DOFA analysis. Therefore, to go further, he identifies four specific problems: 1) misinterpretation of the fundamental; 2) inequity in judgments about the three dimensions of sustainability; 3) explicit and clear boundaries lack; and 4) lack of support for guaranteeing appropriate decision-making.

According to Mauerhofer, these shortcomings are surpassed (theoretically and in practice) with the 3D-Sustainability approach, which although it is a little more complex, is conceptually much richer than the schemes generally used to analyse and measure sustainability. In particular, the approach to carrying capacity in the three dimensions of sustainability is argued to be the main solution offered. The author refers to the application of the 3D-Sustainability criteria in several real examples, through which he highlights the usefulness of the model to support decision-making, pointing to the hierarchy of bottom-up solutions (more sustainable) as the great contribution of this in the solution of conflicts of interests and inequality within the three dimensions of sustainability (Mauerhofer, 2008).

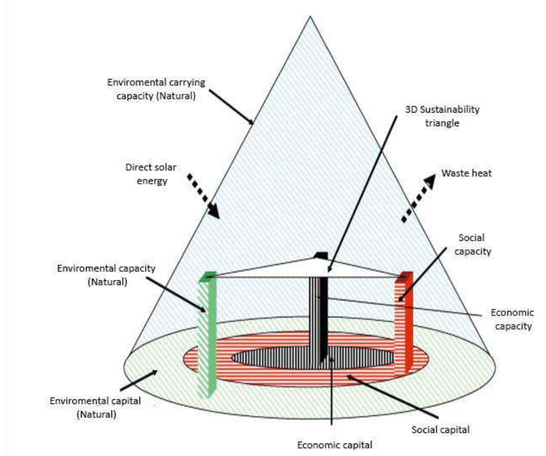

Figure 3. *3-D Sustainability. Retrieved Mauerhofer (2008).*

As shown in Figure 3, for the 3D-Sustainability model, economic capital is embedded within social capital and in turn, these two are embedded within the (natural) environmental capital. This, unlike other models, implies a clear preponderance with respect to environmental capital because from the point of view of scale, it is assumed that it contains the other two capitals and therefore, the social and economic capitals depend on the carrying capacity of capital environmental.

The advantage of this representation is that it shows us the need for the sustainability triangle -supported by these columns- as regulator the height of the columns to achieve equity in the demand for the resources of the three capitals; for this reason, the importance of equitably resolving conflicts of interest between the three types of sustainability.

From the perspective of 3D-Sustainability, a necessary condition for the sustainability of social and economic capital is to achieve the environmental objectives associated with the preservation of environmental capital. However, Mauerhofer notes that while a company may meet environmental objectives, social and economic costs are always and ultimately assumed by environmental capital. This model invites us to move from purely anthropocentric thinking to a position that seeks to achieve equity and environmental sufficiency, which implies that companies must assume environmental responsibility to guarantee their social responsibility and therefore Corporate Sustainability.

Ergoecology and Green Ergonomics

For its part, Ergoecology, (G. García-Acosta, Saravia, Romero, & Lange, 2014) and Green Ergonomics (Thatcher, 2013), coincide in their vision about the systemic approach that allow to become aware of the interdependence between social capital and natural capital. Clearly, their concern goes beyond economic capital to focus on achieving the dynamic balance between socio-technical systems and natural systems. From this perspective, nature is seen as a provider of eco-systemic services whose balance guarantees integral sustainability in the long term, promoting equity in the access of resources and services to all living beings on the planet. For this reason, both models prioritize the protection of natural systems and their eco-systemic services, in order to legitimize the sustainable performance of socio-technical systems (Lange-Morales, Thatcher, & García-Acosta, 2014).

Ergoecology proposes three principles to achieve this balance. The first is an *anthropocentric approach with an ecospheric consciousness*, from which we study the interactions between systems, whose purpose is related to human needs and actions, taking into account the effects of these both on human beings and their built environments, as in other species and its eco-systems. The second is a *sustainable approach* which base is Integral Ecological Sustainability, established on relationships of interdependence among social, cultural, economic, technological and political sustainability, as it seeks to balance all these dimensions. Third, Ergoecology poses a *systemic approach*; this allows us to consider performance and existing relationships (interactions) between all the elements of a system with complex behaviour, favouring its improvement from the analysis and construction of indicators of specific situations, in function of the inputs and outputs of energy, matter and information (knowledge). This third principle is compatible with the *scalability feature*, which allows vary the analysis level to move from the micro level (operations and processes), to the macro level (business and community habitat) and to the supra level (eco systems and their interactions).

The authors of Ergoecology argue that to achieve sustainability, certain levels of *eco-productivity* and *systemic eco-efficiency* must be achieved. Must be said that this “systemic eco-efficiency” widely differ from the traditional eco-efficiency, established from Sustainable Development.

Here eco-productivity is defined as the capacity of human productive systems to transform energy, matter and information (knowledge) into a product /service, without generating waste or producing negative impacts on other systems. It also functions as an indicator of the increase in the equilibrium between the dynamics of human systems and natural systems (Garcia-Acosta, Saravia, & Riba, 2012), that is to say that eco-productivity is achieved when the productive system remains in equilibrium during several periods (Thatcher et al., 2013) allowing natural resources recovery.

For its part, *systemic eco-efficiency* is proposed as the balanced performance between human-technological systems and terrestrial-natural systems, which can only be achieved if there are no negative impacts, (G. García-Acosta et al., 2014). Thus, Ergoecology focuses on studying human activities, and their immediate technological environment, both in the transformations of the productive system (for example, resulting waste, conversions and energy losses), and in the transformations of ecosystems. In this sense, although Ergoecology is based on an anthropocentric approach, related to the study of human activities, it is also concerned with interdependent relationships with ecosystems and the natural environment; that is why it refers to the ecospheric consciousness.

In turn, Green Ergonomics, focuses on human affinity with the natural world. It recognizes the planet as a closed system in such a way that a disturbance in a part of it, will necessarily have repercussions in other elements of the system. Thus, Green Ergonomics recognizes two-way relationships between humans and the natural environment. It studies how human beings influence the health of their natural environment and, in turn, how the health of the natural environment impacts on the health and well-being of human beings. Like Ergoecology, Green Ergonomics promotes *balance between systems* by emphasizing the importance of natural systems; That is, that it places ergonomic interventions specifically in reciprocal connections between humans and nature, which necessarily also includes the social and economics’ humans needs (Thatcher, 2013).

Green Ergonomics put forward in first place, that human systems must facilitate the conservation, preservation and restoration of natural capital, since it is not possible to speak of human effectiveness and sustainability, when the natural environment is degraded and impoverished. From this perspective, it proposes to reduce the impact of human systems on eco-systemic services, through ergonomic design, in order to avoid or reduce natural and humanitarian crises. Second, Green Ergonomics considers how human connections with nature could facilitate human well-being and effectiveness by integrating the concepts of "*biophilia*" and "biomimetic" into the design and evaluation of workplaces, households and playgrounds. Thirdly, it proposes to assume a life cycle approach, taking into account all its stages of either a product or a system. Thatcher points out that the potential damage that a product or system can cause to the environment is equal to the sum of its environmental impacts at each stage of the life cycle. This would involve considerations from the perspective of ergonomics in favour of nature, in the design stages, production, use, recycling and final disposal.

Thatcher et al. (2013) propose, based on Ergoecology, four design principles for Green Ergonomics. The first is *evaluation, design and innovation for eco-efficiency, eco-productivity and eco-effectiveness* in a broad sense that transcends the workplace and enables understanding of energy flow, cycles of nutrients and patterns of resource recovery. The second is *evaluation, design and innovation congruent with ecological resilience*, understood as the ecosystems capacity to recuperate after disturbances. Points out how socio-technical systems have important bidirectional relationships with ecosystems at both the micro and macro levels of analysis scales. The third *is evaluation, design and innovation for vernacular solutions*. In this sense, Thatcher et al. suggest that knowledge of the local ecosystem is also required. And, finally, the fourth principle of Green Ergonomics, promotes the adoption of lessons that nature given that we can see how she has learned, adapts and innovates. In practical terms, the authors emphasize that this principle means embracing uncertainty, taking a cautious stance and recognizing the rights and needs of future generations. From these conceptual bases, the proposal of Green Ergonomics, focuses on the development of human systems that integrate completely and in a sustainable way with natural environments.

In future works and discussions this conceptual framework can be complemented with other approaches addressed from the economy where it is also discussed the clarity with which the concept of Sustainable Development has been assumed. For some authors who approach *Financial Economics* (R. M. Solow, 1991; R. M. Solow, 1993) the concept is closely linked to the economic growth of nations and companies, maintaining the financial dynamics as the basis of Sustainable Development. However, for other authors this position is seen as an oxymoron, that is, it contains a contradiction because the development understood as growth, is not sustainable. In the latter posture we can refer authors such as Georgescu-Roegen (1975), Costanza (1989) and Daily and Ellison (2012), who from the proposal of the *Ecological Economy* criticize the development assumed as growth, moving away from the monetary capital and focusing on natural capital value and the sun as sources of wealth and energy. And others such as Latouche (2009) and Martinez-Alier (2010) whom go further and propose the *Degrowth Economics* as an alternative.

3. Method

The methodology used was a systematic review of specialized literature with an analytical-descriptive approach using the software Nvivo-11. The basis for the review were the Ergoecological Fundamentals, which include: principles (anthropocentric approach, sustainability and systemic approach), postulates (eco-productivity, eco-efficiency (G. García-Acosta et al., 2014) and eco-effectiveness (Thatcher et al., 2013).

A matrix relating these concepts with notions (macroconcepts) regarding design, product development, innovation, sustainability, ecology, and ergonomics was built, in order to identify the keywords to be used for building the search equations (Saravia Pinilla, García Acosta, & Daza Beltrán, 2014).

After reviewing almost 850 documents from different databases we found 15 that mentioned at least two of the three postulates of Ergoecology. From this documents we identify and analyse comparatively some of the most relevant models proposed by both, economists and ergonomists about Corporate Sustainability. Finally, with the literature review it was confirmed that there is a different manner to approach forward and understand Sustainability as shown at the framework and results (Saravia-Pinilla, Daza-Beltrán, & García-Acosta, 2016).

4. Results and Discussion

Given this semblance, it is important to note that even in the diversity of disciplinary approaches of the authors, and of the historical moments of their proposals, there are two important coincidences between them: in the first place the systemic approach of relationship among social aspects, environmental aspects and economic aspects; as well its effects which must be emphasized. Second, the assessment of the limit of natural capital as a regulator of relations between systems.

Despite these findings from the theoretical approach, the work around Corporate Sustainability in practice fails to internalize, in a concrete way, how to assume the limit of natural capital expressed for example in the loss of non-renewable resources (i.e. there are five timber species about to be extinguished in Colombia such as cedar, mahogany, abarco, palo rosa and canelo). From this perspective, the literature review also confirmed the need for the transition from the anthropocentric principle to an ecospheric approach.

This need is confirmed when Sustainable Development is understood as permanent growth, both socially and economically, that fosters the exploitation of resources (natural capital) and leads to the exhaustion of species, even to extinction, generating environmental crises that inevitably lead to humanitarian crises.

Although the theoretical model poses a balance between three vertices (social, environmental and economic), two of them are anthropocentric (social and economic), which ends up stimulating the maintenance of social and economic welfare while neglecting the only one Real capital, which is the natural.

The transition that Ergoecology is inviting to, it’s to hang on to what may be sustainable, understanding it not as growth but that which can be "sustained in time," recognizing that natural resource recovery must be allowed, fostering conservation and even restitution of them (natural capital), to obtain a dynamic inter-species equilibrium where human beings recognize ourselves as one actor of the eco-system.

There it's not doubt that the orthodox economic vision that invites "to grow permanently", must be replaced without fear for "sustaining in time", which implies fluctuating between growing and decreasing. This fluctuation is comprehended widely at the Ecological Economy and Economic Degrowth approaches.

Table 1. *Orientation towards a transition for an ecospheric approach (authors).*

ORIENTATION TOWARDS TRANSITION	
ANTHROPOCENTRIC APPROACH	**ECOSPHERIC APPROACH**
CONCEPTS	
Sustainable Development (Economy)	Sustainability
Continued growth	Sustainable over time
ACTIONS	
Exploitation	Recovery
Depletion	Conservation
Crisis	Balance (Dynamic)
Keep growing	Fluctuate

Corporate Sustainability raised from economic models must pass from theory to practice and for that two conditions are required: first, recognize that not only can be grown, but fluctuate to be maintained; and second, to build strategies to achieve dynamic equilibrium over time. Thus, based on two of the Ergoecology principles –systemic approach and sustainability– and after understanding the enormous responsibility of companies to achieve Corporate Sustainability, we propose some routes as guides that will allow them to construct strategies to assume the transition from the anthropocentric principle to the ecospheric approach:

1. ***Consciousness of dependence on natural capital.*** Companies must understand that they are part of a larger system, the ecosphere, and at the same time contain smaller systems (recursiveness). Therefore, their productive actions affect not only the natural system to which they belong (with possible irreversible consequences) and the other subsystems that compose it, but also affect their own permanence. This means understanding that to survive in the market in the long term, land and species cannot be seen as simple resources to exploit but that each natural subsystem contributes to ecosystem services, which may be affected by overexploitation. Therefore, there must be a cooperative relationship (synergy), for which the company must establish codes of environmental ethical actions, visible in its mission and vision that aim for the dynamic balance between natural systems and socio-technical systems. One way to achieve this dynamic equilibrium is to identify the

elements of the natural capital they use, to know their resilience capacity and to anticipate the necessary actions to avoid their damage and depletion.

2. ***Energy and information exchange between the company and the environment.*** The company –as an open system– operates and keeps taking energy and information from the environment and in its productive processes transforms said resources into heat, waste and products that are given to the environment. This shows a relationship of interdependence and the need of companies to be adapted to guarantee its survival and continuity. In this sense, companies should seek to confirm that their productive actions benefit the interactions and exchanges that are established with the environment to ensure the sustainable use of energy and avoid waste. To achieve the greatest energy use, companies could form clusters where companies with high energy demand can provide their dissipated or residual energy to other companies with medium or low energy demand.

3. ***Eco-dependency and inter-dependence recognition.*** Businesses can stimulate the use of eco-systemic services, where the eco-dependence and interdependence of humans with other species is palpable. Therefore it is important to re-evaluate other types of inter-species relationships such as symbiotic and mutualist relations. In this sense, industries can take the organics, natural and self-sustainable paths, in such a way as to avoid the use of pesticides and mono-varieties favouring the balanced use of resources and highlighting eco-dependence. Examples include healthy eating (organic), natural medicine (herbal and medicinal plants) and self-sustaining farms (agroecology).

4. ***Achieve a dynamic balance between business and resources.*** In order to achieve a dynamic balance between the companies and the available resources as the natural capital, companies must know changes, fluctuations and recovery times of renewable resources as well the reserve limits of non-renewables. Therefore –inside the system– they must model their own dynamics to anticipate the necessary changes or transitions for such adaptation. Thus, companies that use renewable resources must consider their resilience; and those that use non-renewable resources must build strategies for the transition toward to use renewable resources before exhausting reserves.

5. ***Co-create and cooperate to coexist.*** The corporate strategy must focus its creative and innovative efforts to find productive and environmental friendly solutions to their challenges; be cooperative with other companies and other sectors; as well as be aware of the capabilities and rights of its employees. This means that companies can recognize that all their actors are valuable and have the potential to contribute creatively to the solutions of their own problems as well as those of the company through co-creation. They must also recognize that competition is not the only way to survive corporately, but that cooperation is also a valid strategy to coexist.

6. ***Autoregulation.*** Similarly to the natural systems, companies have complex dynamics, which must include the ability to autoregulation. In this sense, they must be prepared to model the dynamics of their ecosystem and identify the limits of their growth as well as to define the necessary transitions that allow its integral sustainability in the long term. Companies that have been projected for sustained growth must reorient their vision to maintain or even decrease to remain in the time, especially those companies that depend on non-renewable resources.

7. ***Promote diversity with equity.*** Companies have internal and external clients with different lifestyles, so they must be able to offer flexible and differentiated products and services that are oriented to the equity, quality and well-being of individuals and communities in general. This, to

favour the local demand and not the consumption by the consumption (hedonistic) that drives to globalization. Likewise, they should privilege the demand for local supplies that prevent the loss of native varieties and species. Companies should identify those native varieties and set up business models to first cover local markets by ensuring equity.

5. Conclusions

From the literature review, it is possible to show the importance and necessity of integrating ergonomics and sustainability in order to bring value to companies in terms of corporate sustainability, both in the social and environmental fields.

The concept of the Triple Balance is assumed as ideal, however, in practice and under the proposal of Sustainable Development, the aspect of economic growth is the main, neglecting environmental and social aspects.

The representation of Mauerhofer's 3D-Sustainability model helps to understand the historical mistake that has been generated by the simplified interpretation of the sustainability triangle, since the triangle assumes the priority of economic capital over social and natural capital because of its location in the top vertex.

The Green Ergonomics model raises a special challenge for companies, which should analyse how their technologies could be used to conserve, preserve and restore nature and how can to take advantage of eco-systemic services, to facilitate well-being and improve effectiveness of human systems.

Both Ergoecology and Green Ergonomics allow us to think that the participation of ergonomics in Corporate Sustainability must be assumed from an ecospheric and not just anthropocentric vision, being consistent with Mauerhofer's evidence and assuming that environmental sustainability determines social sustainability.

It may be said that under the shadow of Sustainable Development, the eco-efficiency criterion has become the main objective of organizations, which misrepresented the interpretation of *economic growth* and neglected environmental and social aspects. Likewise, it is need to develop other criteria to address issues such as *ecological equity* with a view to achieving social sustainability.

Eco-effectiveness is still unknown in many sectors, so it is necessary to achieve greater academic and practical development of this concept. This call has been made since 2002. However, it has been 14 years and our systematic review confirms the little attention given to this call. Also, there was and still is not a systematic framework to take as specific indicators both socio-efficiency and socio-effectiveness.

A robust conceptual framework is needed to build a stronger theory of Corporate Sustainability, encompassing social sustainability and ecological sustainability. Also there is the need to define new indicators that allow the transition from the anthropocentric to the ecospheric, as is the case of eco-productivity. The private sector must be involved in this process.

In order to reach this transition, from the ergonomic approach, seven routes were proposed, which can guide companies in the construction of corporate sustainability strategies with greater ecospheric awareness, allowing them to survive without affecting the ecosystems with which they interact, not only in the short term, but in the medium and long term. These routes will allow to identify the actions that the organizations must realize to reach true corporate sustainability with ecospheric approach.

The rigor that seeks to achieve scientific celebration is necessary, but not enough. Companies, in their vision and values, have to assume that natural capital is the real limit of growth and it is independent of financial dynamics. In this sense, companies must take responsibility, on the one hand, to avoid both the depletion of resources and the deterioration of the environment, and on the other hand to embrace the strategies of cooperation, coercion and coexistence, to guarantee human well-being with equity.

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Private contribution on public schools and academic performance
Efficiency measures using non-parametric frontier techniques

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Abstract

This study measures the effect of voluntary contributions from private companies on the academic quality of public schools in Colombia. The impact is measured by integrating non-parametric frontier techniques in efficiency analysis (*order-m*) with a meta-frontier framework, which is a contribution of this study to the empirical literature on efficiency in education. This methodology decomposes the students' total inefficiency to estimate the direction and magnitude of the *Private Contribution Effect (PCE).* With a sample of 101,874 students, we found a positive PCE that for certain regions reaches a maximum equivalent, on average, equal to 25% of the total effect.

Keywords: School effectiveness, Allocative Efficiency, *Order-m*, Private contribution, Corporate Social Responsibility

JEL Classification: I25, I26, D61, M14

1. Introduction

There is growing interest among academics (Anand et al. 2009; Mizala & Urquiola 2013) and *policy makers*(Lewis & Patrinos 2012) for evaluating and generating evidence of the impact of private sector participation in education. This participation occurs through private public alliances (Barrera-Osorio & Raju 2015; Chen & Soo 2010; Verger 2012), the operation by private of public schools through concession agreements (Barrera-Osorio 2007) or contributions directly to schools(Garrett & Rhine 2010; Nelson & Gazley 2014).

The purpose of this paper is to define and estimate the effect of voluntary contributions from private companies to public schools on the educational performance of their students. From now on, we will refer to this effect as the *Private Contribution Effect (PCE).* The objective is to validate the hypothesis that private contributions have a positive effect on educational performance once the socio-economic condition of the student and the school, and the educational quality thereof.

In Colombia, 472 initiatives have been registered by 164 private organizations, which in the period 2010-2015 have impacted 3,825 schools (6.1% of all public schools) in 48% of the municipalities with the highest population density (Fundación Empresarios por la Educación EXE 2016). However, there are no prior assessments of the impact of these investments at the aggregate level.

A database is used, which integrates the results in the standardized tests for last school-year students enrolled in public schools of the municipal heads of all the municipalities of the 4 main provinces of Colombia. For the first time, this database is cross-referenced with a database of educational initiatives at school level carried out by private companies. This sample includes 139,045 students who represent 46.6% of students in public schools, 73% of whom (101,874) are enrolled in schools that received some type of private contribution.

One contribution of this study is the application of meta-frontiers to decompose the private contribution effect in related samples. It is a question of decomposing what portion of the total efficiency (inefficiency) is obtained by the students in maximizing their output can be attributed to factors inside the schools and how much to factors among schools. For this second component, it consists of decomposing it again to estimate the direction and magnitude of the effect that can be attributed to the investment that private companies have made in public schools (*PCE*). To this end, a non-parametric technique with an output orientation that develops the meta-frontier function proposed by Battese & Prasada Rao (2002) is used, and that of other antecedents applied to decompose effects in education using different techniques, such as DEA (Thanassoulis et al. 2016), *FDH* (Giménez et al. 2017), or *order-m* (Cordero, Santín, et al. 2015; Cordero, Prior, et al. 2015; De Witte et al. 2010; Thieme et al. 2016). The technique used mitigates the effect of atypical observations and dimensionality problems that are common in these techniques (Cooper et al. 2007).

A variant of the methodology of decomposition of effects proposed by Silva Portela & Thanassoulis (Silva Portela & Thanassoulis 2001) is used and to which Thieme et al. (2013) add a multilevel decomposition. In this case, the specification defines outputs at the student level, and inputs at both the student and school levels. The possibility of comparing among four provinces and inside them by isolating their capital cities allows to deepen the understanding of the effect as a proxy of the neighborhood of the companies that make the contributions to the schools that receive them.

Alternatively, the literature also assesses this issue using a causal effect approach through impact assessment methodologies (Anand et al. 2009; Barrera-Osorio 2007; Barrera-Osorio et al. 2011; Bernal 2015; Newman et al. 2002). Although the treatment of the causal effect is an important contribution in this approach, this study uses an efficiency approach justified mainly by two reasons: each student's performance against efficient frontiers is valued instead of the effect on the means, and the academic performance with more than one output is controlled. Doing it in a non-parametric way also allows not to assume a functional form or restrictive assumptions about the distribution of errors. As already mentioned, the choice of partial frontiers through *order-m* mitigates the effects of atypical data, generalizing global estimates (*Free Disposal Hull* type, *FDH*), and allowing these data to be located outside the Possibilities Production Frontier. In other words, this allows super-efficient observations (Cazals et al. 2002).

The rest of the document includes the description of the method and data (section 2), and results with which it presents the elements of discussion (section 3) and conclusions on the efficiency of the private contributions on the educational performance (Section 4).

2. Methods

This methodology proposes the estimation of more than one frontiers to estimate the distance between them, as a measure of the marginal effect of one with respect to the other by adapting the approach proposed by Thanassoulis & Silva Portela (2002) and developed by Thieme et al. (2013). In it, an additional frontier is introduced, which represents the contributions of the private companies to public schools, and which define the *Private Contribution Effect (PCE)* that is the object of study. The notation also coincides with the reference literature.

In this case, as shown in **Figure 1** (a) and given the output orientation, it is a question of evaluating the efficiency (inefficiency) of a student *c* that, given an input level x_c could maximize his output level y_c face to the reference frontier. Either a global frontier *y"* (the best students in the whole reference group with an input level like his) or a local frontier *y'* (the best students in the school with a comparable level of input). Distances y''/y_c and y'/y_c represent, then, a measure of the inefficiency of the student *c* in front of his reference group. At distance y''/y_c that measures the local inefficiency will be called *Overall Effect (OE* = y''/ y_c*)*, and it includes all sources of inefficiency. Meanwhile, distance y'/y_c that measures the local inefficiency will be called *Within Effect (WE* = y'/ y_c*)*, and we will attribute to it the sources of inefficiency inside the school. The residual effect, therefore is attributed to the sources of inefficiency associated to the effect called *Between Effect (BE)*. By construction, since *OE = WE x BE*, *BE = OE/WE* in such a way that replacing the terms *BE = y"/y'*.

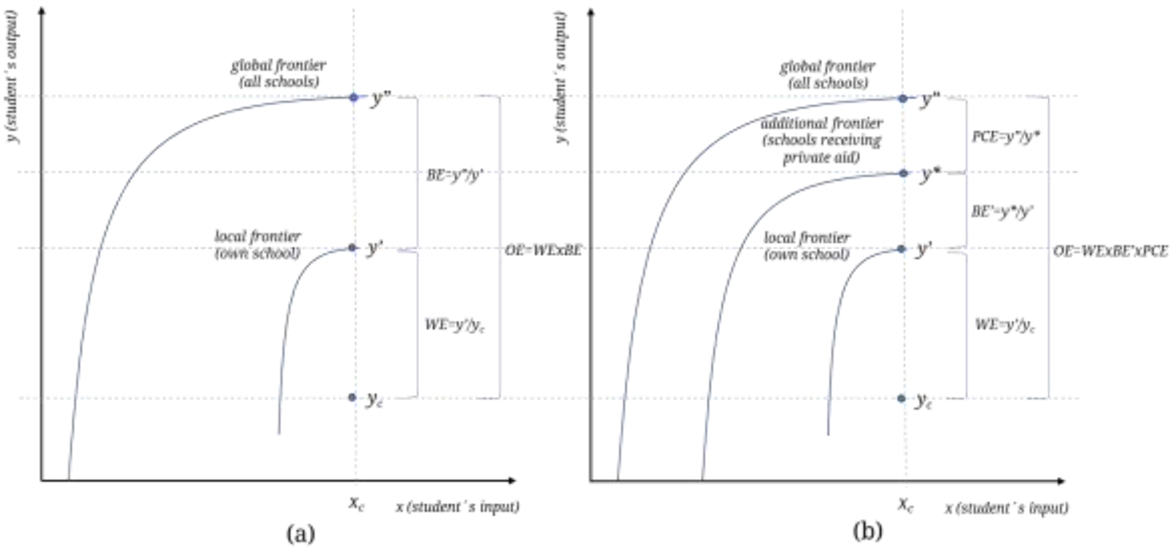

Figure 1. *Proposed decomposition of student's inefficiency based on Silva Portela and Thanassoulis (2001). Comparison between student c performance (yc) and local frontier, global frontier (a), and schools receiving private contributions frontier (b). Overall effect (OE) = within effect (WE) x adjusted between effect (BE') x private contribution effect (PCE)*

Similarly, a second stage (b) includes an additional frontier that contains only those students who are enrolled in schools that received voluntary contributions from private companies, as a reference group. While *WE* remains unaltered, *BE* is decomposed between a *Private Contribution Effect (PCE)* that accounts for the sources of inefficiency associated to that private contribution and, on a residual basis, an *Adjusted Between Effect (BE')* that contains the remaining sources of inefficiency among schools. Now *OE = WE x BE' x PCE, where WE = y'/yc, BE' = y*/y'* and *PCE = OE/(WE X BE'') = y"/y*.*

In summary, as shown in **Figure 2**, the *OE* is first decomposed into *WE* and *BE*, and then, with an additional frontier, *BE* is decomposed into a second stage in *BE'* and *PCE*.

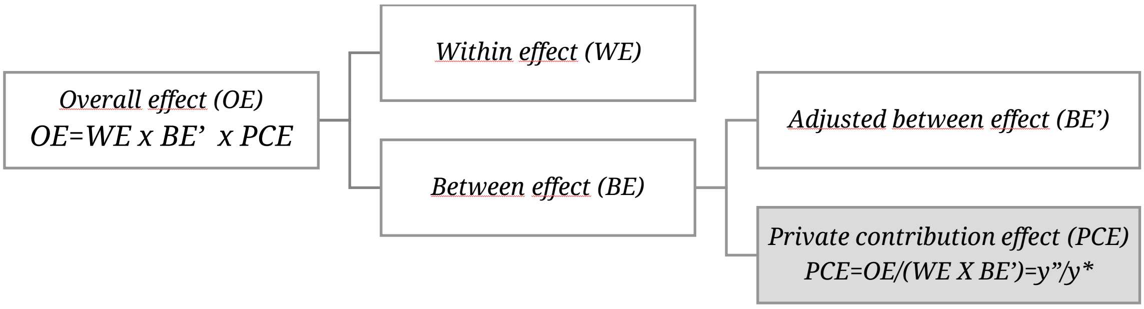

Figure 2. *Decomposition effect of student's inefficiency*

Empirically, *order-m*, an efficient frontier non-parametric technique (Cazals et al. 2002; Daraio & Simar 2005) is used to estimate the coefficients of the effects. The *order-m* estimation approach shares, with its predecessor the *Data Envelopment Analysis (DEA),* the ability to evaluate the relative efficiency of homogeneous *Decision Making Units (DMU)* against efficient frontiers using more than one output without having to assume a functional form or establishing assumptions about the distribution of errors (Charnes et al. 1978), which are characteristics that make it attractive face to a regression analysis (Silva Portela & Thanassoulis 2001). Unlike DEA models, but coinciding with the *Free Disposal Hull (FDH)* (Deprins et al. 1984), *order-m* does not assume convexity, this is only comparisons are possible with observable *DMUs* and not with linear combinations of thereof. *Order-m* also manages to be less sensitive to extreme and outlier values ,and does not suffer from curse of dimensionality. Several studies on education include *order-m* estimations (Cherchye et al. 2010; Cordero, Santín, et al. 2015; De Witte & Kortelainen 2013), but very few do it using *order-m* simultaneously with a meta-frontier approach) (De Witte et al. 2010; Thieme et al. 2013; Thieme et al. 2016) (De Witte et al. al. 2010, Thieme et al. 2013, Thieme et al 2016).

In addition to other efficient-frontier techniques, in the optimization process of such an *order-m* efficiency measure, a random sample with m-size replacement is defined comparing the output level observed in each *DMU* ($y_{c,j}$) with random *m DMU* that comply with the condition of having an output level greater than the observed [$y_{m,j} > y_{c,j}$ of m random variables ($y_{m,j}$,..., $y_{m,j}$)]. This efficiency measure of such artificial reference sample is known as pseudo *FDH efficiency* $\hat{\theta}_{mi}^{\widehat{FDH_b}}$. Following, the technique introduces a bootstrapping component by performing *B* times this procedure, in such a way that the efficiency measure results from the average of the *B* subsamples (Daraio & Simar 2007).

$$\hat{\theta}_{mi}^{\widehat{OM}} = \frac{1}{B}\sum_{b=1}^{B}\hat{\theta}_{mi}^{\widehat{FDH_b}}$$

Because *FDH* is sensitive to atypical values, among larger is *m*, more likely these observations are to be included in the sample, and *order-m* will be closer to the *FDH* estimation. Due to large samples and the differences of the number of observations among them, *m* was defined as 1% of the sample in the estimation of global frontiers (all students of a region) and partial frontiers (those students whose schools receive private contributions). For local frontiers (schools), an m = 30 was defined. This value coincides with the constraint this study imposed for the conformation of the sample in which only the efficiency of students in schools with at least 30 students is evaluated. The parameter *B* is equal to 200 (tests with higher

values did not show significant changes in the magnitude of coefficients, but they did in the duration of computational processes). This bootstrapping condition for the estimation of efficiency coefficients and magnitudes of m and B impose computational requirements reported in the literature (Tauchmann 2012), and that this study has solved using part of the code of the “Doparallel” routine in the *“nonparaeff” package* for R to optimize the use of resources (processors) in parallel. This is one of the reasons why it is not usual to find estimates of this nature in the literature with equivalent sample sizes: 47,076 observations in Thieme et al. (2016); 22,313 Cordero, Prior, et al. (2015), and 11,319 in Thieme et al. (2013), among others.
The chosen production function is a conventional one in the literature on efficiency in education. A comprehensive review of the most commonly used variables, among other has been done by De Witte & López-Torres (2014). This study in which last school-year students are the *DMUs* defines their scores in Reading (y_1) and Mathematics (y_2) as outputs in a standardized test. The inputs define 3 sources of efficiency (inefficiency): the socioeconomic and cultural level of the student (x_1), the quality of the school he or she attends (x_2), and the socioeconomic and cultural level of his or her peers (x_3). The first variable is at the student level and the other two at the school level. To define x_1, a latent variable is estimated through a *Factorial Confirmatory Analysis (FCA)*, considering the mother’s education years, father’s education years, and monthly family income. The quality measure of the school x_2 uses the Synthetic Quality Index (SCI) corresponding to the High School (grade 10 and 11). This index is calculated by the National Educational Evaluation Authority (ICFES, in Spanish) (the national authority of educational evaluation), and for the Hugh School level, it weighs 3 components: progress, performance, and efficiency. By construction, x_2 considers the performance of each school in the years prior to the year evaluated, in one of its components, from the performance of other cohorts of students. Finally, x_3 is calculated by averaging x_1 for each school. Unlike previous studies where each input is added progressively to see its contribution (Thieme et al. 2013), this study maintains the specification of the model y_1, y_2 *(outputs)*, x_1, x_2, x_3 *(inputs),* and in turn evaluates different reference sub-samples to estimate the frontiers with which the effects are calculated.

Figure 3, from the sample shown below illustrates some of the criteria described that justify the selection of the technique. The presence of outliers and extreme values, and the differences in output levels for students with the same input level is evident (the figure illustrates this as an example for x_1 vs. y_1 although the relation is similar for both outputs face to each input and between them), distinguishing sub-samples for the capital cities and set of the rest of the cities for the four provinces of study, and for the condition of receiving or not private contribution.

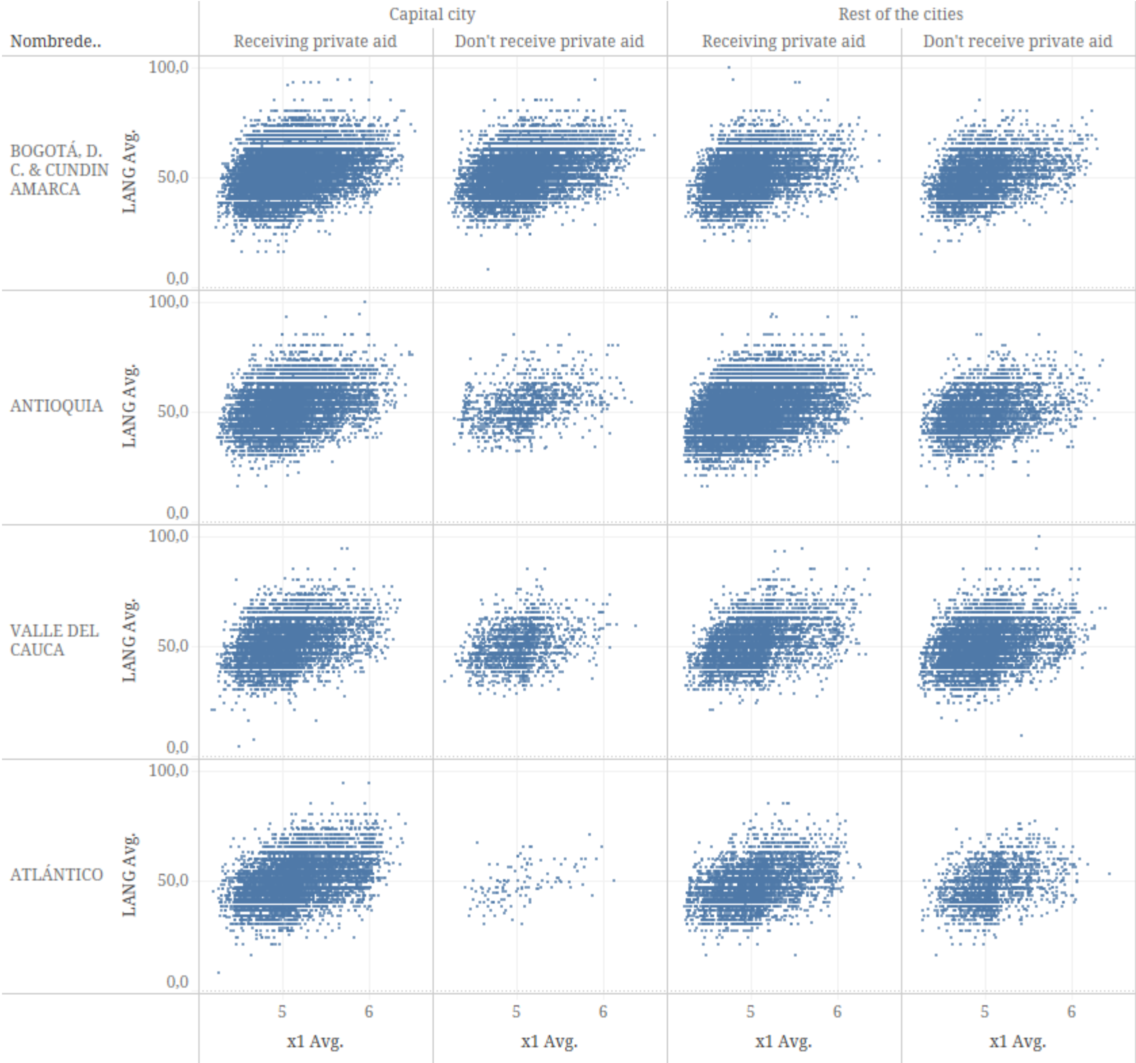

Figure 3. *Academic performance in reading vs. socio-economic and cultural level of the student's family by region and private contribution*

This distinction between capital cities and the rest of the cities within each province also aims to make the *DMU* more homogeneous and comparable. The proximity of companies to large urban centers (in this case capital cities) is one of the main reasons for this decision. The design of the sample also favors this purpose by including only the students of schools located in the municipal head of each municipality and excluding rural schools. In the absence of geo-referenced data that allow to adjust the proximity to location patterns, the criterion for grouping has been the administrative political division with the limitations it represents: on the one hand, the possibility of including municipalities too distant to the capital cities, and on the other hand, forcing the comparison of Bogotá (which is an independent district) with the province that contains most its municipalities of influence.

Figure 4 shows the average performances in reading and mathematics within the four provinces (capital cities face to the rest of the province) depending on whether the schools are receiving help from private companies or not. There are gaps in the average score for reading, from 52.2 in schools that do not receive private contributions in the rest of municipalities of Antioquia, up to 47.2 in the same type of schools in the other municipalities of Atlántico. Similarly, in mathematics: from 51.8 in schools that do not receive any aid in Bogotá D.C. to 47.1 in schools that receive indeed these contributions in Barranquilla (the capital city of the province of Atlántico). Students enrolled in schools located in capital cities receive on average better scores than those enrolled in other cities, and students enrolled in schools that receive contributions from private companies, also on average get a higher score compared to those that do not. Even so, for example, in Medellín (the capital city of the province of Antioquia), the average performance of students in schools that do not receive contributions is higher, or although in most cases reading has a higher average performance than mathematics, in Bogotá D. C., and in Cundinamarca and in Barranquilla mathematics is doing better than reading. These discrepancies between groups justify the disaggregation of the analysis into sub-samples.

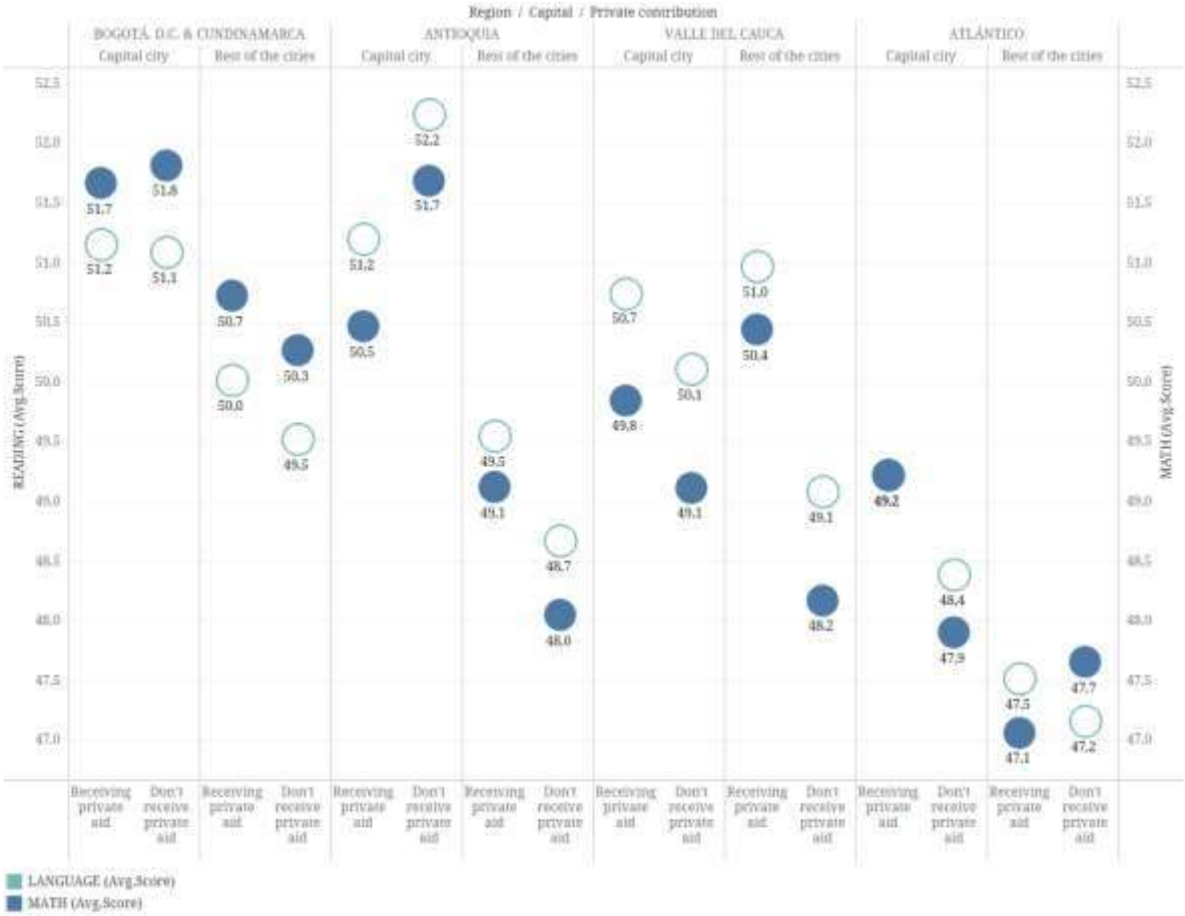

Figure 4. *Average performance of students in language and mathematics by region and private contribution (Colombia 2015, ICFES, Saber 11).*

For the consolidation of the database with which the different models are estimated (a sample that includes 139,045 observations from four provinces), four different databases were used. The first one contains information on all the students who carried out the Saber 11 standardized tests in 2015 (568,903 observations) applied to last school-year students by the ICFES. The individual performance of each student for reading and mathematics is obtained from it, as well as the family income and education of both parents with which the index of socio-economic and cultural conditions of the student's family is estimated. The second database is the unified catalog of educational establishments at national level (62,758 schools), which contains useful information for the characterization of the school (sector, area, etc.). 76% of these schools are public. This database is prepared by the DANE (the statistical authority of the national government) through a census carried out by administrative registry. The third database is the *Índice Sintético de Calidad Educativa (Educational Quality Index*, *ISCE*, in Spanish) that was previously described and only has public access to public schools. The ISCE is presented for several levels of education, but this study only considers the High School level (grades 10 and 11). The most important innovation in data construction is the inclusion of a variable that describes the contribution of private companies to educational initiatives for the first time. This is achieved by a fourth base of SIIPE, the *Information System of Private Intervention in Education* that consolidates the offer of private contributions in education and is led by *Empresarios por la Educación* (Entrepreneurs for Education), a private non-profit foundation. This base identifies 472 initiatives led by 164 private organizations that cross at the school level, and during the period 2010 to 2015 have impacted 3,825 schools detailing the type and level of intervention and target population among other variables. In this work, this base is crossed to the level of educational establishment and those initiatives advanced in 2014 and 2015 that were directed to the High School are selected.

In summary, our database contains information on the educational performance, and socio-economic and cultural conditions of 139,045 last school-year who presented the Saber 11 test, 1,320 of whom are in public schools in the municipal heads of all municipalities of Bogotá D.C. and Cundinamarca, Antioquia, Valle del Cauca, and Atlántico. Strictly for reasons of homogeneity of *DMU*, two exclusions were applied: those students who declared disability, and those schools that have less than 30 students enrolled. **Table 1** shows the number of schools and students per province distinguishing the type of city and type of contribution. The selection of these four provinces is also associated with the relation of private contributions with the proximity of enterprises to schools: in these four territories 58.3% of the country's economic activity is concentrated, 46.6% of the students who presented the Saber 11 test, and by far, the proportion of students enrolled in schools that receive private contributions is higher (on average 73%).

Table 1. *Sample: number of students and schools by region, type of cities, and type of school by private contribution condition (Colombia, 2015).*

State/Capital city	Variable	Capital city		Rest of the cities		% private contribution	Total obs.
		Schools receiving private aid		Schools receiving private aid			
		Yes	No	Yes	No		
Bogotá, D.C. & Cundinamarca / Bogotá D.C.	Schools	209	111	96	69	63%	485
	Students	30,045	13,064	10,707	6,073	68%	59,889
Antioquia / Medellín	Schools	146	17	225	51	85%	439
	Students	12,422	1,222	21,254	4,601	85%	39,499
Valle Del Cauca / Cali	Schools	59	16	51	85	52%	211
	Students	7,433	1,751	5,344	8,085	57%	22,613
Atlántico / Barranquilla	Schools	111	3	47	24	85%	185
	Students	9,346	119	5,323	2,256	86%	17,044
Total	Schools	525	147	419	229	72%	1,320
	Students	59,246	16,156	42,628	21,015	73%	139,045

Table 2 summarizes descriptive statistics for each sub-sample to which the model is applied. In total, 12 sub-sets of data are evaluated that result from multiplying the four provinces by 3 levels of aggregation in each of them (capital, rest, and total). Also, for each of these 3 sub-sets, 3 frontiers (global, local and private contribution) are estimated resulting in 25 estimates (12 global frontiers, 12 private-contribution frontiers, and a single local frontier for the entire test). Global estimations are done using the entire sub-sample of the reference territory, while private contributions ones are made for those receiving private

contributions (the number in parentheses). As an example, in Bogotá, D.C. and Cundinamarca, a global frontier for 59,889 observations; a private-contribution frontier for 40,752 observations; and 485 local frontiers (one per school) with the same 59,889 observations are estimated. However, the calculation of effects only considers the sub-set of those that receive private contributions.

Table 2. *Summary statistics of the used variables in the models.*

			Region				Capital cities				Rest of the cities			
Bogotá, D.C. & Cundinamarca / Bogotá D.C.			Obs: 59,889 (40,752)*				Obs: 43,109 (30,045)*				Obs: 16,178 (10,707)*			
Level	Variable	Description	Min	Max	Media	Std.Dev.	Min	Max	Media	Std.Dev.	Min	Max	Media	Std.Dev.
Student	y1	Language Score (Critical Reading)	16,00	100,00	50,85	8,25	16,00	94,00	51,15	8,23	21,00	100,00	50,02	8,25
Student	y2	Math score	16,00	100,00	51,41	10,17	16,00	100,00	51,66	10,15	19,00	100,00	50,72	10,20
Student	x1	Socioeconomic and cultural level of the student's family	4,24	6,54	5,03	0,32	4,24	6,54	5,05	0,32	4,25	6,50	4,95	0,31
School	x2	ISCE Synthetic index of educational quality	3,75	7,89	6,39	1,43	3,98	7,89	6,48	1,40	3,75	7,72	6,14	1,48
School	x3	School's average of Socioeconomic and cultural level of the student's family	4,67	5,37	5,03	0,13	4,70	5,37	5,05	0,12	4,67	5,33	4,95	0,12
Antioquia / Medellín			Obs: 39,499 (33,676)*				Obs: 13,644 (12,422)*				Obs: 25,855 (21,454)*			
Student	y1	Language Score (Critical Reading)	16,00	100,00	50,16	8,86	16,00	100,00	51,19	8,70	16,00	94,00	49,55	8,90
Student	y2	Math score	8,00	100,00	49,61	10,98	13,00	100,00	50,46	10,43	8,00	100,00	49,12	11,26
Student	x1	Socioeconomic and cultural level of the student's family	4,23	6,50	5,00	0,35	4,26	6,50	5,06	0,34	4,23	6,42	4,96	0,35
School	x2	ISCE Synthetic index of educational quality	3,65	8,12	5,73	1,53	3,65	7,98	5,78	1,52	3,75	8,12	5,70	1,54
School	x3	School's average of Socioeconomic and cultural level of the student's family	4,53	5,54	5,00	0,18	4,53	5,41	5,06	0,17	4,57	5,54	4,96	0,18
Valle Del Cauca / Cali			Obs: 22,613 (12,777)*				Obs: 9,184 (7,433)*				Obs: 13,426 (5,344)*			
Student	y1	Language Score (Critical Reading)	4,00	94,00	50,83	8,91	4,00	94,00	50,74	8,95	21,00	94,00	50,96	8,84
Student	y2	Math score	13,00	100,00	50,09	10,98	13,00	100,00	49,85	10,69	13,00	100,00	50,44	11,38
Student	x1	Socioeconomic and cultural level of the student's family	4,19	6,38	5,04	0,34	4,19	6,37	5,04	0,34	4,24	6,38	5,04	0,34
School	x2	ISCE Synthetic index of educational quality	3,83	7,83	5,86	1,54	3,87	7,72	5,88	1,53	3,83	7,83	5,85	1,57
School	x3	School's average of Socioeconomic and cultural level of the student's family	4,58	5,47	5,04	0,18	4,77	5,47	5,04	0,17	4,58	5,46	5,04	0,18
Atlántico / Barranquilla			Obs: 17,044 (14,669)*				Obs: 9,465 (9,346)*				Obs: 7,579 (5,323)*			
Student	y1	Language Score (Critical Reading)	8,00	94,00	48,60	8,85	8,00	94,00	49,21	8,89	16,00	85,00	47,51	8,66
Student	y2	Math score	7,00	100,00	48,44	10,80	7,00	100,00	49,22	11,01	16,00	100,00	47,06	10,27
Student	x1	Socioeconomic and cultural level of the student's family	4,21	6,42	5,10	0,36	4,21	6,42	5,13	0,36	4,24	6,27	5,04	0,34
School	x2	ISCE Synthetic index of educational quality	3,75	9,40	5,36	1,51	3,83	9,40	5,69	1,54	3,75	7,61	4,77	1,24
School	x3	School's average of Socioeconomic and cultural level of the student's family	4,62	5,78	5,10	0,23	4,62	5,78	5,13	0,24	4,64	5,39	5,04	0,20

3. Results

Because these are output-oriented estimates, the effect coefficients are expected to be greater than 1. They are interpreted as a measure of the inefficiency *DMU* have in maximizing their outputs, given a level of input. In other words, among more close they are to 1, the more efficient the *DMU* is; even values less than 1 represent super-efficient observations. Otherwise, for numbers greater than 1, the higher the coefficient, the greater the student's inefficiency is in maximizing their academic performance from the socio-economic and cultural conditions of their own family and the average level of these conditions in their group and quality of their own school.

¡Error! No se encuentra el origen de la referencia. shows the magnitudes of the effects for the first decomposition, this is, *intr*a and *among* school effects (*OE = WE x BE*) for the four provinces. Global frontiers are estimated for the total number of students in the province, while partial frontiers and geometric means of all effects are calculated for the sub-sample receiving private contributions in the same reference area (their number of observations and percentage share against the total of the sample is included in the column of titles of **Table 3**). On average, using geometric means, the total inefficiency obtained by maximizing the outputs of 40,752 students from 305 public schools in municipal head-offices of Bogotá and Cundinamarca that receive some type of support from private companies in secondary education was 1,3628 compared to the total number of students in the same group who receive and do not receive help (column 1). This value is greater than 1,1829, which corresponds to the total inefficiency of the same students when compared against their local frontier (for example, face to their own school). In other words, 54.2% of this inefficiency is attributable to factors that occur within the school (*Within Effect, WE*). Consequently, the remaining 45.8% (*BE* = *OE/WE*; 1,1521 = 1,3628/1,1829) is attributable to factors associated with differences between schools (*Between Effect, BE*). Consistent with the literature, on average the contribution of *WE* is much greater than that attributable to *BE*. We concentrate on the magnitude of this last effect that will be decomposed later to estimate the *Private Contribution Effect, PCE*. Like Bogotá and Cundinamarca, in Antioquia, on average for 33,676 students from 371 schools representing 85% of the total of the reference group, *BE* is equal to 1,1482 compared to an *OE* of 1,3551, equivalent to 45.4% of total inefficiency. Valle del Cauca and Atlántico (12,777, 57% and 14,699, 86%, respectively) have a lower *BE* 1,0962 (34.9%) and 1,0627 (26.9%). Columns (2) to (8) additionally present statistics of each distribution (minimum and maximum values, quartiles, means, and standard deviation) to have a better understanding of them in each of the effects.

***Table 3**. First decomposition of overall efficiency by Provinces: Overall Effect (OE) = Within Effect (WE) x Between Effect (BE), summary statistics.*

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Region	Inefficiency component	Geometric mean	Minimun	1st quartile	Median	3rd quartile	Maximun	Std. Dev.	Mean (inefficient)
Bogotá & Cundinamarca Obs: 40,752 (68%)	OE	1,3628	0,7510	1,2337	1,3602	1,5003	4,4325	0,2091	1,3717
	WE	1,1829	0,7360	1,0596	1,1721	1,3011	3,7513	0,1803	1,2244
	BE	1,1521	0,5006	1,1061	1,1496	1,1953	1,8671	0,0804	1,1554
Antioquia Obs:33,676 (85%)	OE	1,3551	0,7618	1,2164	1,3509	1,5034	3,1590	0,2246	1,3690
	WE	1,1802	0,6976	1,0483	1,1663	1,3013	2,7683	0,1869	1,2275
	BE	1,1482	0,5821	1,0871	1,1389	1,2050	1,8338	0,0997	1,1547
Valle del Cauca Obs: 12,777 (57%)	OE	1,3009	0,7580	1,1708	1,3001	1,4407	2,9917	0,2114	1,3231
	WE	1,1868	0,6816	1,0546	1,1763	1,3114	3,6838	0,1887	1,2320
	BE	1,0962	0,3224	1,0450	1,0868	1,1439	1,8589	0,0878	1,1080
Atlántico Obs:14,699 (86%)	OE	1,2543	0,7100	1,1279	1,2500	1,3881	2,3585	0,2003	1,2813
	WE	1,1802	0,7464	1,0517	1,1676	1,2983	2,4445	0,1821	1,2259
	BE	1,0627	0,5529	1,0166	1,0557	1,1045	1,9069	0,0843	1,0845

Table 4 presents the results corresponding to the decomposition of the *OE* in a second stage in which the *BE* is decomposed due to the introduction of a new frontier that only includes students of schools that received private contributions. From this refinement *PCE* = *BE/BE'* is obtained. For all provinces, the *PCE* has a positive effect on total inefficiency. In Bogotá and Cundinamarca, on average, the effect is equal to 1,0164, while *BE'* is 1,1336. This means that 11.5% of the former *BE* is attributable to the *PCE*. Face to the *OE*, in Bogotá and Cundinamarca, *PCE* would be attributed 5.2%. The highest relative weight of *PCE* is in Valle del Cauca (12.7%) with a 1,0339 coefficient followed by Antioquia (6.2%, 1.0190), Bogotá, and Cundinamarca (5.2%, 1,0164), and finally, Atlántico 3.8%; 1,0087).

Table 4. *Second decomposition of Overall Efficiency: Overall Effect (OE) = Within Effect (WE) x Private Contribution Effect (PCE) x adjusted Between Effect (BE'), summary statistics*

Region	Inefficiency component	(1) Geometric mean	(2) Minimun	(3) 1st quartile	(4) Median	(5) 3rd quartile	(6) Maximun	(7) Std. Dev.	(8) Mean (inefficient)
Bogotá & Cundinamarca Obs: 40,752 (68%)	OE	1,3628	0,7510	1,2337	1,3602	1,5003	4,4325	0,2091	1,3717
	WE	1,1829	0,7360	1,0596	1,1721	1,3011	3,7513	0,1803	1,2244
	PCE	1,0164	0,4071	1,0068	1,0126	1,0192	1,5250	0,0229	1,0183
	BE'	1,1336	0,4785	1,0893	1,1326	1,1770	1,7830	0,0774	1,1380
Antioquia Obs:33,676 (85%)	OE	1,3551	0,7618	1,2164	1,3509	1,5034	3,1590	0,2246	1,3690
	WE	1,1802	0,6976	1,0483	1,1663	1,3013	2,7683	0,1869	1,2275
	PCE	1,0190	0,5188	1,0056	1,0126	1,0211	1,3938	0,0318	1,0213
	BE'	1,1268	0,5821	1,0713	1,1191	1,1775	1,8361	0,0926	1,1347
Valle del Cauca Obs: 12,777 (57%)	OE	1,3009	0,7580	1,1708	1,3001	1,4407	2,9917	0,2114	1,3231
	WE	1,1868	0,6816	1,0546	1,1763	1,3114	3,6838	0,1887	1,2320
	PCE	1,0339	0,3302	1,0211	1,0298	1,0394	1,4762	1,0344	1,0348
	BE'	1,0602	0,5443	1,0141	1,0510	1,1040	1,7709	0,0800	1,0811
Atlántico Obs:14,699 (86%)	OE	1,2543	0,7100	1,1279	1,2500	1,3881	2,3585	0,2003	1,2813
	WE	1,1802	0,7464	1,0517	1,1676	1,2983	2,4445	0,1821	1,2259
	PCE	1,0087	0,9701	1,0016	1,0075	1,0140	1,1658	0,0104	1,0114
	BE'	1,0536	0,5529	1,0087	1,0474	1,0945	1,8748	0,0826	1,0788

In summary (¡Error! No se encuentra el origen de la referencia.), the effect attributable to *WE* varies between 54.2% in Bogota and 73.1% in Atlántico consistent with the literature. This effect is greater between the smaller and poorer the region evaluated. Decomposing *BE*, we obtain *PCE* between 3.8% for Atlántico and 12.7% for Valle del Cauca although the latter is the province in which *BE* (before decomposition) is lower. Evaluating the relative weight of the *Private Contribution Effect, PCE* within the second decomposition, the positive effect on the inefficiency and percentage of students with coefficients greater than 1 (inefficient) is significantly higher in Valle del Cauca (36.3%) of the BE, while the same effect in other provinces is between 11.5% for Bogotá and Cundinamarca, and 14.2% for Atlántico. For each couple of distributions (*PCE* versus the other effects), it has been tested that *PCE* distribution is always different. The Wilcoxon Test (1945), a non-parametric test for related samples has been applied, evaluating the null hypothesis that distributions are equal (Harris & Hardin 2013). In all cases, the *p-value* face to the *z-statistic* is less than 10^{-4}, so this study does not report these coefficients.

Table 5. *Summary of decomposition of Overall Efficiency: Overall Effect (OE) = Within Effect (WE) x Private Contribution Effect (PCE) x adjusted Between Effect (BE'), coefficients, and marginal contributions (%) by provinces*

Region	OE	WE		PCE				BE'	
		Coefficient	%	Coefficient	%	Mean (inefficient)	Inefficient students (%)	Coefficient	%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Regions									
Bogotá & Cundinamarca	1,3628	1,1829	54,2%	1,0164	5,2%	1,0183	91,9%	1,1336	40,5%
Antioquia	1,3551	1,1802	54,5%	1,0190	6,2%	1,0213	90,5%	1,1268	39,3%
Valle del Cauca	1,3009	1,1868	65,1%	1,0339	12,7%	1,0348	98,1%	1,0602	22,2%
Atlántico	1,2543	1,1802	73,1%	1,0087	3,8%	1,0114	81,9%	1,0536	23,0%

Table 6 and **Table 7** report the results once each sample is disaggregated between the students who attend schools in the capital city and the rest of municipalities of the province to validate if there are differences between both groups. In all cases, if these results are compared with those of each added province (the capital city and rest of municipalities), coefficients in average reflect the same positive effect of private contributions on the total inefficiency of students when maximizing their outputs given the inputs they have.

Table 6. *Decomposition of Overall Efficiency for main city by province: Overall Effect (OE) = Within Effect (WE) x Private Contribution Effect (PCE) x adjusted Between Effect (BE'), summary statistics*

Region	Inefficiency component	(1) Geometric mean	(2) Minimun	(3) 1st quartile	(4) Median	(5) 3rd quartile	(6) Maximun	(7) Std. Dev.	(8) Mean (inefficient)
Bogotá D.C. Obs: 30,045 (70%)	OE	1,3506	0,8084	1,2241	1,3477	1,4862	4,3847	0,2063	1,3602
	WE	1,1851	0,7360	1,0629	1,1750	1,3040	3,7513	0,1803	1,2258
	PCE	1,0145	0,4161	1,0049	1,0110	1,0176	1,4000	0,0023	1,0173
	BE'	1,1233	0,4785	1,0797	1,1209	1,1657	1,7413	0,0739	1,1276
Medellín Obs: 12,422 (91%)	OE	1,3021	0,7530	1,1724	1,2973	1,4380	2,7999	0,2130	1,3224
	WE	1,1842	0,7523	1,0547	1,1709	1,3034	2,4750	0,1865	1,2296
	PCE	1,0152	0,6740	1,0047	1,0122	1,0203	1,2969	0,0201	1,0178
	BE'	1,0831	0,5834	1,0294	1,0774	1,1284	1,7500	0,0834	1,0972
Cali Obs: 7,433 (81%)	OE	1,2512	0,7538	1,1249	1,2509	1,3864	2,8663	0,2034	1,2831
	WE	1,1968	0,6816	1,0653	1,1900	1,3242	3,6838	0,1911	1,2400
	PCE	1,0100	0,3349	1,0041	1,0094	1,0151	1,1121	0,0122	1,0117
	BE'	1,0351	0,5443	0,9945	1,0258	1,0718	1,6450	0,0715	1,0650
Barranquilla Obs: 9,346 (99%)	OE	1,2093	0,7086	1,0877	1,2044	1,3345	3,0066	0,1929	1,2470
	WE	1,1768	0,7638	1,0477	1,1637	1,2943	2,4445	0,1813	1,2233
	PCE	1,0006	0,9746	0,9966	1,0002	1,0044	1,0551	0,0067	1,0054
	BE'	1,0271	0,5563	0,9872	1,0222	1,0653	1,7312	0,0755	1,0638

Table 7. *Decomposition of Overall Efficiency by province without main city: Overall Effect (OE) = Within Effect (WE) x Private Contribution Effect (PCE) x adjusted Between Effect (BE'), summary statistics*

Region	Inefficiency component	(1) Geometric mean	(2) Minimun	(3) 1st quartile	(4) Median	(5) 3rd quartile	(6) Maximun	(7) Std. Dev.	(8) Mean (inefficient)
Cundinamarca Obs: 10,707 (64%)	OE	1,2696	0,6924	1,1459	1,2666	1,3965	2,6913	0,1959	1,2902
	WE	1,1765	0,7758	1,0500	1,1644	1,2939	2,5046	0,1800	1,2206
	PCE	1,0237	0,5368	1,0115	1,0222	1,0327	1,5000	0,0235	1,0270
	BE'	1,0541	0,6475	1,0171	1,0511	1,0866	1,5993	0,0689	1,0711
Antioquia without Medellín Obs: 21,254 (82%)	OE	1,3000	0,7363	1,1650	1,2968	1,4443	3,1119	0,2141	1,3210
	WE	1,1779	0,6976	1,0448	1,1634	1,2998	2,7683	0,1870	1,2263
	PCE	1,0082	0,5363	1,0018	1,0068	1,0126	1,2609	0,0112	1,0102
	BE'	1,0947	0,5821	1,0420	1,0841	1,1416	1,7753	0,0897	1,1076
Valle without Cali Obs: 5,344 (40%)	OE	1,2569	0,7406	1,1331	1,2533	1,3885	2,2538	0,2035	1,2857
	WE	1,1729	0,7690	1,0421	1,1596	1,2926	2,2730	0,1842	1,2205
	PCE	1,0589	0,5985	1,0394	1,0533	1,0678	1,4740	0,0429	1,0599
	BE'	1,0120	0,6390	0,9746	1,0070	1,0531	1,6964	0,0756	1,0593
Atlántico without Barranquilla Obs: 5,323 (70%)	OE	1,2088	0,6726	1,0849	1,2015	1,3347	2,0744	0,1928	1,2470
	WE	1,1863	0,7464	1,0577	1,1759	1,3057	2,0210	0,1835	1,2304
	PCE	1,0182	0,9741	1,0095	1,0174	1,0259	1,1551	0,0133	1,0197
	BE'	1,0007	0,6384	0,9619	1,0010	1,0374	1,4832	0,0757	1,0548

Table 8 summarizes the effects for both groups. It reaffirms the interpretation of *WE*, the greater of the effects, which is greater when the population is smaller and poorer. It also coincides with the same factors, but in inverse relation; they determine the probability that a school receives a private contribution, and draws attention on the criteria of targeting of companies, but that are outside the scope of this study. On the other hand, the percentage of inefficient observations for *PCE* (column 7) is lower in capital cities (in a range between 51.7% for Barranquilla to 89.8% for Cali) face to other municipalities in their reference region (between 90.7% for Cundinamarca and 99.0% for Valle del Cauca) except for Medellín (*PCE* = 1,0152) against Antioquia (1,0082). In the four capital cities, the magnitude of the *PCE* (column 4) is significantly lower than that of the *BE'* (column 8). The same result applies to Cundinamarca and rest of municipalities of Antioquia. On the contrary, for other municipalities of Valle del Cauca and Atlántico, *PCE* is greater than

BE'. In fact, in the rest of the municipalities of the Valle del Cauca, a *PCE* of 1,0589 is the most noteworthy, accounting for 25.0% of its *OE*.

Table 8. *Summary of decomposition of Overall Efficiency: Overall Effect (OE) = Within Effect (WE) x Private Contribution Effect (PCE) x adjusted Between Effect (BE'), coefficients, and marginal contributions (%) by capital cities versus rest of the cities*

Region	OE	WE		PCE				BE'	
		Coefficient	%	Coefficient	%	Mean (inefficient)	Inefficient students (%)	Coefficient	%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Bogotá D.C.	1,3506	1,1851	56,5%	1,0145	4,8%	1,0173	88,1%	1,1233	38,7%
Medellín	1,3021	1,1842	64,0%	1,0152	5,7%	1,0178	88,4%	1,0831	30,3%
Cali	1,2512	1,1968	80,2%	1,0100	4,4%	1,0117	89,8%	1,0351	15,4%
Barranquilla	1,2093	1,1768	85,6%	1,0006	0,3%	1,0054	51,7%	1,0271	14,0%
Rest of the cities by State									
Cundinamarca	1,2696	1,1765	68,1%	1,0237	9,8%	1,0270	90,7%	1,0541	22,1%
Antioquia without Medellín	1,3000	1,1779	62,4%	1,0082	3,1%	1,0102	84,3%	1,0947	34,5%
Valle del Cauca without Cali	1,2569	1,1729	69,8%	1,0589	25,0%	1,0599	99,0%	1,0120	5,2%
Atlántico without Barranquilla	1,2088	1,1863	90,1%	1,0182	9,5%	1,0197	94,1%	1,0007	0,4%

As for aggregate models, Wilcoxon's nonparametric test for related samples rejects the null hypothesis in all pairs of *PCE* combinations with *p-values* lower than 10^{-4} versus the *z-statistic*. **Figure 5** and **Figure 6** present the kernel density plots of overall efficiency by regions for the 4 effects in the disaggregated models in which one can observe how the *PCE* differs from other effects. Densities were estimated using a Gaussian kernel (Cox 2005).

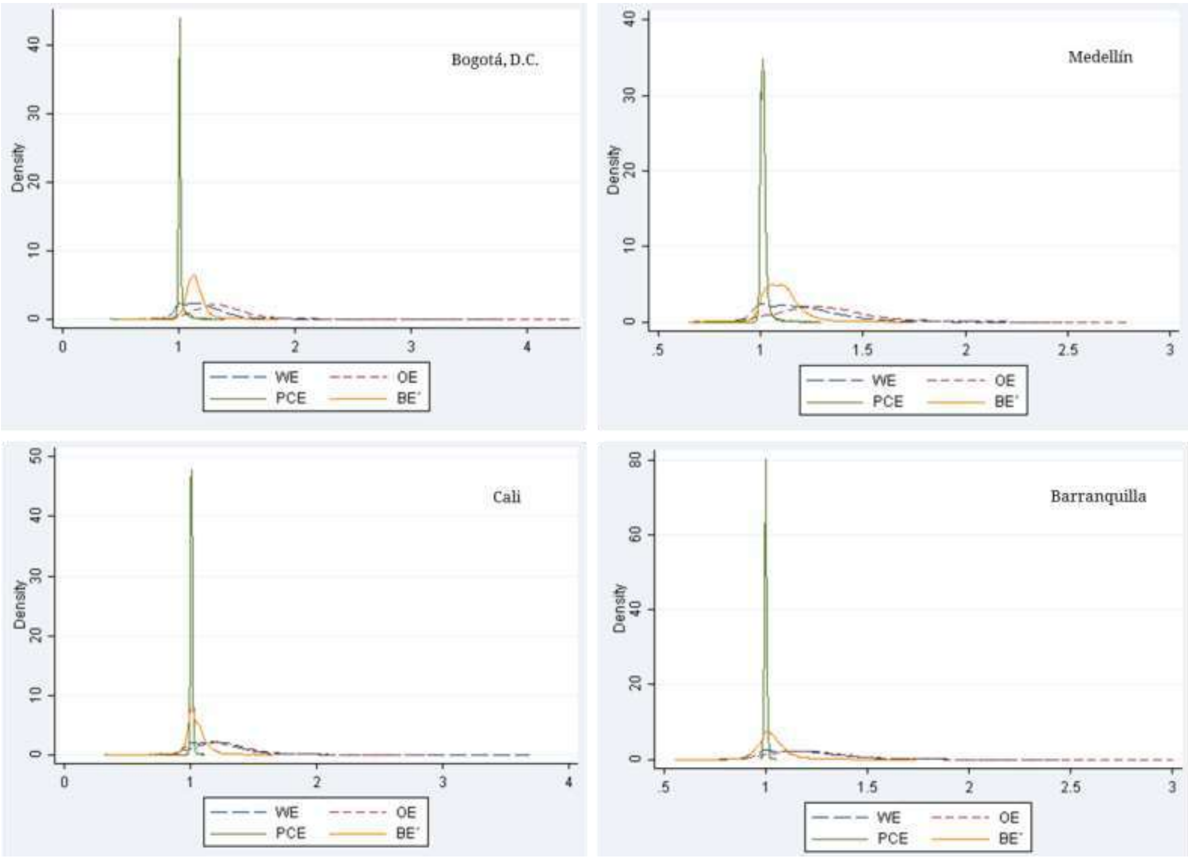

Figure 5. *Kernel density plots of Overall Efficiency by capital cities: Overall Effect (OE) = Within Effect (WE) x Private Contribution Effect (PCE) x adjusted Between Effect (BE'). Densities were estimated using a Gaussian kernel.*

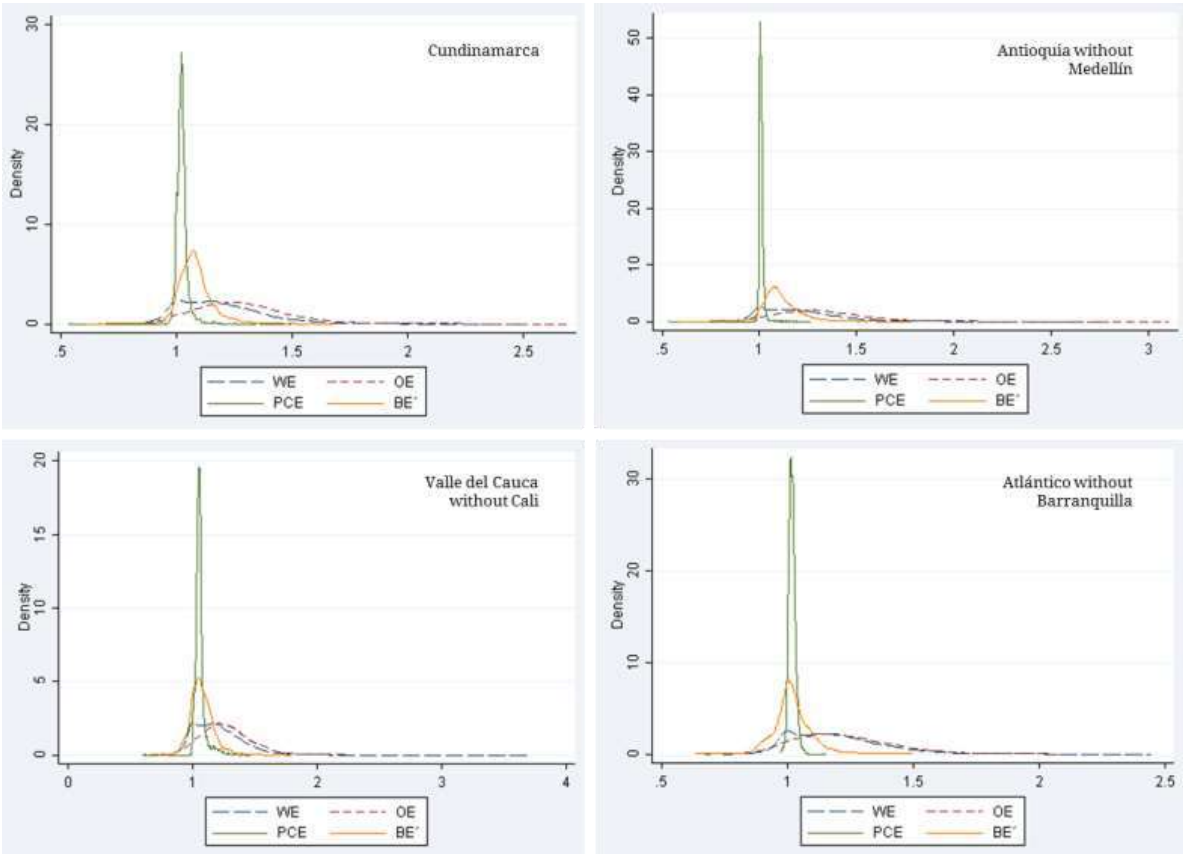

Figure 6. *Kernel density plots of overall efficiency by States without capital cities: overall effect (OE) = within effect (WE) x private contribution effect (PCE) x adjusted between effect (BE'). Densities were estimated using a Gaussian kernel.*

In summary, based on these results, a positive *PCE* was founded. Effects differ between provinces, and also between capital cities and the rest of cities of each province.

4. Conclusions

The purpose of this study was to define and estimate the effect of voluntary contributions from private companies to public schools on the educational performance of their students. The estimation employs *order-m*, a non-parametric frontier efficient technique, and an effect decomposition approach through meta-fronts applied to a database of standardized test results of students enrolled in schools receiving private contributions.

Methodologically, a first contribution of this study is the definition of the *Private Contribution Effect (PCE)* from the decomposition in 2 stages of the inefficiency measure that results from comparing different partial frontiers and taking a sub-sample of those groups (who receive private contributions) to estimate the magnitude of the effects. This is a variant to the decomposition by levels used by Silva Portela & Thanassoulis (2001) and Thieme et al (2013). Empirically, a second contribution corresponds to the estimation of the direction and magnitude of the *PCE*. The computational requirements associated with the sample size, and with the random component in the optimization of pseudo-*FDH* estimators and bootstrapping were also attenuated.

In a first stage, the *Overall Effect (OE)* was decomposed in 2 components: one called *Within Effect (WE)*, which is attributed the sources of inefficiency inside the school and which represents the greater of the effects (greater when the region evaluated is poorer). This result suggests a later question about the affinity of the criteria of targeting with which the companies choose to their beneficiary schools and public objectives pursued, and with this, a better articulation between the private sector (that only intervenes on the schools) and the public sector to coordinate such direct interventions on students and their families, which are more appropriate to social policy.

In a second stage where the original *Between Effect (BE)* is decomposed and the *Private Contribution Effect (PCE)* is obtained, a positive effect on total inefficiency (*OE*) is estimated in all subsamples evaluated. The magnitude of this effect is greater in the other cities than in the capitals, and is a differentiated effect between and within the regions, and in most cases, it is significantly lower than the adjusted *Between Effect (BE'')* in which all factors of inefficiency that are not inside the schools are included residually. One way to approach it in future research is to adopt an approach of environmental factors to better discriminate the effects the context has on this measure of efficiency.

In conclusion, this study finds evidence that voluntary and differentiated contributions made by companies to public schools, most of which are close to their areas of influence are positive and reach magnitudes of up to 25% on average.

Future research opportunities that result from this work, in addition to environmental factors already mentioned include: 1. A refinement of results from the typification of private contributions, 2. The contrast of these efficiency measures (which evaluate the sources of improvement of students and schools with the levels of input given) with measures of effectiveness (as a proxy for educational quality) and equity (preventing intra and among school and region gaps accentuate, and 3. Deepen in motivations companies have to make these contributions.

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WOOD AS A TOOL FOR SUSTAINABLE URBAN MOBILITY

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Abstract

The use of bicycles for transportation activities has shown a high contribution to the environmental care in urban contexts. Between all bicycles types, folding bicycle is presented as the most effective for intermodal transport strategy since combine easily its use with the use of subways, buses and streetcars, among others. On the other hand, wooden bikes has been built since the beginning of the bicycle history, however, during the XXI century, the wood has reborn as a material full of metaphysical, mechanical and environmental properties for the building of bicycle frames. There are a lot of bicycles frames made out of wood, but there is no one commercial folding bicycle built with this material. The aim of this project was to design a frame for a folding bike using local wood available in Colombia. To do this a strategic alliance between the Design Studies Research Group GED at the Universidad Pontificia Bolivariana and the Materials Research Group for Furniture (MATERMOB) of the National Learning Service institution (SENA) arises. A methodological scheme of systematic concurrent design process was used in which science of materials, structural design, techniques of digital manufacturing and industrial design converged in a multidisciplinary design team. The requirements for the project were identified as well as the wood was selected, the geometry of the parts and the structure and the different components were defined. Finally, the folding mechanism was developed and several prototypes were built and validated in order to define the final specifications for the product. The final model was made out of teak strip board showing not only aesthetic features but also an acceptable structural behavior. It was found that teak strip board could be used for folding bikes frame if a set of variables related with an optimum combination between shape, material and structure are considered. Morphological transitions between all the parts of the frame, wood grain orientation, adhesive materials and flexural behavior were identified as the main design

Keywords: Folding bike, Urban Mobility, Wood, Design, Sustainable Mobility

1. Introduction

Nowadays, is well known that the growth and densification of the population in the different cities generates, proportionally, an increase in the number of cars. This promotes serious situations of pollution, traffic, accidents, scarce resources and dependence on non-renewable energy sources. Due to this, some government entities have set out to create strategies that aim for urban sustainable mobility systems based on the bicycle as a proposal of autonomous, efficient and sustainable means of transport for short journeys which are integrated with the existing public transport systems. As an example of this is the system of the Public Bicycle System of the Valley of Aburrá - ENCICLA, and the optimization of the road network of the City in its quest for sustainable mobility (Ospina, 2016).

Within the different existing bicycle models, the folding bicycles are presented as the most appropriate to articulate with multimodal urban mobility strategies (Krizek, K., and Stonebraker, 2010) (Harris, 2011). The capability to reduce its size and increase the load capacity of a person, make this type of bicycles a clear reference for the optimization of urban movements in highly congested cities. There are several commercial models of this type of bicycle, however, it is clear that it is possible to improve them from aspects such as weight / volume ratio in the folded state, ergonomic conditions when the user is moving the bicycle in the folded state and the visual appearance. Hence, we have identified valuable projects (Tosi, et al., 2012) (Niu, et al., 2014), (Luo and Lu, 2014) that target to this goal as well as new developments of commercials brands. However, iin the marked none of them use the wood as material for the development of the frame of a folding bicycle.

Since the end of the 18th century the wood has been used as a material for the design of bicycle frames (Valencia-Escobar, 2015). During the last 10 years, and after a lethargy of almost 100 years, the wooden bicycles increase relevance. Hence, the Universidad Pontificia Bolivariana, at the head of its Research Group of Studies in Design (GED) of the Industrial Design faculty, presents itself as one of the few worldwide academic institutions that demonstrates a wide and successful work on the design of wooden bicycles (Figure 1). Moreover, the Materials Research Group for Furniture (MATERMOB) of the National Learning Service institution (SENA) has been working extensively on projects focused on the traditional and innovative use of wood as a material for design, being also recognized as a reference at the national level for the technical and technological level that have had their projects.

Figure 1. *Wooden bike model developed by the GED research group.*

Although it is clear that there are a large number of models of wooden bicycles in the world, only have been identified two models, non-commercial, which approaches to the folding bicycle typology. One of them is based on the same principle that possess the Strida® bicycle which is presented as a DIY project with materials and adapted components from other applications (Figure 2a). The second case is a model designed and developed in Indonesia that consists in a double triangle with a hinges system in the middle part of the wooden frame (Figure 2b). Despite this, the mentioned project does not present any relevant information regarding its design and analysis process and do not refer to the possibility to have some commercial impact. In addition, it is clear that the levels of functionality of these two models in terms of their structural capacity in relation to weight are not optimal with respect to commercial models of this type of bicycles.

(a)

(b)

Figure 2. *Wooden folding bicycle models with (a) monotriangular structure and (b) double triangle structure.*

The aim of this work is to present the methodology used for the design of an urban folding bicycle with a solid wood frame, the selection criteria of the material and the definition of the structural pattern taking into account the exploration of the state of the art and the consideration of the manufacturing and design process of bicycles in the local area of the city of Medellin-Colombia. In addition, this paper wants to describe how the scientific research contributed with the development of the wooden folding bicycle.

2. Methods

The design project was performed based on three stages of development: *(i)* information, *(ii)* formalization and *(iii)* making. This stages were supported with scientific research activities with the aim of support the technical knowledge generation For the **information stage** a documental research was approached with the aim to define the background and the state of the art with respect to fundamental aspects such as the design requirements and the existing functional validation protocols. As first instance a detailed exploration of 20 models of commercial folding bicycle was made looking for to obtain information about measurements, components and folding mechanisms. From this, it was preceded with the definition of the bicycle geometric pattern, which consists of the special disposition of seven reference points that allow the development of the structural pattern: dropouts, front axle, bottom bracket, the seat, the start of the head tube, the end of the head tube and the handlebar. The geometric pattern is responsibly for defining the ergonomic conditions of bicycle handling and is related to the type of bicycle that is expected to be designed. An analysis of the context of bicycle use was also made as well as the conceptualization process of the project, searching references for both the brand and the form generation.

At the same time, it was worked on the identification of the models of rigid bicycles with more representative wooden frame in the international and national market, looking for the denomination of the type of wood or woods that are used for their manufacture. This information was organized with the aim to build the required material profile for the project in term of mechanical, chemical, aesthetical and physical properties of the wood. Then, in order to define the type of wood most appropriate for the project, a materials selection process was made using analysis and similitude methodology (Ashby y Johnson, 2013). The selection process of the wood was accompanied by a three point flexural test performed to the more ranked candidate in contrast with pine plywood, used as a reference due this is one of the most used materials for the manufacture of wood bicycles. The flexural test was performed based on the ASTM D7264 standard using pine plywood and teak samples with 18 mm in thickness.

Since it was expected that the productive development of the frame includes the joining of various wood sheets with the aid of adhesives, the level of structural reliability of the adhesive in the construction system was also considered for the mechanical test. The evaluated adhesives were Carpincol 2500 (polyvinyl acetate based adhesive) and epoxy adhesive, both products special for the joining of wood. The aim of this study was to evaluate the mechanical strength and stiffness of the adhesive and to validate how it influenced the mechanical behavior of the wood laminates against fracture.

The **formalization stage** consisted in the collection of the list of requirements and geometric patterns identified in the previous stage of the methodology in order to carry out the two-dimensional development of the structural pattern considering the technical aspects and the defined conceptual information (Figure 3). Such structural pattern was established considering three variables: length, cross section and longitudinal section of each of the constituent elements of the frame. The use of a central zone with elliptical shape was considered in function of the improvement in the distribution of the efforts in the wood. For this, it was worked with an ideation process based on "design thinking" in order to promote the generation of a large number of ideas from all members of the team. Then, two models were selected based on aesthetic, manufacturing viability and technical considerations. Such selected models were three-dimensional modeled using the softwares Rhinoceros® and Inventor®. After this, one model was selected.

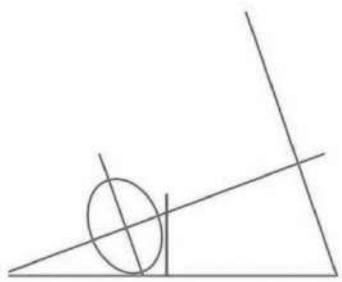


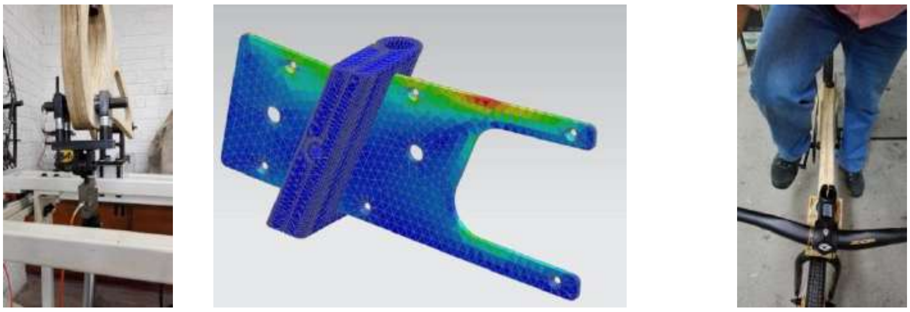
Figure 3. *Defined structural pattern*

Each variation was modeled digitally and then prototyped to scale in laser cut MDF sheets. With such models, the final structural pattern was selected and re-prototyped on a 1:1 scale in CNC router cut MDF sheets. This prototype aimed to define geometric and constructive conditions and to validate the general appearance of the bicycle. After this, a new prototype was made in 1:1 scale in pine plywood, looking for a first approximation to the structural validation. These first two prototypes did not have the folding mechanism, since the identification of the critical points within the rigid structure was first sought. Simultaneously a finite element analysis (FEA) was carried out using the Ansys® software, which sought to refer to the critical points of the structural system and to evaluate the mechanical behavior in the zones of interaction between the wood and the metal pieces expected to be used, especially in the area of the drop-outs, the bottom bracket, the hinge area and the head tube. This modeling was constantly updated with regard to the changes that were taking place and the information that the tests yielded.

After the initial tests, which were carried out in a structural test bench for bicycles, a new model was prototyped in the wood selected in the information phase. The models were prototyped using a five axis CNC machine MAKSER FORMAT 4 profit H20. With this process, the **making stage** begins. This new prototype was subjected to a protocol of structural, constructive and operative tests in order to fine tune all the characteristics of the same one. At this point, a folding mechanism had already been developed that was included in the frame. This process was repeated five (5) times with improved prototypes until sufficient performance was obtained. Each of the prototypes mentioned included both formal changes and adjustments in the orientation of wood grain. The frame parts manufacturing was initially developed in a numerical control router for the formation of pieces of wood and then a process of dimensional adjustment and manual joining of parts and components was used (figure 4). A PVA-based adhesive was used for joining between pieces of wood and an epoxy adhesive for the joining of the metal parts with the wood.

Figure 4. Dimensional adjustment of one of the models.

Although the tests were constant, it can be said that the validation stage is developed in all its depth with the final prototypes including the selected wood, the dimensions established and the internal reinforcement components designed and attached. This validation includes, as was said, structural tests on a test bench (Figure 5a), in addition to a finite element analysis process that sought to identify the most critical points in the structure (figure 5b). In addition, basic driving tests were performed to determine the level of ergonomic adjustment (Figure 5c). Finally, a perceptual validation was made in order to identify the contribution that the shape and material gave the bike. The tests carried out on the test bench involved carrying the frame up to mechanical failure in order to identify the most critical real points and act on their reinforcement.



(a) (b) (c)

Figure 5. (a) Testing of one of the ptototyped frames. (b) FEA image of the hinge. (c) Anthopometric adjustment testing.

One of the distinguishing elements of this process was the use of a static load testing bench for bicycle frames. This bench, allowed to validate the structural conditions from the strength, stiffnes and stability of each of the pieces that conformed the frame. The tests in the bench consisted in the sequential application of a vertical load in the bottom bracket zone from 0 and up to 400kg and the simultaneous measurement of deformations in different parts of the frame, being the most important the horizontal displacement of the head tube, the vertical displacement of the bottom bracket and the lateral displacement of the chain stay. These deformation values were compared with respect to existing references in a database developed in an earlier project with BMX type frames.

3. Results and discussion

It is possible to define a specific result of each of the methodological phases. From the information stage, the geometric pattern required for the design of the new frame was obtained. In addition, the type of material to be used was selected. The teak as a type of wood and the wood lumber finger joint board with 18mm thick was the result of the selection process. This raw material responds to the technical, environmental, productive and aesthetic requirements that the project raised. Urbánica, was the name defined for the new bicycle and the logo associated with this name was also developed. At this point it is important to mention that the multidisciplinary design team represented an added value for the project in this phase, since each of the members supported directly and specifically from their knowledge.

It was found that the PVA type adhesive was the most suitable product for the joining of wood pieces, since it not only provided resistance, but also some flexibility that avoided the catastrophic fracture of the wood sheets that was observed with the epoxy adhesive. On the other hand, the union of the metallic pieces with the pieces of wood was made with the help of an epoxy adhesive layer and steel screws.

From the making stage, a 100% functional prototype of a folding bicycle was obtained whose frame was fabricated in teak wood and internally reinforced with 3/8” thick cold rolled 1020 steel plates, which reached an acceptable level of structural performance with a significant contribution from the appearance and sensory perception. The folding mechanism - hinge - was also specially designed for this project. We opted for a piece machined by numerical control from a block of 7075-T6 aluminum alloy. The users involved manifested positive reactions to seeing and interacting with the bicycle. Finally, the validation allowed validating a protocol of structural tests that had been initially proposed for BMX bicycle frames showing good results. Also, validation combined computational analysis with physical testing in terms of design optimization. One of the most critical aspects that were identified during this phase was the definition of the orientation of the wood veins in each part of the frame. It was found that the same orientation could not be used for the entire bicycle since the distribution of the forces in each zone required different wood performances. In addition, the wood board that was used had pieces of wood taken from different parts of the tree, which generated a substantial difference in its mechanical properties. It is not possible to show the final result of the process since it is currently in the process of registering for its patent.

The contribution of scientific research in this project is recognized as another of its added values. The generation of new knowledge about the type of wood to be used, the adhesives that improved the functionality, the orientation of the grain of the wood according to its structural requirement and the development of a new type of frame, makes this project a unique proposal with high potential for innovation.

5. Conclusions

Wood has the potential to be used in the design of complex structural systems in which not only adequate mechanical performance but also a significant aesthetic contribution is expected. Although wood has been present for more than 200 years in the design of bicycles, this project allows to affirm that, with an adequate design process, alternative uses can be proposed that value this material. The combination of a scientific research process with design thinking contributes work tools that allow the results to be adjusted to the technical and aesthetic requirements. Besides, from the development of this project it is possible to conclude that interdisciplinary and interinstitutional work is an adequate strategy for research and development projects. The design of a brand new teak wood frame for folding bicycles was made possible through the union of a detailed process and the participation of experts in each of the fundamental aspects of the project.

As aspects of improvement for future developments the process of assembly of all the parts of the bicycle, the weight of the frame and the frame stiffness were identified. The joining of several parts of wood and metal generate interferences that force to use the manual manufacture in some cases. It is hoped that in the future all parts of the system can be manufactured through digital manufacturing processes. It is still possible to optimize the size of some of the pieces through advanced computational analysis and thus improve the weight. Although all wooden bicycles have a lower stiffness than bicycles made of metal tubes or composite materials, the final model achieved could optimize their lateral stiffness level, possibly using cross sections in the seat stay and in the chain stay that maximize the second moment of inertia of the cross-section.

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[Critical factors for implementing sustainable Product-Service systems in emergent contexts. Colombia Study Case]

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Abstract
The Product-service systems are integral product and service solutions seeking to supply the needs of a user through its function (use) rather than of a product, since their dematerialization level and form other than consumption to traditional (rent, leasing, payment per use), are solutions with a high potential of economic, environmental and social benefits being accepted globally as a response to the sustainability dilemma. Regardless of its maturity and development degree, its implementing has involved several challenges to the organization, as it demands specialized conditions for its development: high innovation degree, favorable legislation, knowledge in life cycle economics, risk capacity, design capacities among others. Its implementing has functioned in Post-industrial European economies, based on the service and knowledge, contrary to emerging economies such as the Colombian, based on massive goods production, involving high exploitation of resources, environmental solutions revolve around reactive solutions at the end of the tube and emerging guidelines of Eco-efficiency. Aimed to transfer economic, environmental and social benefits from the Product Service System solutions to the national economy, and at the same time generate a contribution to surpass implementing barriers in emerging countries, the present article sets out the identification of Critical Factors in Implementing PSS solutions in an emerging economy such as the Colombian, highlighting the Factors: E-9 Innovation Culture, E-7 Knowledge Level of Environmental Economy and Product Service System, D-16 Design Capacities, R-13 Reliability and G-15 Public Policies. As Factors with a high promissory level of contribution in the development of Product Service System.

Keywords: Product-Service System (PSS), Sustainability, Design, Business, Emergent Context

1. Introduction

During 20 years of research, many are the concepts of Product Service System proposed; its origin is located around the mid half of the 90's. The first concept and most referenced in literature is the one by Goedkoop (1999) who defines it as a combination of systems and products able to totally supply the needs of a user: " ***(Product+Service) + User's Needs***"; Brezet (2001), sets out a definition as from Design: Eco-efficient services are product and service systems developed to cause minimum environmental impact with a maximum value generation: ***" (Product+Service) + User's Needs + Environment";*** the most cited article in literature***;*** Clarifying the PSS Concept by the Researcher Mont, it defines it as: a Product and Service System, supported on networks and infrastructure designed to be competitive, satisfy needs of the user and have a low environmental impact less than traditional business models Mont (2002): "***(Product+Service) +User's Needs + Environment+ Competitiveness (Networks-Infrastructure)";*** in the 2003 Manzini, it is defined as the Result from a strategic innovation that changes the emphasis of designing and selling physical products only to products and services which have the capacity to supply specific demands of users Manzini (2003): **(Product+Service) + User's Needs + Environment+ Innovation**; Tucker (2006), defines it as "a combination of tangible products and intangible services designed in such a manner to be able to supply the needs of the final user: ***" (Product+*** **Service) +User's Needs**"; finally Vezzoli (2014), as from design introduces a recent definition: An offer model that provides and integrates products and services able to satisfy the specific demand of users (offering "satisfaction units ") based on innovating relations between the value production system's stakeholders (satisfaction system), where the economy and interest of competition continuously provide new solutions with environmental and social benefits: "***(Product+Service) +User+ Innovation networks + environmental+ social".***

As conclusion the product-service systems are integrated product and service solutions that seek to supply the needs of a user through its function (use) more than from a product, due to its dematerialization level and different form of consumption to the traditional (rent, leasing, payment per use), these are solutions with high potential of environmental and social benefits being globally accepted as a response to the sustainability dilemma.

The Product –Service Systems solutions (PSS) have been implemented since the decade of 2000, mainly in European countries such as: Germany, England, Sweden, Finland, Denmark and in the last decade in Asian countries, with several benefits, identified by authors such as (2003), Mont O (2002), Goedkoop (1999), Rocchi (2005), Vezzoli and Ceschin (2015): Strong customer loyalty through high contextualization of offered solutions, operating costs reduction, increase in local employment generation through the component of associative, improving the positioning strategy, new market niches and potential to general sustainable economies, the latter characteristic of great interest for governments as support to generate sustainable state policies such as is the case of the German Sustainable Economic Policy.

Although, Product-Service Systems and its benefits have functioned in Post-industrial European economies, based on service and knowledge, it is not the case of emerging economies such as the Colombian, based on the massive production of goods, involving a high exploitation of resources, environmental solutions revolve around reactive solutions of end of tube and guidelines emerging from the Eco-efficiency. Awareness of solutions such as Life Cycle Design, Dematerialization, Product Service Systems have not been transferred because the desirable characteristics for its development have not been given; Developed economies, centered on service, technology and knowledge, societies with high sense of environmental implications, association capacity and favorable standards frameworks. The environmental division of the United Nations, sets out as from a research lead by the researchers Manzini and Vezzoli, in respect to implementing PSS in non-developed countries that the main barrier could be availability of advanced technological knowledge and information to produce a social and feasible economically PSS, other barriers are the lack of tools and design methods, entrepreneurship capacities, experience in service process management and a legal support framework. UNEP (2002).

Aimed to transfer the economic, environmental and social benefits from Product Service System solutions to the national economy, and at the same time generate a support to exceed implementing barriers in emerging countries, the present article sets out: How to accomplish designing Product Service System solutions in emerging economies in order to obtain appropriation of their economic, social and environmental benefits?

State of the art of Product Service System.

Due to its potential to contribute to Sustainability and innovation the Product –Service System has been object of studies in the last two decades, its research presents a maturity stage where publications have quadrupled in a decade (2006-2016), the largest production of goods is found as from 2013. See **Figure 1**

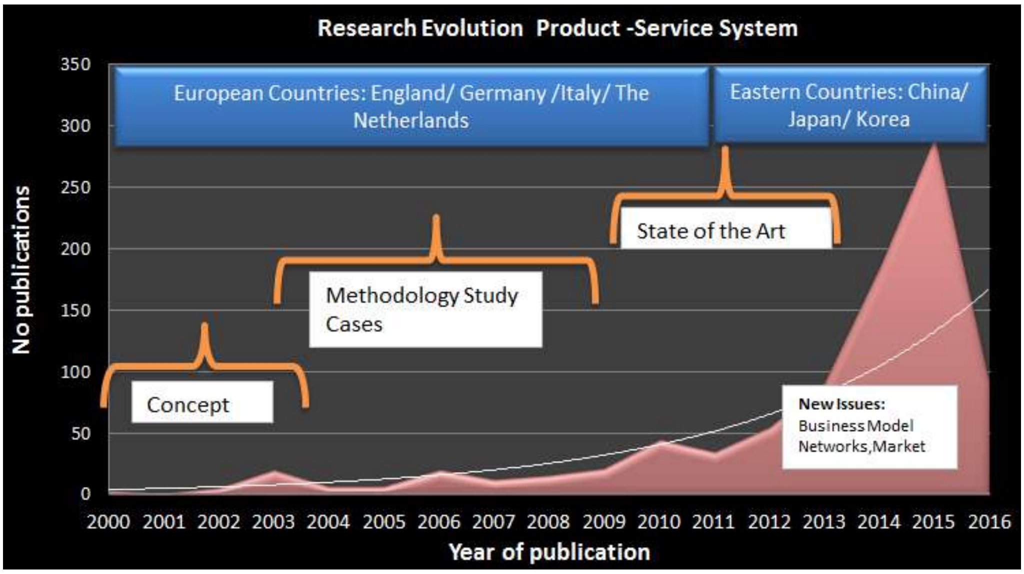

Figure 1 Research Evolution Product –Service Systems. 2000-2016. Bibliometric Study. Sources: Science Direct, Scopus, Design Issues.

The graphic shows the theme's theoretical evolution; from 2000 to 2006 the PSS concept was developed, during 2005-2010 it was exploited through methodological proposals which have been applied to study cases during the period 2006-2012, the analysis and conclusions from said implementation have been presented as State of the Art in the years 2012 and 2013. In recent years (2014-2016), there has been in depth expansion in themes such as the designing of Business Model, Sustainability and concerned parties' networks.

Disciplines in which the Product-Service Systems' benefits are more evident are upon which the research has been focused: Business Model, Manufacturing (Product-Service) Technology (TIC's), Sustainability and Design. See
Figure 2

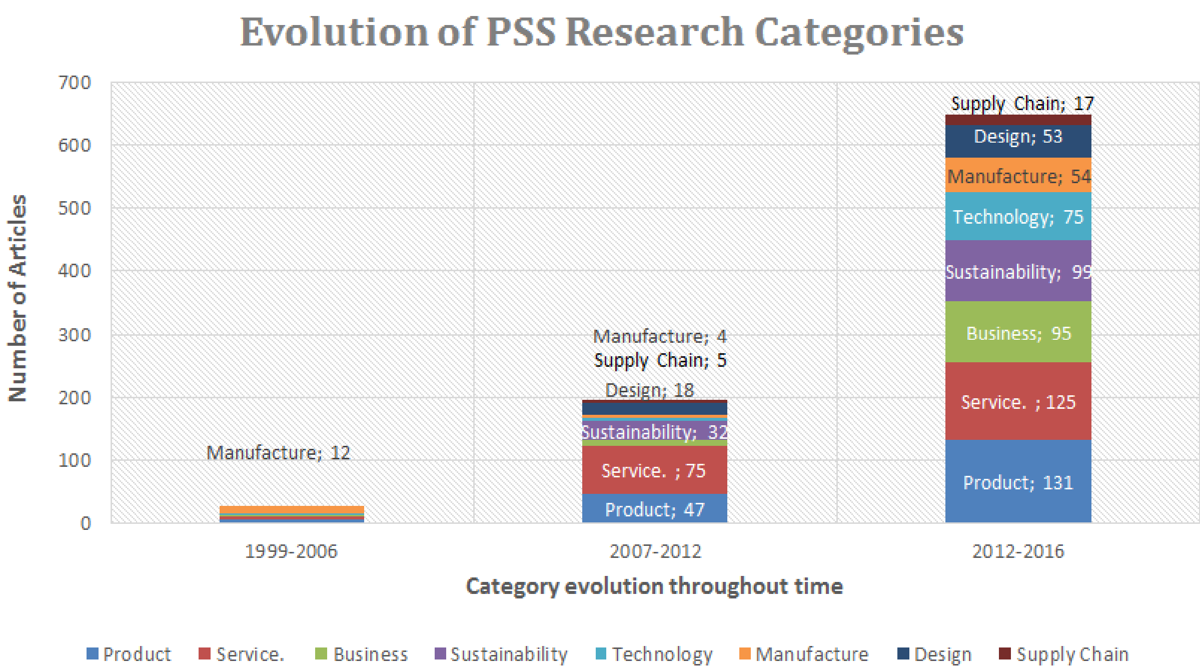

Figure 2: Theme Evolution as from which the PSS are researched. Preparing as from Bibliometric Study.

Regions as from which the research has been approached are Europe initially and in the last decade Asia, with main themes such as concept construction, implementing methodologies, environmental coexistence, study case analysis and State of the Art. Within this theoretical construction research percentage from Latin American countries is of (3%) originated in Brazil.

The leading country in PSS literature is the United Kingdom, followed by Germany, the Netherlands (Sweden, Denmark, Holland). China, Japan and Korea have been leaders in research in the East and finally Brazil is the only country supporting formal research in Latin America. See 3

No	Países	Porcentaje de Publicaciones
1	United Kingdom	16%
2	Germany	11%
3	China	10%
4	Sweden	9%
5	USES	7%
6	Japan	5%
7	Netherlands	5%
8	Italy	5%
9	Denmark	3%
10	France	3%
11	Finland	3%
12	Korea	2%
13	Australia	2%
14	Brazil	2%
15	Croatia	2%
16	Taiwan	1%
17	Taiwan	1%
18	Spain	1%
19	Portugal	1%
20	India	1%

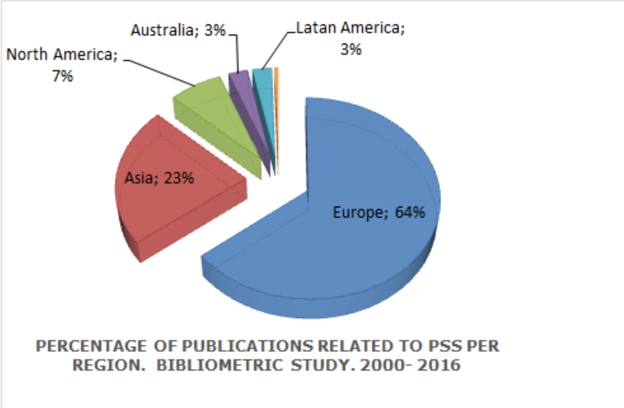

Figure 3 Main Regions and Countries where the PSS is research. Bibliometric Study

Critical implementing Factors of the Prodcut Service System

Regardless of recognizing benefits to the Product Service System solutions and of having a mature theoretical development, the implementing degree inside organizations has been low in European countries, situation studied by authors such as: Mont O (2002), Vezzoliand Manzini (2008), Tsai (2010), Tukker (2013), Schenkl (2014). In the year 2012 the magazine Journal of Cleaner Production has called upon articles to prepare a special edition entitled: "Why have Sustainable Product-Service Systems not been widely implemented?, with the same approach Vezzoli (2015) sets out:"In accordance with this limited implementation and in order to use up its benefits and contribute to the construction of a sustainable development, it is urgent to have better understanding of the benefits, critical factors and barriers of its implementing".

Due to the above, the awareness and management of critical implementing factors (C.I.F.) of PSS solutions is necessary and mandatory in the conceptual, methodological and practical development of this type of business. Authors such as Mont and Manzini as from 2003 have identified key and necessary factors in their implementing; in the last decade these factors have been ratified, complemented, several validated through the study case. With the purpose of identifying academic advanced to this respect, an in depth analysis was made from 23 articles, explicitly focused on the study of Critical Implementing Factors (C.I.F) of the PSS solutions. The study provided a total of 43 Critical Implementing Factors according to the number of quotes from the most relevant authors. Goedkoop (1999), Mont (2002), UNEP (2002), Behrendt (2003), Manzini (2003), Boada (2005), Baines (2007), White AL (2005), Cavalieri (2013), Hänsch (2013), Ceschin (2013), Catulli (2013) , Schenkl (2014), Laperche (2013), Vezzoli (2015). Table 1 shows the most relevant Factors and in Annex A can be studies the total of identified Factors.

Table 1 Main Critical Implementing Factors (CIF)

Name of Factor	Article where it is Referenced	Year of most recent citation	Number of times identified
F-6 Property paradigm	Baines (2007), Manzini (2003),Hänsch (2013), Cavalieri (2012), Boada and Mont (2005), (Fishbein 2000), (Ceschin), Behrendt (2003), (Goedkoop 1999), (Schenkl 2014), (Manzini), (UNEP 2002), (Vezzoli 2015), (Stoughton 1998), (White AL 2005), (Fishbein 2000), (Catulli 2013), (Mont 2002), (Laperche 2013), (Vezzoli 2014).	2014	20
F-9 Absence of public policy	(Tukker 2013), (Michelini 2004), (Boada Mont 2005), (Hertwich 2003), (Charkiewicz 1998), (Rocchi 2002), (Ceschin 2013), (Mont 2003), (Vezzoli, 2010), (Tsai-2009), (Hanafiah), (Bartolome M 2003), (Besch K 2004), (Mont O, 2006), (Manzini E, 2003), (Maxwell D 2006), Mont, O. (2001).	2013	17
F-4 Risk level	(Baines 2007), (Hänsch 2013), (Cavalieri 2012), (Boada Mont 2005), (Ceschin 2013), (Mont), 2014), (Gómez 2009), (Siemer F. 2004), (Garrel J 2009), (Vezzoli 2015), (Mont O 2004), (EC) aperche 2013), (Vezzoli 2014).	2015	15
F-7 Low awareness in Life Cycle Economy	(Boada Mont 2005), (Votta 2001), (White 1999), (Ceschin 2013), (White 1999), (Schenkl 2014), (Mont O. 2002), (Ehrlenspiel 2014), (UNEP 2008), (Vezzoli 2015), (White AL 2005), (Bartolomeo 2003), (Vezzoli 2014),	2015	13
F- 10 Organizational Structure focused to manufacture	(Baines 2007), (Tukker 2013), (Hänsch 2013), (Cavalieri 2012), (Boada Mont 2005), (Ceschin 2013), (Schenkl 2014), (Bertolini M 2004), (Tsai-2009), (Mont O 2004), (Vezzoli 2015), (Martinez V 2010), (Vezzoli 2014).	2015	13
F-11 Business Model Structure	(Baines 2007), (Tukker 2013), (Ceschin 2013), (Mont), (Kindstrom,2010), (Mont et al., 2006), (Masanell 2010), (Yip 2004).	2013	13
F-3 Investment Level	(Tukker 2013), (Ceschin 2013), (Mont), (Cavalieri 2012), (Gebauer 2008), (Gebauer 2005), (A. Neelyn2009), (Schenkl 2014), (Straub 2011), (Vezzoli 2015), (Besch K 2005), (Laperche 2013).	2015	12
F-17 Reliability	(Cavalieri 2012), (Boada Mont 2005), (Schenkl 2014), (Siemer 2004), (Garrel J 2009), (Hypko P 2010), (Jauch LR 1979), (Becker 2009), (Vezzoli 2015), (Mont O 2004).	2015	10
F-19 Solution Prices	(Baines 2007), (Boada Mont 2005), (Schenkl 2014), (Ford 1989), (Srumf R. 2006), (Straub 2001), (Mont O 2004).	2014	7
F-1 Service Economy	(Tukker 2013), (Boada Mont 2005), (Ceschin 2013), (UNEP 2002), (Vezzoli 2015), (Cook M 2006).	2015	6

Nota: Critical Implementing Factors identified in literature according to most frequented cited articles and authors. Bibliometric Study.

Throughout a 15-year research, factors from the F-6 Paradigm of Property understood as the consumer's position to not accept the idea of owning property due to cultural and status reasons; F-9 Absence of public policies that promote and support this type of solutions and F-7 low awareness in life cycle economy have been ratified by the different authors as the main critical implementing factors.
However, in the last years the Factors related to the business configuration have become more relevant as the PSS implementing identifies them as one of the largest barriers to resolve: F-4 Risk Level, F-11 Organizational Structure focused to manufacture, F-11 Structure of Business Model.

The different authors confirm the importance of context factors that make possible the success of Product –Service Systems solution: F-1 Service Economy, F-15 Collaborating Companies, F-17 Reliability.

The theory introduces the contribution of the designing discipline as determinant factor of the success or failure of the PSS. The successful implementing of Products Service Systems with its approach to providing profit not only economic but also environmental and social, depends greatly on the Design of the Product Service System in which the social, environmental and economic factors shall be included, likewise it is fundamental to include the user as solution validator. Baines (2007), Cavalieri (2013), Vezzoli (2015), Mont O (2002), UNEP (2002), Manzini and Vezzoli (2003).

F-C. I Emerging Markets
The reviewed literature source of the above critical factor identification originated in Europe, United States, Asia. The identified factors correspond to social, economic and environmental conditions of industrialized countries. In the review of international literature, Manzini and Vezzoli (2003) approach the PSS theme in emerging countries upon the request of the United Nations, the base question made was: Are the PSS applicable in emerging context and of low income? Conclusions from said study are that it could be a business opportunity in emerging economies, by surpassing the individual consumption stage for an economy stage based on satisfaction and in the low use of resources, this is a service economy. UNEP (2002).
As from this study was set out that the main barrier can be the awareness and advanced technological information availability to produce a PSS, socially and economically feasible; other mentioned barriers are the lack of tools and design methods, entrepreneurship capacities, experience in service process management and a legal support framework. UNEP (2002).

2. Methods

In order to validate theoretical results in respect to Critical Implementing Factors of the Product Service System, the Study Case Method was selected as explanatory approach since it aims to validate within an emerging economy context the theoretical results from the research.

The research comprised two phases: theoretical and field research. In the theoretical phase we constructed the PSS State of the Art in order to identify the Critical Implementing Factors (C.I.F.) through a Bibliometric Analysis, quantitative instrument based on the Bibliometric, science that enables us to perform a review to scientific information with mathematical and statistical methods. Search was limited to approaches relating to the research: service, business, user, design, life cycle, business models, sustainability, environmental, service-product, companies. The period analyzed was: Open -2016. Initially the search provided 1625 articles, which were reviewed and debugged to finally identify 844 articles related to the Product –Service System, identifying the most relevant articles within citation and authors terms for the theoretical identification stage of critical implementing factors from the Product –Service System.

As soon as the articles had been identified, there an in-depth review made to the articles, identifying the recurring factors and most referenced by the authors as critical to implement the Product-Service System; then a grouping of (C.I.F) Grouping per type of actors of a Product Service System solution and consolidated to identify the core (C.I.F) to validate in field. See Table 2

Table 2. Critical Factors to Validate in Field

PSS Actor	Factor to Validate	Integrated Factors
Company	**E-6 Manufacture Approach**	F- 10 Organizational Structure focused to Manufacture
		F-36 Production Capacities
		F-43 Labor Costs
	E-7 Awareness Level Environmental Economy and PSS	F-38 SPP Efficiency Measurement
		F-5 Difficulty to measure Environmental, Social and Economic Benefits
		F-7 Low awareness in Life Cycle Economy
		F-21 Low Knowledge in PSS
	E-8 Management and Technology Capacities	F-25 Low capacities in Management
		F-37 Logistic Capacity
		F-22 Technology support closed production cycles
		F-31 Low management of information technology
	E-9 Innovation Culture	F-32 Entrepreneur capacity
		F-2 Innovation Culture
		F-42 Sector's competitiveness level
Shareholders	**A-10 Risk Level**	F-3 Investment Level
		F-4 Risk Level
	A-11 Business Model	F-28 Business Return Period
		F-11 Business Model Structure
		F-24 Profit system change
		F-14 Contract Design
		F-40 Reduction business control
	A-12 Managerial Commitment	F-39 Managerial Commitment
Business Network	**R-13 Reliability**	F-17 Reliability
		F- 22 Position in value chain
		F-41 Conflict of interest
Government	**G-15 Lack of Public Policy**	F-8 Lack of Government incentives
		F-9 Lack of public policy
Designers	**D-16 Designing capacity**	F- 35 Designing capacities (Tools, Methodology)
		F-13 Designing Capacity Business Models PSS
		F-18 Separating Design Function Product and Service Development
		F-16 Including user in PSS design
Context	**C-17 Favorable Context**	F-42 Sector's competitiveness level
		F-23 Social Conditions of Context
		F-1 Service Economy
		F-15 Collaborating Companies

Note: Critical Factor Integration per common approach to identify 12 Critical Factors to Validate in Field.

Validation of Critical Factors within context consisted of assessing the presence or absence of each of the C.I.F. in developed Study Cases, using the categories of Inhibitor or Enhancer. Once the C.I.F. is assessed to be Enhancer or Inhibitor, a second evaluation was carried out in respect to the influence degree on the Product Service System solution. See **Table 3**.

Table 3 Categories according to Influence Degree of the C.I.F.

Assessment	Influence Degree	Type of Factor	Description.
Very Strong Influence	4	Enhancer	If the assessed C.I.F. is positively determinant in the Design process of Product-Service Systems.
Moderate Influence	3	Enhancer	If the assessed C.I.F. has a strong influence but individually is not able to enhance the Design process of the PSS.
Very Weak Influence	1	Enhancer	If the assessed C.I.F. has a low positive influence.
Not assessed	0	Neutral	If the assessed C.I.F. has marginal presence.
Very Weak Influence	-1	Inhibitor	If the assessed C.I.F. or its absence has a low negative influence.
Moderate Influence	-3	Inhibitor	If the assessed C.I.F. or its absence has a strong influence and individually is not capable to inhibit the PSS Design process.
Very Strong Influence	-4	Inhibitor	If the assessed C.I.F. or its absence is negatively determinant in the Design process of the Product-Service Systems.

Note: Assessment Influence Degree of each C.I.F., performed in each Study Case.

Study Case Development.

With the purpose of validating the critical implementing factors the research in field stage was based on the development of three study cases, documentation of a successful case and preparing 12 Interviews. The study cases were chosen with theoretical criteria, non-statistical, in order to replicate findings and extend them to the theory construction proposed in the research. Companies with greater environmental commitment promote favorable conditions to implement Product –Service Systems due to its requirement to include the economic, environmental and social variables in business. Under this condition we decided to work with organizations that would assume within their strategic vision the environmental and/or social theme as a main component and not marginal. The research project was developed with the Environmentally Sustainable Company Network from the District Environment Secretariat in Bogota (Red de Empresas Ambientalmente Sostenibles de la Secretaría Distrital de Ambiente de Bogotá) (SDA). The objective of the Network is: “promote the association of companies, guilds and institution concerning Project and/or environmental activities’ development that will allow the improvement of the environmental performance from the entrepreneurial sector of the city”. (SDA; , 2016).

Study cases, consisted of designing a business model under the concept of the Product-Service System using the initial Prototype of the Methodological Model (M.M.PSS) proposed in the research. Planning and designing stage of each case included criteria provided in the conclusions of each case; in this manner the initial model prototype was adjusted and validating Critical Implementing Factors.

Selected cases in the research were: Sustainable Mobility, Package Assessment Case; Energetic Efficiency Case and the study case documented: Assessment of reels. See table 4.

Study case	Type	Context	Companies	Designed Product-Service Systems	Information Collection Method	Protocol
Reel assessment	Documented Success Case	Companies with environmental theme within its Entrepreneurial Strategy	Procables	Product-Service Systems for Reel Assessment	Documentation Interviews	1-1 Protocol Reel Assessment Case
Sustainable Mobility	Developed	Environmental Company Network. District Secretariat of Environment. Bogota	Biomax SI 99 Confipetrol Helm Procables	Design of a Product-Service System of Sustainable Mobility for companies of the Environmental Excellence Program PREAD	Participating Observation through Designing proposal Methodology of Product –Service Systems, Interviews	2-1Protocol Sustainable Mobility Case
Package Assessment	Developed		ECSI Biomax Procables	Design of a Pr oduct-Service System for the Assessment of Lubricant Packages		3-1Protocol Package Assessment case
Energetic Efficiency	Developed	Companies with high innovation profile and with complementary business.	Codensa Procables	Design of a Product-Service System for cable Assessment		4-1Protocol Energetic Efficiency Case

Table 4. Summary of Cases Developed in the field research

In each case was following the Study case methodology proposed by Yin R. K (2014), designing a protocol with the following stages: Study Case Design, Preparing Study Case, Data Collection, Analysis and Conclusions. Proposal guiding the study cases was: There are contextual factors that inhibit or enhance the development process of business models under the concept of Product-Service System.

In order to carry out the data triangulation exercise, we decided to carry out 12 interviews with the study case participants, the government actor and experts from the Product- Service System and Design theme.

Interviews focused on validating the C.I.F. and identifying with participants their perception and learning in the Project, their methodology appropriation level and contributions for the adjustment and complementing of the methodological prototype. Interviews were personal, semi-structured, for each act a questionnaire was designed based on open questions aimed to the role of each participant in the project. Interviews made with the study case participants were focused on the methodology validation, while interviews made to the Experts and Government, were focused on validating the C.I.F.

Data analysis was based on two strategies: Identification of common patterns of the collected information and data triangulation: with data obtained as from the different used instruments (Study Case –Interviews –Successful Case) and data triangulation with Theoretical. Analysis of information related to critical factors had as objective to identify key implementing factors within the context of Colombia. As from the Measurement Instrument 3-Ins-1 Theoretical Factor Assessment, was made an individual analysis of each case validating factors and identifying new factors arisen in the context, then a comparison between cases was made to finally contrast results from the Successful Study Case and the result from the interviews. Conclusions from each case were included as design criteria for the following case.
Table 3 provides a short summary of each study case.

Table 5. Summary Study Cases performed in the Research.

Study Case	Company Network	PSS Approach	Designed Product- Service Systems	Benefits	
Sustainable Mobility	1. SI 99 2. Procables 3. Confipetrol 4. Helm 5. P.M.P 6. ECSI	Service	Consists of a private Company-Home transportation service aimed to companies belonging to the companies part of the Environmental Company Network. Service is rendered through an APP application where users could select routes according to their need; the application includes current platforms for services of Transmilenio, Taxis and Bikes. Transportation consists on a private bus fleet conditioned to offer a high comfort level in order to provide a travelling experience with a high wellbeing level.	Economic	• Economic Return per service demand. •Creation of a new Company.
				Environmental	•Reduction Carbon Footprint. •Legal Compliance.
				Social	•Better Life Quality •Option to Unlawful transportation.
Recovery of lubricant containers	1. Biomax 2. ECSI	Service	The business consists on the development of a close cycle of lubricant package recovery economy of the Company Biomax. Business comprises package preparing service carried out by the company Reciproil (Collection of packages at the lubricant service stations, which including washing packages, transportation and delivery to ECSI) and grinding of packages for the production of recovered raw material which shall be used in the production of these same packages for the company Biomax.	Economic	• Lower costs of packages. • The Company ECSI, (National) acquires new customers and strengthens it eco-environmental product line • Creation of a new Business line for the Recycling Company.
				Environmental	• Solution to final disposal of packages • Development of the close Production Cycle. (raw material is re-incorporated to the product process)
				Social	• Generation of employment • Support to vulnerable population • Contribution to the package fraud problematic of the Lubrication Sector
Energetic Efficiency	1. Codensa 2. Procables	Service	The Product Service System consists of a copper waste recovery service present in the cable installation process of the Company Codensa to recover copper in new products by Procables who has a furnace to reprocess copper and manufacture copper sheets.	Economic	•Recovery of copper considered the black gold due to its value.
				Environmental	•Recovery of copper, preventing original exploitation impacts. •Reduction of the Carbon Footprint from not having to transport it to China. •Cable After-consumption policy development.
				Social	•Generation of employment for cable preparing
Reel Recovery	1. Procables 2. Recovering Company 3. Final Customers Procables	Service	Wooden reel collection and repair service, used in packing power cables sold by the Company Procables S.A C.I Reels are purchased to final customers of Procables, collected at the customer's premises, recovered and included once again in the productive cycle.	Economic	•Savings of $1.730.000 (20014-2015-2016). For Procables.
				Environmental	•Reduction in Wood consumption, of energy. Of waste generation, reduction in gas emission in transportation.
				Social	•Employment generation, a new Company collecting reels was constituted.

Note: Summary of Developed Study Cases in field research stage according to Methodology Yin (2014)

Results and Discussion.

According to approached measurement instrument, we have the following table, where presence or absence from Critical Theoretical Factors is identified with its influence level. Table 6

Table 6. Results from C.I.F Validation

C.I.F. Factors	CASO 1: Sustainable Mobility	CASO 2: Recovery of lubricant containers	CASO 3: Energetic Efficiency	CASO 4: Success Case Reels
E-6 Manufacture Approach	-1	1	-1	3
E-7 Environmental Knowledge & PSS	-1	-1	-4	4
E-8 Management and Technology Capacities	-4	-4	4	4
E-9 Innovation Culture	-4	-4	1	3
A-10 Risk Level	-4	1	3	1
A-11 Business Model	-4	1	1	3
R-13 Confidence	-1	4	-1	4
N- Summoning Capacity	4	4	-1	0
N- Shared Value entailment	4	4	3	4
N- Complementary Business	-4	-1	4	4
N- Multidisciplinary Participation	-4	-1	-1	4
A-12 Managerial Commitment	-3	3	1	4
G-15 lack of Public Policy	-1	-4	-1	4
D-16 Designing Capacities	-4	-4	1	0
C-17 Favorable Context	-1	-1	-1	1

Note: Result from C.I.F. Validation in Study Cases.
Red tone Inhibiting Factors per absence: (-4: Strong Inhibitor; -2 Moderate Inhibitor;-1 Weak Inhibitor).
Green Tone Enhancing Factors per presence: (4 Strong Enhancer; 3 Moderate Enhancer; 1 Weak Enhancer). Blue tone new Factors: (4 Strong Enhancer; -4 Strong Enhancer; -1 Weak Enhancer).

As result from the research we were able to specify the meaning of each Critical Factor within the study context. See **Annex B**

This research confirms through study cases, the influence from 11 Critical Implementing Factors identified in the theory stage: E-6 Manufacture Approach, E-7 Knowledge Level of Environmental Economy and Product-Service System. E-8 Management and Technology Capacities, E-9 Innovation Culture, A-10 Risk Level, A-11 Business Model, A-12 Managerial Commitment, R-13 Reliability, G-15 Public Policy, D-16 Designing Capacity, C17-Favorable Context, concluding the relation between the success of the PSS development and the presence percentage for Factors acting as Enhancers: At higher presence level of these factors, higher is the success probability of a Product-Service System, the absence of any factor will become into a development inhibitor for the Product-Service System.

We confirm the interdependence of the factors and the need for carrying out a reading and holistic management of these to enhance the existing factors and offset the weak ones. Critical implementing factors are confirmed for emerging countries identified by the UNEP: availability of knowledge and advanced technological information to produce a socially and economically feasible PSS, lack of tools and design methods, entrepreneur capacities, experience in service process management and a legal support framework. (UNEP, 2002).
The research identified 5 new Critical Implementing Factors from the studied context: N-1-Summoning Capacity, N-2 Entailment of companies as from a shared value, N-3 Complementary Business, N-4 Multidisciplinary Participation, N-5 Managerial Commitment.
Within the Colombian entrepreneurial context where study cases were implemented, was identified the need to enhance five key factors which offer a success promissory level for the development of a Product-Service System: E-9 Innovation Culture, E-7 Knowledge level of Environmental Economy and Product-Service System, D-16 Designing Capacity, R-13 Reliability y G-15 Public Policy.
Within the studied emerging context, is validated the importance and need for the success of a Product-Service System solution from the factor F-6 Designing Capacity; beyond its inherent contribution as Design discipline, in an emerging context is evidenced a greater contribution related to the reduction of knowledge gaps and capacities required to develop sustainable businesses; for its holistic approach, integrating and its role in the construction of cultural codes it may resolve key aspects for the success of Product-Service System solutions such as: breaking the property paradigm, enhance interaction and contextualization of users, consolidate interaction flows of the concerned parties, construct reliability, include environmental and social criteria in designing the integral offer, assert new social values focused on sustainability.

Within the studies context are introduced the following implementing considerations: Factor E-9 Innovation Culture can be assured through business development (PSS) with companies classified as large which guarantee a mature innovation culture, provide resources, exercise the summoning role and/or small new companies with high entrepreneurial capacity immerse in the new awareness and sustainability paradigms. For E-7 Knowledge Level of Environmental Economy and Product-Service System: the development of the business with a strong sustainability strategy is suggested within the environmental management or social liability fields, or to include a private social agent or public expert in the theme. In relation to D-16 Designing Capacity the use of tools and Design concepts is desirable for: User's understanding, design of low life cycle guidelines, eco-design; Communication tools and visual design for network designing, in the same line it is mandatory to work in the Factor R-13 Reliability: Manage concerned parties' network within terms of capacities, expectations, visions, responsibilities, roles in all the Project stages, as it guarantees in great part the success of the business, finally in respect to the public policy: G-15 Public Policy we recommend to develop business within the public Policy of National Green Businesses and train in the use of Project funding mechanisms, the state shall continue with the development of micro policies that generate enabling standard frameworks, insure the continuity for programs that boost sustainable businesses as from the Government, allocate state funds to implement policies, exercise the government's educator role and power benefits from government programs for entrepreneurs.

Finally, the research provides a collection and rating of the theoretical Critical Implementing Factors and of useful context for the work of designers and entrepreneurs in the exercise of designing and developing a Product-Service System solution.

Future challenges for the research include in depth analysis of the Factors identified as critical within the context; E-9 Innovation Culture, E-7 Knowledge Level of Environmental Economy Y Product-Service System, D-16 Designing Capacity, R-13 Reliability y G-15 Public Policy in order to identify a common articulation that will enable its development in social and economic conditions of the emerging country.

It is necessary to approach factors relating to the user of PSS solutions in emerging contexts: PSS F-6 Property Paradigm, F-19 Solution Prices, F-34 Highest Offer cost perception, F-29 Level of Offer flexibility, F-20 Low acceptance from Market to Product-Service System Offer, F-30 possibility of knowledge acquisition by the customer, F-26 Loss of control from customer on offer, F-27 Loss of confidentiality.

Development of proposals as from different disciplines to improve he knowledge theme of Product Service Systems, Environmental Economy and Life Cycle Economy. Likewise, it is imperative to research on the contribution from new economic approaches as the circular economy in emerging economies to implement Product-Service System solutions, as alternative to the favorable context Factor.

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Appendice A. Lis ting of Critical Implementing Factors of the PSS

C.I.F. Factors	Article Where Reference	Last year of citation	Times
F-6 Property paradigm	Baines (2007), Manzini (2003),Hänsch (2013), Cavalieri (2012), Boada and Mont (2005), (Fishbein 2000), (Ceschin), Behrendt (2003), (Goedkoop 1999), (Schenkl 2014), (Manzini), (UNEP 2002), (Vezzoli 2015), (Stoughton 1998), (White AL 2005), (Fishbein 2000), (Catulli 2013), (Mont 2002), (Laperche 2013), (Vezzoli 2014).	2014	20
F-9 Absence of public policy	(Tukker 2013), (Michelini 2004), (Boada Mont 2005), (Hertwich 2003), (Charkiewicz 1998), (Rocchi 2002), (Ceschin 2013), (Mont 2003), (Vezzoli, 2010), (Tsai-2009), (Hanafiah), (Bartolome M 2003), (Besch K 2004), (Mont O, 2006), (Manzini E, 2003), (Maxwell D 2006), Mont, O. (2001).	2013	17
F-4 Risk level	(Baines 2007), (Hänsch 2013), (Cavalieri 2012), (Boada Mont 2005), (Ceschin 2013), (Mont), (Schenkl 2014), (Gómez 2009), (Siemer F. 2004), (Garrel J 2009), (Vezzoli 2015), (Mont O 2004), (EC) (2001)), (Laperche 2013), (Vezzoli 2014).	2015	15
F-7 Low awareness in Life Cycle Economy	(Boada Mont 2005), (Votta 2001), (White 1999), (Ceschin 2013), (White 1999), (Schenkl 2014), (Mont O. 2002), (Ehrlenspiel 2014), (UNEP 2008), (Vezzoli 2015), (White AL 2005), (Bartolomeo 2003), (Vezzoli 2014),	2015	13
F- 10 Organizational Structure focused to manufacture	(Baines 2007), (Tukker 2013), (Hänsch 2013), (Cavalieri 2012), (Boada Mont 2005), (Ceschin 2013), (Schenkl 2014), (Bertolini M 2004), (Tsai-2009), (Mont O 2004), (Vezzoli 2015), (Martinez V 2010), (Vezzoli 2014).	2015	13
F-11 Business Model Structure	(Baines 2007), (Tukker 2013), (Ceschin 2013), (Mont), (Kindstrom,2010), (Mont et al., 2006), (Masanell 2010), (Yip 2004).	2013	13
F-3 Investment Level	(Tukker 2013), (Ceschin 2013), (Mont), (Cavalieri 2012), (Gebauer 2008), (Gebauer 2005), (A. Neelyn2009), (Schenkl 2014), (Straub 2011), (Vezzoli 2015), (Besch K 2005), (Laperche 2013).	2015	12
F-17 Reliability	(Cavalieri 2012), (Boada Mont 2005), (Schenkl 2014), (Siemer 2004), (Garrel J 2009), (Hypko P 2010), (Jauch LR 1979), (Becker 2009), (Vezzoli 2015), (Mont O 2004).	2015	10
F-19 Solution Prices	(Baines 2007), (Boada Mont 2005), (Schenkl 2014), (Ford 1989), (Srumf R. 2006), (Straub 2001), (Mont O 2004).	2014	7
F-1 Service Economy	(Tukker 2013), (Boada Mont 2005), (Ceschin 2013), (UNEP 2002), (Vezzoli 2015), (Cook M 2006).	2015	6
F-13 Capacity Designing Business Models SPP	(Reim 2014), (Hänsch 2013), (Ceschin 2013), (UNEP 2008), (Laperche 2013), (Vezzoli 2014).	2014	6
F-15 Collaborating Companies	(Baines 2007), (Tsai-2009), (Hanafiah 2003), (Vezzoli 2015), Wong (M 2004), (Vezzoli 2014).	2015	6
F- 35 Designing capacities (Tools, Methodology)	(Baines 2007), (Vezzoli 2015), (Mont O 2004), (Vezzoli 2015), (UNEP 2008), (Vezzoli 2014).	2015	6
F-5 Difficulty to measure Environmental, Social and Economic Benefits	(Ceschin 2013), (Boada Mont 2005), (UNEP 2008), (Vezzoli 2015), (Vezzoli 2014).	2015	5
F-12 Capacities to develop new logistic capabilities	(Tukker 2013), (Fleischman M, 1997), (Tsai-2009), (UNEP 2008), (Vezzoli 2014).	2014	5
F-24 Profit system change	(Boada Mont 2005), (Ceschin 2013), (Mont), (Vezzoli 2015), (Mont O	2015	5
F-25 Low capacities in Management	(Ceschin 2013), (Tsai-2009), (Besch K 2004), (Manzini E, 2003), (Vezzoli 2014).	2014	5
F-41 Conflict of interest	(Boada Mont 2005), (White 1999), (Cooper 2000), (Vezzoli 2015), (Cooper T 2000).	2015	5
F-2 Innovation Culture	(Ceschin 2013), (UNEP 2002), (Vezzoli 2015), (Cook M 2006).	2015	4
F-16 Including user in PSS design	(Baines 2007), (Tukker 2013), (Ceschin), (Hopkinson (2002).	2013	4
F-20 Low Market Acceptance of SPS Offer	(Boada Mont 2005), (Tsai-2009), (Besch K 2004), (Mont O, 2006).	2009	4
F-21 Low Knowledge in PSS	(Boada Mont 2005), (Tsai-2009), (Mont O 2004),(Vezzoli 2014).	2014	4
F-29 Level of flexibility in the offer	(Boada Mont 2005), (Schenkl 2014), (Platts K 2002), (Buck-Lew M 1992).	2014	4
F-33 Technology support of closed production cycles	(UNEP 2008), (Vezzoli 2014).	2008	4
F-37 Logistic Capacity	(Baines 2007), (Vezzoli 2015), (Mont O 2004), (Vezzoli 2014).	2015	4
F-8 Lack of Government incentives	(Ceschin 2013), (Mont 2003), (Boada Mont 2005).	2013	3
F-31 Low management of information technology	(UNEP 2008), (Daugherty 2002), (McCullar N 2005).	2008	3
F-36 Production Capacities	(Baines 2007), (Vezzoli 2015), (Mont O 2004).	2015	3
F-39 Managerial Commitment	(Boada Mont 2005), (Vezzoli 2015), (Bartolomeo 2003).	2015	3
F-40 Reduction of business control	(Vezzoli 2015), (UNEP 2002), (Vezzoli 2014).	2015	3
F-42 Sector's competitiveness level	(Boada Mont 2005), (Betilsson 2000), (Vezzoli 2014).	2014	3
F-23 Social Conditions of Context	(Baines 2007), (Ceschin 2013).	2013	2
F-26 Loss of customer control over offer	(Schenkl 2014), (Ng I 2009).	2014	2
F-27 Loss of confidentiality	(Schenkl 2014), (Mont O. 2002).	2014	2
F-28 Business Return Period	(Schenkl 2014), (Lay G 2006).	2014	2
F-30 Possibility of acquisition of knowledge by the client	(Schenkl 2014), (Siemer F 2004).	2014	2
F-32 Entrepreneur capacity	(Boada Mont 2005), (UNEP 2008).	2008	2
F-38 SPP Efficiency Measurement	(Vezzoli 2015), (Martinez V 2010).	2015	2
F-43 Labor Costs	(Boada Mont 2005), (Vezzoli 2014).	2014	2
F-44 Time of use of the solution.	(Boada Mont 2005), (Bertilsson 2000).	2005	2
F-14 Contract Design	(Reim 2014).	2014	1
F-18 Separating Design Function Product and Service Development	(Cavalieri 2012).	2012	1
F- 22 Position in value chain	(Laperche 2013).	2013	1
F-34 Perceived cost of the highest bid	(Vezzoli 2015).	2015	1

Appendice B Meaning in Context of C.I.F.

Critical Factor	**Theoretical Aspects Associated to Factor**	**Meaning in Context Associated to Factor.**
E-6 Manufacture Approach	F- 10 Organizational Structure focused to manufacture	•Need to adapt organizational structure to integrated business flow: product and service. •Resistance to change
	F-36 Production capacities	•Knowledge curve required to design products and/or design services.
	F-43 Labor Costs	•Fund Availability Need to carry out necessary changes according to service.
E-7 Knowledge Level of Environmental Economy y PSS	F-38 PSS Efficiency Measurement	•The environmental is not associated to Business.
	F-5 Difficulty to measure environmental, social and economic benefits	Strong trend on Social Liability Objective companies
	F-7 Low knowledge in Life Cycle Economy	•Ignorance of Life Cycle concept
	F-21 Low knowledge in PSS	•Ignorance of sustainable business and Environmental Economy management tools.
E-8 Management and Technology Capacities	F-25 Low Management capacities	•Low entrepreneur capacities •
	F-37 Logistic Capacities	•Low capacity of reverted Logistic Processes
	F-22 Technology support production close cyle	• Lack of recycling technologies.
	F-31 Low management of information technology	•Low capacity in Project management
E-9 Innovation Culture	F-32 Entrepreneur Capacity	Low capacities on information technologies
	F-2 Innovation Culture	•Low innovation capacities in small and medium businesses. (94%) •Presence of companies rated as Large or Multinational with established innovation culture. (6%)
	F-42 Sector's competitiveness Level	•Highly competitive environment
A-10 Risk Level	F-3 Investment Level	•Moderate initial investment with high uncertainty degree.
	F-4 Risk Level	•New ways to perceive benefits from this type of Business,
		•High Uncertainty Level from results.
A-11 Business Model	F-28 Business Return Period	•Medium or long term investment return.
	F-11 Business Model Structure	•Need to adapt organizational structure to integrated business flow
	F-24 Profits System change	•New ways to perceive benefits from this type of business,
	F-14 Contract Design	•Difficulty in carrying out agreements with concerned parties.
A-12 Managerial Commitment	F-39 Managerial Commitment	•The most highlighted associated aspect is ignorance of top management on sustainable business themes finding it is not associated to the environmental and social with business possibilities.
		•Including the environmental and social within the Organization's Strategic Planning.
R-13 Reliability	F-17 Reliability	• Emerging context promotes confidence generation spaces

	F- 22 Position in Value Chain	•Need to generate solutions with limited funds favors confidence
G-15 Lack of Public Policy	F-8 Absence of Government Incentives	•Need for continuity of government programs.
		•Need for state funds for investment
		•. Exercise of the government educator's role
	F-9 Lack of Public Policy	•Enhance benefits from government programs to entrepreneurs. •Presence of a promissory legislative framework
		• Generation of economic instruments
D-16 Designing Capacity	F- 35 Design capacity (Tools, methodologies)	• Low appropriation of tools and methodologies
	F-13 Capacity to Design SPP Business Models	•Difficulty in offer integration and concerned parties to carry out a new business.
	F-18 Separation of the Product Design Function and Service Development	•Lack of capacity to design integral service and product offers.
	F-16 Including user in the PSS Design	•Difficulty to include user in the PSS design.
C-17 Favorable Context	F-42 Sector's Competitiveness Level	• Emerging economic and social conditions
	F-23 Social Context Conditions	•High competence level
	F-1 Service Economy	•Economic approach on environmental and social
	F-15 Collaborating Companies	• Restrictive conditions that generate innovation.

Improve material efficiency through an assessment and mapping tool

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Abstract

Material efficiency in manufacturing results directly in cost and energy savings in fabrication, transformation, transportation and disposal, as well as reduced greenhouse gas emissions through increases success rates of waste management initiatives. Previous sustainability related studies on manufacturing companies indicated several barriers towards material efficiency and circular economy, including lack of a suitable tool for environmental initiatives, limited environmental motivation and engagement, lack of effective measures to evaluate sustainability, poor visualization and limited intra-organisational interaction. This paper aims to adjoin this functional gap via simplified Environmental Value Stream Maps (EVSM) to evaluate, measure and visualize material/waste flows of a limited operation in manufacturing. Two case studies were performed on (1) productive material flow (2) auxiliary material flows. Applying EVSM proved to be a practical solution to engage different organizational functions in material efficiency improvement, to visualize material and waste streams, to realize the value of wasted material and costs associated to waste handling and treatment, to define or update relevant KPIs and to support lean principles such as "go to gemba". This paper contributes to the area of lean and green and circular economy through aiding manufacturing companies to better manage, measure and visualize industrial waste and material consumption in order to go up the waste hierarchy, reduce waste and material consumption.

Keywords: Environmental value stream mapping, Material efficiency, Lean and green

1. Introduction

To achieve *Sustainable Development* goals (Brundtland, 1987), it is essential to include current industrial system which has helped to increase living standards and has also contributed to negative environmental impacts. According to Garetti and Taisch (2011) *Sustainable Manufacturing* can be defined as "the ability to smartly use natural resources for manufacturing, by creating products and solutions that, thanks to new technology, regulatory measures and coherent social behaviours, are able to satisfy economic, environmental and social objectives, thus preserving the environment while continuing to improve the quality of human life". With publication of Our Common Future report (Brundtland, 1987), sustainability objectives gradually commenced in business strategies (Möller and Schaltegger, 2005), environmental performance indicators were considered in managerial decision makings (Bai and Sarkis, 2014), and externally communicated in form of environmental reports (Azapagic and Perdan, 2000). However, the environmental considerations in production and performance management systems are still top-down approaches, aggregated for the whole manufacturing plant and often related to a separated department. Despite the main core areas of old-school production systems such as productivity, quality, delivery precision and cost efficiency, environmental improvement and sustainability has not yet received satisfactory attention. Although there are sufficient practical tools for lowest operational level (shop floor) to measure and evaluate quality, productivity and efficiency, the number of practical tools for environmental initiatives on shop floor is fairly low (Bey et al., 2013). *Lean and Green* studies have been trying to fill this gap to some extent (Kurdve et al., 2012, Zokaei et al., 2013), but the lack of detailed methodologies or practical tools for manufacturing improvement in terms of environmental sustainability and operational performance is still evident (Smith and Ball, 2012).

Material efficiency is an important area to achieve sustainable manufacturing (Allwood et al., 2012) and circular economy (European Commission, 2011) by capturing wasted values in industry. Material efficiency in manufacturing can be related to improved manufacturing practices using less materials per product and/or generating less waste per product (Shahbazi et al., 2016). Nevertheless, material efficiency in manufacturing has not received to its full potentials, while improvement opportunities are high (Smith and Ball, 2012, Worrell et al., 2016), particularly with regards to using appropriate tools on shop floor (bottom-up approach). There is also a requirement from environmental management to effectively evaluate and measure processes, make decisions and implement improvements (Kurdve and Wiktorsson, 2013). This is where that Lean and Green concept and tools can integrate environmental goals within the production system with continues improvement tools. Perhaps the most known lean tool is Value Stream Mapping (VSM) that identifies time inefficiencies within a manufacturing process. United States Environmental Protection Agency - EPA (2015) has introduced Environmental Value Stream Mapping (EVSM) to take environmental aspects of a process into consideration for improvement, but less has been published on using EVSM on material flow and waste generation only. Therefore, this paper aims to help material efficiency management to map, measure and assess material and waste flows through simplified EVSM. This paper also adjoin the gap between environmental studies (here material efficiency) and operation management via presenting empirical data on application of EVSM on material efficiency in manufacturing. This study considered two flows of input material (1) productive and (2) auxiliary, each investigated in separate case studies.

2. Theoretical background

Looking to different sustainability definitions associated to an industrial system such as *sustainable manufacturing* (Garetti and Taisch, 2011), *sustainable production* (Veleva et al., 2001) or *corporate sustainability* (IISD, 1992), the importance of manufacturing process can be perceived. However, previous research has indicated several barriers towards sustainability in manufacturing including: lack of suitable tools for environmental initiatives (Bey et al., 2013, Shahbazi et al., 2016), limited environmental motivation and engagement (Ammenberg and Sundin, 2005, Murillo-Luna et al., 2011) and lack of detailed methodologies for manufacturing improvement in terms of environmental and operational performances to measure and evaluate environmental sustainability (Al Zaabi et al., 2013, Zhu et al., 2011) and limited intra-organizational cooperation and interaction (Simpson, 2010, Sarkis et al., 2007). Several researches have tried to fill this gap by lean integration and introducing tools and methods to measure sustainability in manufacturing. Here we present a snapshot of literature on lean and green studies aiming to fill this gap.

Tóth (2003) evaluated the environmental performance of companies via analytical explanation and evaluation of different methods and classification of them. He concluded his research with a set of application and benefits of his environmental performance evaluation tool. Arina and Viktoria (2007) introduced and tested Eco-mapping as a visual, simple and practical tool to integrate environmental management systems at SMEs in Estonia. They concluded increase of environmental awareness via understanding the environmental and economic benefits that eco-mapping brings which can be used for upcoming sustainability regulations. Furthermore, Torres and Gati (2009) used EVSM as a managerial tool for sustainability to align the economic and environmental aspects of a production process in Alcohol and Sugar manufacturing industry. However, the main focus remained on raw water usage. Dadashzadeh and Wharton (2012) used Green-VSM for information technology function area of organizations with different indicators such as materials, energy, water, emission, garbage, biodiversity and transport. Faulkner and Badurdeen (2014) developed Sustainable-VSM to include different indicators of environmental and social sustainability. In addition, Müller et al. (2014), and Posselt et al. (2014) focused on energy saving and efficiency, without including any other environmental impact like waste or material consumption.

Even within limited studies on material efficiency in manufacturing, the main focus has been lied on the higher levels of a manufacturing i.e. national, sectorial and supply chain, for example see Worrell et al. (2016) and Pajunen et al. (2013) for national level, and Milford et al. (2011) for supply chain level. Among few studies on an operation level, Smith and Ball (2012) investigated material, energy and waste flow modelling to support the pursuit of sustainable manufacturing. Their qualitative model helps identification and selection of environmental efficiency improvements through a guideline. Liao et al. (2015) used a high-resolution waste input-output table to trace waste flows into corresponding waste treatments. The result included identification of deriving forces of waste in an economic system as well as consumption patterns via categorizing final demand.

3. Methods

This paper is mainly based on empirical studies at manufacturing companies, although a structured literature review on material efficiency and waste stream mapping has been carried out. The literature selection incorporated the keywords search in scientific data bases along with qualitative up-stream and down-stream search for references. Keywords include "material efficiency" and "waste stream", "material flow", as well as their combination with "tool" and "manufacturing". The literature search focused on papers addressing a situation similar to the defined problem in automotive industry; even though papers outside of this area tackling relevant issues (e.g. other sorts of material or in different industry) have been also included. The empirical study included two single case studies at large automotive manufacturing companies located in Sweden. With a limited understanding, the adopted case study methodology was appropriate to comprehend the phenomenon (here the material efficiency performance assessment and measurement) and to fulfil the research aim. Case studies were performed during the period of 2016 – 2017, as parts of two Swedish research projects, here called CIM and SPM. The research area of each project directly contributes to different aspects and material flows. CIM project aims to develop Life Cycle Cost (LCC) and Life Cycle Assessment (LCA) models for extended recycling loops, to develop collaboration and explore opportunities for cooperation in recycling loops. SPM project focuses on developing a performance measurement systems to support companies in development and redesign of performance measurement systems taking sustainability into consideration (Sustainable Performance Measurements). Table 1 indicates a brief description of involved companies.

Table 1. *Company description.*

	Company description	Total No. of employees	Studied operation	Projects
Company I	Manufacturer and assembler of trucks	1,500	Fabrication	SPM
Company II	Manufacturer of trucks and buses	10,000	Assembly line	CIM

The first author had an active role as “participants as observers” (Saunders et al., 2009) with access to different sorts of data from both operation and waste management. The empirical data were collected via multiple sources of evidence as suggested by Yin (2014), including observations and site-visits for two weeks in company I and a week in company II, meetings and also document reviews of internal environmental and operational reports. The document reviews helped to get a basic insight about companies, their overall strategy and environmental target and current improvement projects. For better understanding and validating the empirical findings, collected data, thoughts, suggestions and mapped material/waste flows were compounded with discussions with different organizational functions such as environmental manager, team manager, production manager, waste management entrepreneur, production planner and production technicians. On an overall level, the empirical data analysis followed the process suggested by Miles and Huberman (1994), including data reduction, data display, and conclusion drawing and verification. Therefore, the empirical collected data were simplified, organized and interpreted. The results, were thereafter compared and analysed via an interactive back and forth process between cases and literature to increase understanding and generalizability of empirical findings.

4. Empirical findings

The main idea behind two single case studies were to test and validate EVSM with focus on material in two different flows. The first flow is *Productive material* that includes any type of material or semi-final product that usually end up in the primary product i.e. adding value to the primary end product. An example of wasted productive material is metal scarp or quality-failed products. The second flow is *Auxiliary material* that includes any type of material or semi-final product that is used in the production of the primary product, but usually is not a part of the primary product and does not add value to the final product; the term is synonymous with non-value added material, non-productive material, or process material. An example of auxiliary material ending up as products is necessary lubricants used in engine assembly line. In our case studies in automotive industry, metal was the main productive material, whereas common types of auxiliary materials included packaging material, plastics, wood, paper, maintenance tools, personal protection equipment, as well as chemicals and lubricants. Both productive material and auxiliary material can end up as *Residual material*, which is defined as any remnant or leftover material or product derived from a manufacturing process i.e. almost any material excluding the primary product. Residual material is synonymous with rest material and by-product, waste, co-products, intermediate products, non-core products or sub-products. The value of these materials is almost always neglected, particularly packaging and plastics. Figure 1 illustrates a simplified version of different material flows within an operation in a factory.

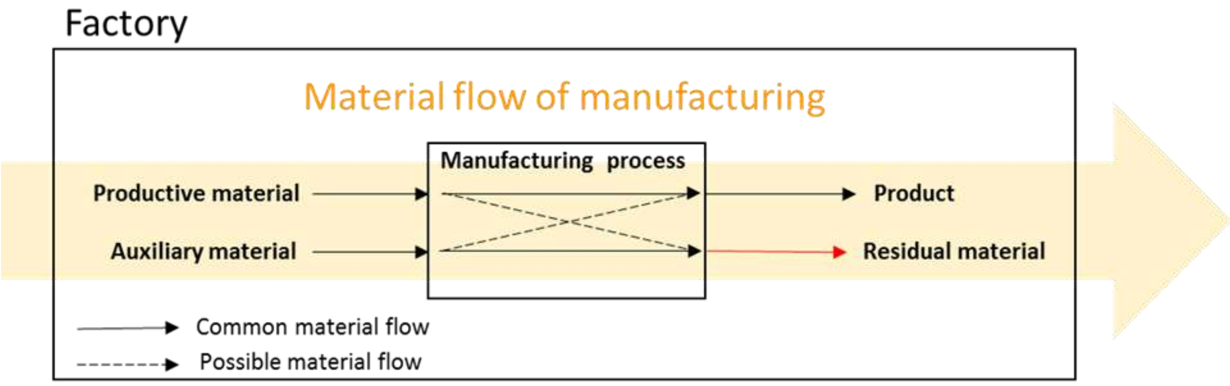

Figure 1. Material flows in operation.

Case study 1 at company I focused on productive material flow where a great amount of them were wasted as metal scrap (residual material). On the other hand, case study 2 at company II focused on great amount of auxiliary material consumption which were ended up as combustible waste. So the ultimate goal is to decrease transition of "productive materials to residual material" and reduce "the consumption of auxiliary materials that end up as residual material". Empirical findings are presented here separately based on the explained material flows and will be discussed in next chapter to draw conclusions.

4.1 Productive material flow

This study was performed on a manufacturing process of a key component in truck's chassis made of steel. The manufacturing process together with scrap generation were mapped based on EVSM, but simplified for the defined purpose. The process in short starts with steel coil transported to the factory, followed by metal sheet forming, punching, plasma cutting, blasting, phosphating, painting, heat treatment and shipping to different customers. To ease the understanding and analysis, the manufacturing process was divided into seven sub-processes to be studied individually and in details. The data collection in each sub-process included type and amount of steel being used, scrap generation and the causes i.e. when, where, how much and why scraps are generated? The additional aggregated information on scrap costs/revenue and volume, final treatment, transportation mode etc. from waste management company were also collected. Figure 2 depicts the process with scrap generation in each sub-process. Based on our investigations, causes of scarp generation could be categorized into three areas: (1) *design*, (2) *set up/process* (3) *quality*. The numbers in the boxes underneath each sub-process associates to the weight given to the tonnes of generated metal scraps within each sub-process in a limited period of time. For instance, quality scrap generation from sub-process P were 4 times bigger than design scraps produced in sub-process R.

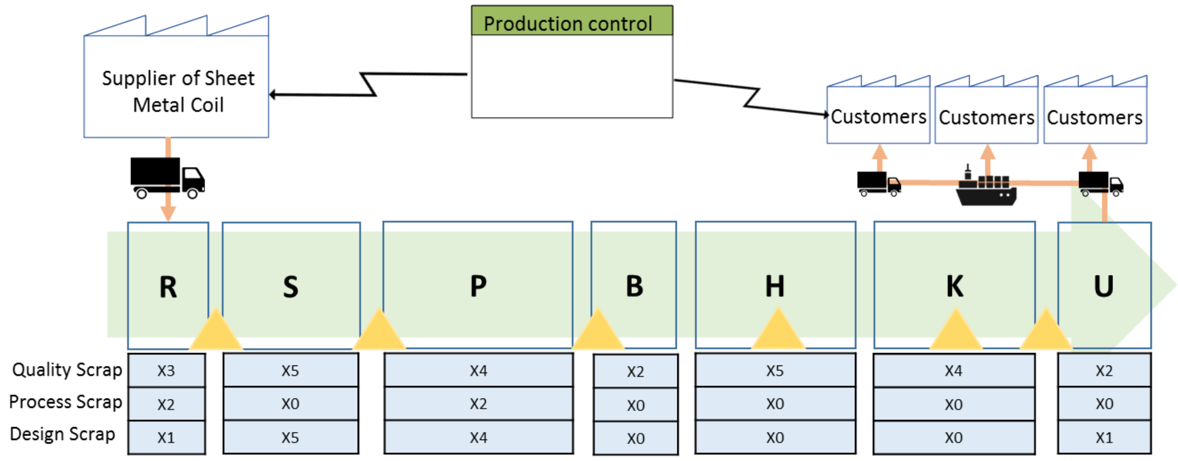

Figure 2. Environmental value stream mapping for wasted productive material.

Scrap generation due to design: this included the wasted metal pieces which were designed to be produced and were inevitable to avoid e.g. coin-form steel pieces generated in punching machine. Although design could be improved in a long term to waste less material, this type of scrap were usually product related and very difficult to be improved by manufacturing engineers within the factory because of the distinct specification of products. Moving from conventional design process to sustainable product development and eco-design (Gagnon et al., 2012) was suggested for future developments to include manufacturing processes and capabilities in the design phase.

Scrap generation due to process or set up issues: this included the scraps which were generated because of the machine set up or the manufacturing process (technology). An example was scrap generation in plasma cutting machine and steel forming machine in the first round of changing products' specification. The avoidance of this kind of scrap was difficult and expensive as it needed changes in process layout, equipment and technology, however it was an essential aspect for a long-term improvement vision. Nevertheless, there were also less expensive possible changes that could be made to improve and avoid this sort of scrap e.g. optimization of production planning with a right sequence of products i.e. production levelling or Heijunka. Another example could be related to upgrading the IT system to log in the scraps and production data, not only for reporting purposes, but also for improvement analysis.

Scrap generation due to quality issues: this included the scraps generated because of quality deviations, insufficient inspections and human errors, for example cutting metal sheets with wrong lengths or scraps owing to unremoved dross on products. In some cases the quality-failed product were going through a number of sub-processes before being identified as a scrap; which was wasting material, energy and production time. In addition, scrap generation statistics among production shifts were indicating the role of human errors in waste generation, which could be owing to oversight and reluctance of operators because of indolence, weariness and exhaustion. All in all, prompt scraps from this category could be considered as the "low-hanging fruit" with big environmental impact (number of scraps) and high associated cost, which had to be targeted first.

4.2 Auxiliary material flow

This study was performed on a truck's engine assembly line where several components e.g. pipes and pumps came with several plastic plugs on them to be assembled on an engine. These plastic plugs were then removed and disposed as combustible waste in small bins located in different stations. The combustible waste are considered as a cost for the company to discard by contracted waste management entrepreneur. To start with, a limited part of the assembly line with nine stations was selected for detail analysis. Different components were assembled in each station and each component had different sort of plastic plugs in terms of shape, colour and material. The assembly line and disposal of plastic plugs were mapped based on EVSM, but simplified for the defined purpose. Data collection in this study included information on the amount of disposed plastic plugs, types of them, as well as functionality and possibility to avoid using them in the first place. Soon, it was understood that engine is a very sensible product and cleanness and protection of equipment are extremely essential for the customer and the manufacturing company itself. As a consequence, avoidance of using plugs or reducing the amount was impossible. Figure 3 depicts the assembly line along with the number of plastic plugs disposed at each station. According to the analysis, plastic plugs were made of three different materials including EVA (Ethylene Vinyl Acetate), PE (Polyethylene) and PVC (Polyvinyl Chloride), and in different colours including red, blue, black, yellow, green and transparent.

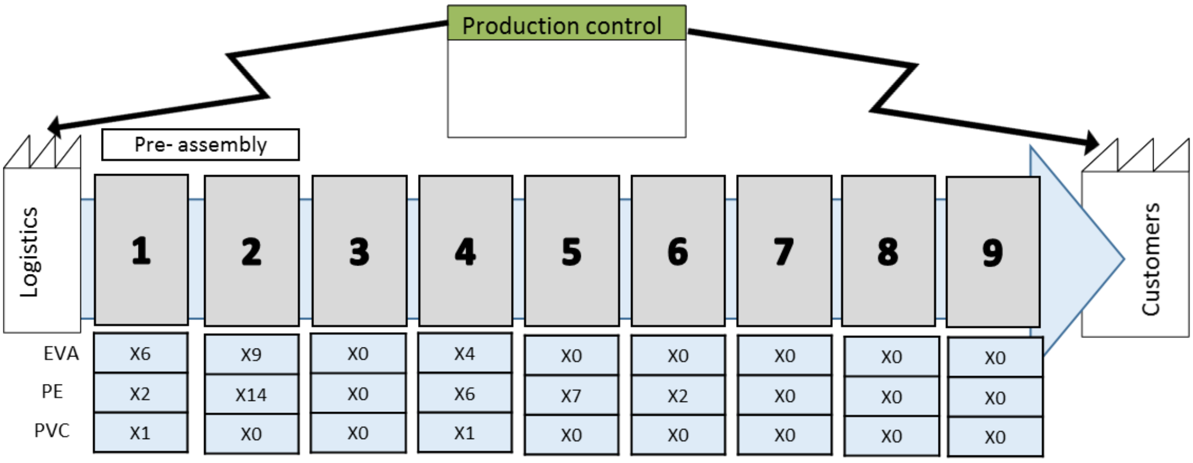

Figure 3. Environmental value stream mapping for auxiliary material.

Taking waste hierarchy into account, *prevention* and *reduction* of plastic plugs were inevitable under any circumstances. Therefore, the *reusing* option was investigated. This option was also not possible with current circumstances, as it required washing of plastic plugs before reusing them due to cleanness requirement of engines. With the current equipment, in-house washing was not possible either, and external washing was neither economically beneficial for the company, although the discussion and investigations were initiated for future improvement activities. Moving to the next option on waste hierarchy, *recycling* found to be highly possible and profitable, particularly for PE plastic plugs, which comprised around 50% of total plastic plugs. It was also feasible to mix PE and EVA (comprise 40%) for recycling, although less environmental and economic benefit were associated. As a result, there was a possible to recycle around 90% of plastic plugs, although the colour of plugs might be a limited barrier for high quality recycling. According to the preliminary investigations, there was not any color-coding associated with plugs on assembly line which imply feasibility of colour harmonization (through discussion with plastic plugs' suppliers) to ease recycling.

5. Discussion

EVSM proved to be a useful tool to map material and waste flow depending on the manufacturing company's requirements or environmental goals. The main criteria for EVSM was simplicity and visualization. Since these two studied involved different organizational functions to assess and measure material flows and waste generation, and scrutinize possibilities or limitations, simplicity and visualization of EVSM were the key factors to create a common platform. In this way everyone could understand and engage in the improvement process of daily operation. Involved organizational functions included waste handling entrepreneur, on-site and central-enterprise environmental management, operators and production technicians, production planner and management, quality assurance and purchasing department. These studies with the help of EVSM, aided the manufacturing companies to engage these functions into a practical improvement project through "go to gemba" approach, which in lean principles referring to going to the location where the actual production (here also include material consumption and waste generation) is taking place and value is created (here also include wasting of material value). Therefore we can conclude that EVSM used for material efficiency improvement in manufacturing, eradicated some barriers mentioned in literature such as limited environmental engagement and intra-organisational interaction (Simpson, 2010, Sarkis et al., 2007), and effective measurement to evaluate sustainability (Al Zaabi et al., 2013, Zhu et al., 2011); here material efficiency aspect.

As it shown in figure 2, there majority of generated metal scraps are due to *quality scrap*. Therefore, quality assurance and production technicians related to that specific problem were consulted to come up with solutions. Although the scrap metals, products and steel sheets are now sold to the waste handling entrepreneur for mixed recycling, the better option (both in terms of environment and economy) is to prevent or reduce scrap generation in the first place. These options help avoiding the unnecessary consumption of productive materials and even auxiliary materials, since in several cases, the scrapped product moved on in the process consuming energy, material (for instance for painting and heat treatment) and production time, while it would be scrapped eventually. Another environmental and economical option was to send the pure steel sheets (*set up or process scarp*, before being fabricated) to the original supplier to be recycled to the original clean unalloyed steel (avoiding downgrading). As a consequence, new Key Performance Indicators (KPIs) related to material consumption and waste generation were defined to measure and monitor scrap generations and track products. The EVSM in the second case study also helped to define new KPIs to measure plastic plugs consumption in total and also per engine. These KPIs were also broken down to different plastic types. As shown in figure 3, PE plugs have the biggest volume to be segregated separately, followed by EVA.

When the EVSM was applied in the case studies with different material streams, it was perceived that the amount of wasted material, type of waste, complexity of process and size of the selected operation might be problematic. Including different materials in the EVSM is not suggested as it brings confusion among different functions. One aggregated EVSM it can be informative to visualize the process and provide a clear picture of material consumption and waste generation, but for detail analysis of material flow and waste streams it is necessary to study one material/waste stream at a time. Another reason for this is the fact that different materials have to be defined separately with different KPIs and with different measurement units. It is usually easier to use EVSM with focus on energy or water as both have a single unit of measurement (e.g. kWh for energy consumption) while different materials have different unit of measurements. Study on one material/waste flow at a time can also help concentrating on a clear and relevant goal on different levels of operation, either vertically or horizontally (Kurdve et al., 2015).

It is vital for environmental improvements to include operation management and follow the performance (both operational and environmental) on a regular basis, and provide data availability, and easy communication within the organization. From our industrial experiences we can conclude that improvement potentials should be highlighted in not only environmental improvement potentials, but also in cost saving/revenues to attract different function to engage, since different functions have different drivers.

6. Conclusions

Improving material efficiency is aligned with *sustainable manufacturing* and *sustainable development* goals, as industry greatly contribute to energy and material consumption, waste and emissions generation. Material efficiency embrace both environmental benefits and economic advantages (even in short-term) through recycling, reusing, reduction and prevention of wasted materials. This paper contributes to the area of lean and green and circular economy through aiding manufacturing companies to better manage, measure and visualize industrial waste and material consumption in order to go up the waste hierarchy i.e. from waste incineration to recycling, reusing, reduction and prevention. This in turn will lead to reduction of solid industrial waste, the demand for virgin raw material and correlated total energy consumption and carbon emissions. Applying EVSM to map the material flow and waste stream proved to be a practical solution to engage different organizational functions in environmental (here material efficiency) improvement via visualizing a detailed insight. Using EVSM for both productive material (case study 1) and auxiliary material (case study 2) flows helped realizing the value of wasted material and costs associated to waste handling and treatment, promoting the waste segregation to different fraction both in metal (pure steel vs mixed metal scrap) and plastic (combustible waste vs pure PE plastics) and providing environmental and economic benefits to the manufacturing company. All in all, material efficiency at studied companies could be improved as the applied EVSM on material/waste flows provided (1) visualization of process, material consumption and waste streams, (2) easy to understand by different functions in organization, (3) engaging different functions into environmental improvement activities, (4) adjoin the gap between material efficiency management and operation management, (5) defining/updating KPIs, (6) supporting lean principle like go to gemba, and (7) standardize way to work in future. However, some difficulties were associated to the tools when using different material/waste streams, which brought some confusion among involved functions. Beside further validation of proposed tool for material/waste flows, future studies will pursue extension of application to other type of manufacturing industry or SMEs.

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Key strategies to implement circular economy in SMEs

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Abstract

Circular Economy (CE) is fast becoming a matter of high importance for researchers, governments, and firms, to pursue social prosperity and to increase the resilience level of the natural environment. In this context, Small and Medium Enterprises (SMEs) has an important role because they represent some of the most important motors of development and progress. Thus, the main objective of this study is to identify the key strategies which may favor the CE paradigm in SMEs. Moreover, these key strategies should encourage the eco-innovation to build competitive advantage and create value in coherence with nature. Regarding the purpose of this study, we used a mixed methodological approach, based on a literature review and a focus group to gather qualitative data. This focus group has been carried out via experts such as researchers and practitioners from recognized universities, sustainable SMEs, and consultancy firms in Spain. As a result, this study proposes a kit of strategies that could help SMEs to mature and orient their corporate strategy towards the circular economy and build a competitive advantage in the market. Moreover, this study proposes a group of internal and external factors that should support the implementation of the kit of strategies. Finally, some useful dynamic capabilities are defined to undertake the CE in the business performance.

Keywords: Circular Economy, SMEs, competitive advantage, environmental management, dynamic capabilities

1. Introduction

The current economic tendency towards growth as well as the incremental society needs, have required that environmental management strategies are oriented to implement the Circular Economy (CE) to pursue social prosperity and to increase the resilience level of the natural environment. The CE is closely linked to eco-innovation based on the fact that eco-innovations are nature-based processes, techniques, practices, systems and products developed to solve the needs of humans and nature within a balanced framework (Hofstra and Huisingh, 2014).

As follows, the eco-innovation determinants should be oriented to CE: governments and institutions can trigger the design of environmental policies, the demand side (consumers) can pressure to the supply side (firms) to develop environmental strategies which boost the eco-innovation (Horbach, 2008; Tsai and Liao, 2016). Besides, eco-innovations will have a positive effect on the creation of competitive advantage (Forsman, 2013). Consequently, the success of the CE is going to be measure by its implementation through policies, consumers' behavior, firms' environmental strategies and eco-innovations developed in the market.

In this context, Small and Medium Enterprises (SMEs) have a key role in CE implementation because they represent one of the most important groups of supply side as motors of development and progress. According to the World Bank, SMEs are responsible for the major part of employments in developed countries, and in emerging economies, they contribute up to 45 percent of total employment and up to 33 percent of national income (GDP) (Ayyagari et al., 2014). Therefore, if SMEs implement the CE, it has an important influence in the global market. Moreover, an environmental strategy and the development of eco-innovations can benefit the SMEs financial performance and create a competitive advantage (Aragón-Correa et al., 2008; del Río et al., 2010).

However, SMEs usually have limited technical and financial resources and they may not see the Circular Economy (CE) as one of their priorities because they do not realize the benefits that this could lead to and the scant support that is given by governments and policy makers (Ormazabal et al., 2016). Here, clearly, lies the risk of a vicious circle of unsustainable and reactive environmental strategies in SMEs that hinder the CE implementation (Figure 1).

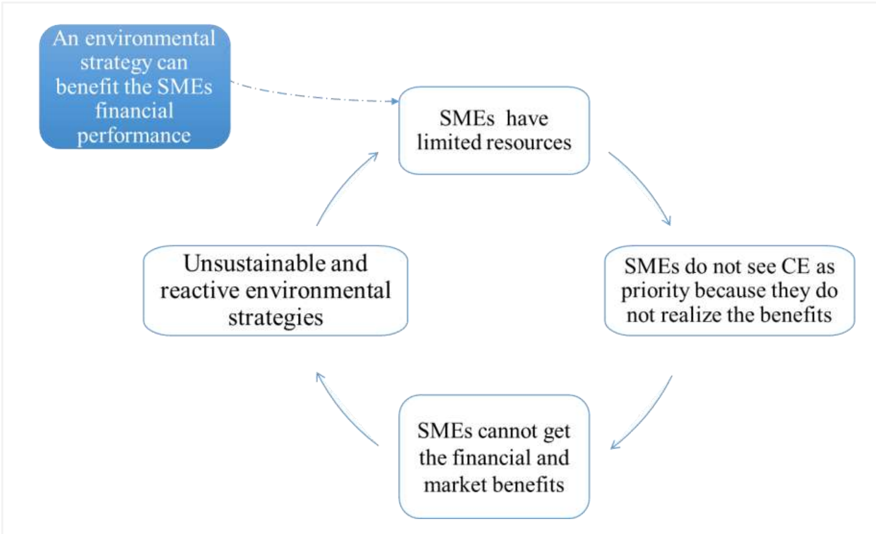

Figure 1. *Vicious circle of unsustainable and reactive environmental strategies in SMEs*

In order to provide advice to SMEs which has the intention to break that vicious circle, the objective of this study is to identify the key strategies to incorporate the CE paradigm in SMEs and analyze what kind of actions they should follow to eco-innovate, to build a competitive advantage, to create value, and consequently, get differentiation in the market. Besides, the strategies should be understood and classified according to the CE fields of action identified through the literature review.

The paper is structured as follows. After this introduction, the following section presents the theoretical background to tackle the relationship between the CE implementation in SMEs with the competitive advantage creation. The next section addresses the research methods. The fourth section reports the results and discussion. Finally, conclusions are presented.

2. Literature Review

Firstly, the literature review was oriented to understand the CE fields of action (taking, make, distribution, use, and recovery) regarding the SMEs' environmental challenges and opportunities. Then, this section presents a competitive advantage model through CE to build competitive advantage in SMEs.

2.1. The CE fields of action regarding the SMEs

The circular economy is a social, environmental, and economic paradigm, whose purpose is to prevent the depletion of resources and seek environmental regeneration through eco-innovative solutions and products that can be reintroduced in biological and technical cycles. Thus, this circular mechanism makes an economic development model feasible by dealing with the fact that infinite physical growth is not possible, but social needs will not disappear. This economic model does not reject economic growth, but sets limits on the exploitation of resources; if human societies pursue growth, they should be limited to the closed-loop of resources and energy, with a minimum amount of emissions. (Geng and Doberstein, 2008; Lieder and Rashid, 2016; Prieto-Sandoval et al., 2016).

Wang et al. (2014) state that CE is based on the 'reduction, reuse, recycle' principle (3R principle), consisting of the characteristics of low consumption, low emission and high efficiency". These principles guide the CE performance which can be understand in five stages: 1) take, 2) make, 3) distribution, 4) use and 5) recovery (Park et al., 2010; Stahel, 2016). In the CE conception, "*take*" refers to the way industries take resources and energy from the environment, then, they transform them into goods and services (*make*) which may be controlled by buyer-owner-consumers or by fleet managers who retain the ownership and sell goods as services. Thirdly, the goods and services are distributed by industries or firms at point of sale (*distribution*). After that, goods and services are purchased by diverse shoppers (even other companies) and *used* by consumers in the market. Finally, the CE boost eco-innovation processes to *recover* waste, materials, and energy that remain the used products at the end of their life cycle (Park et al., 2010; Stahel, 2016). In this way, the waste should be managed in two ways: as a biological or as a technical resource which may be redirected and returned to the biosphere or to the industrial process towards close the loop, respectively (McDonough and Braungart, 2002) (Figure 2).

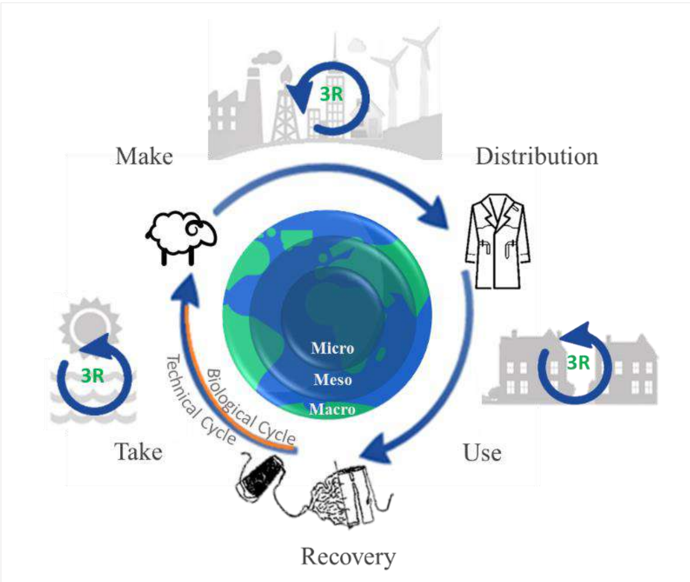

Figure 2. *Circular Economy principles, stages and levels of interaction*

Moreover, this closed-loop process must be supported by a systemic view; it means a steady and coordinated flow of materials in the industries and their stakeholders, as the industrial symbiosis theory proposes (Ayres, 1989; Chertow and Ehrenfeld, 2012; Gibbs et al., 2005). In this way, CE can be understood in three different levels: micro, meso and macro. In micro level, firms work towards a sustainable production of goods and services in separate units. Then, the integration of firms enable the building of a meso level where industry associations or business associations, clusters and eco-industrial parks may interact to stimulate the industrial symbiosis (Ormazabal et al., 2016) and improve considerably their environmental performance indicators (Daddi and Iraldo, 2015). Last, in macro level are the regional governments and institutions that may trigger the CE in cities and countries with an suitable legal framework (Geng et al., 2009) (Figure 2).

2.2. CE to build competitive advantage in SMEs

As was pointed out in the introduction of this paper, CE can provide multiple economic, social and environmental benefits for firms' performance, hence, CE should be part of the firms' business strategy to build a competitive advantage coherent with the natural environment. According to Del Río et al. (2016), the business strategy depends on the interaction between external and internal factors. The external factors include public policy and stakeholders, and internal factors are the firm resources, capabilities, and competences (RCCs). Consequently, the identification of external factors, strategies, and indicators are imperative to guide the SMEs to use properly their available resources and capabilities or invest in new ones, regarding the CE implementation through a strategic way. In this sense, Ormazabal et al. (Ormazabal et al., 2016) found a positive relationship between the environmental management maturity (EMM) level of SMEs with their willingness to implement the circular economy because the most mature companies have learned that environmental improvement may have positive impacts in their prestige and profits.

Del Río et al. (2016) clamed that an environmental business strategy connects RCC with eco-innovation which drives organizational changes and facilitate the creation of competitive advantage in the market. Then, if SMEs understand their EMM level may evolve through the improvement of their RCC (Figure 3). Moreover, the competitive advantage is going to be reflected in the way the company launches eco-innovations and embody the Circular Economy paradigm in its strategy.

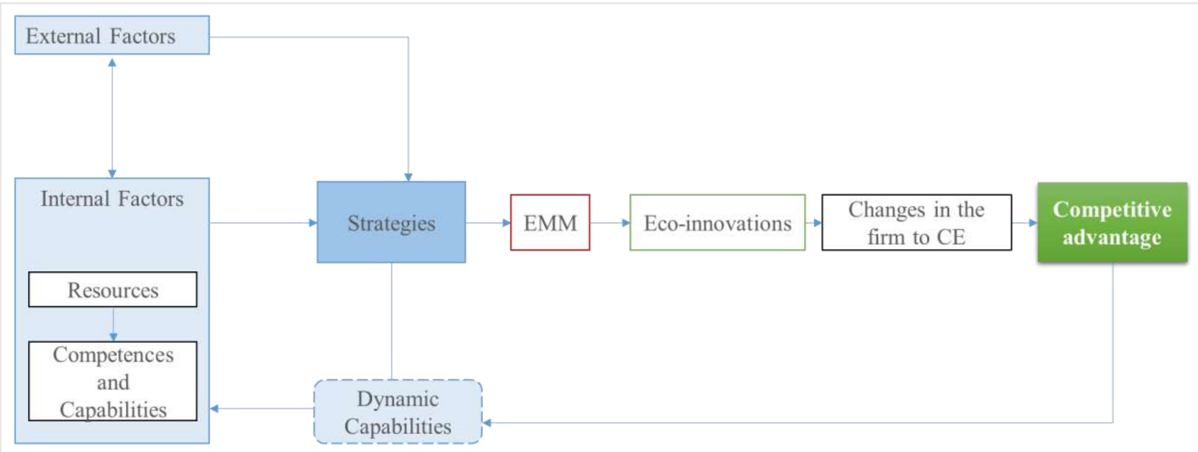

Figure 3. *Competitive advantage model through CE. Adapted from Del Río et al.* (2016)

To better understand this model, we must go back to its base. The study of the resources, competences and capabilities was first carried out by Teece et al. (1997), who explained resources as "firm-specific assets that are difficult, if not impossible to imitate." Those resources can be tangible as infrastructure or intangible as the "know-how" and the "know who" (Alfaro et al., 2017). Then, Teece et al. (1997) explained that competences are the way that resources are used in routines and process of the companies. In this way, core competences are the most developed and experienced. Consequently, they make the companies different from their competitors and difficult to imitate in the marketplace.

The core competences have a strategic value; thus it implies a need to update them continually (Alfaro et al., 2017). Therefore, Teece et al. (1997) proposed the development of dynamic capabilities which they defined "as the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments." As follows, dynamic capabilities may expose the organization's ability to achieve new and innovative forms of competitive advantage given path dependencies and market positions (Leonard-Barton, 1992).

As soon as, SMEs are provided with different RCCs they get at an environmental management maturity level. In 2015, we proposed an environmental management maturity model, named the EMM (Ormazabal et al., (2015), which has its roots in nearly a dozen maturity models and it focuses on the path a firm can follow to move from one stage to another. The understanding of the maturity level of a company can help it to look for resources, competences and dynamic capabilities need to improve its environmental strategy, create a competitive advantage and consequently, create value. As follows, SMEs should identify the resources, competences and dynamic capacities that are useful to implement the CE through an environmental business strategy and consequently build the competitive advantage (Del Río et al., 2016). Thus, the implementation of CE must be attractive to the SMEs and help them to compete successfully in the market (Figure 3).

3. Methods

After the literature review to understand the theoretical background of CE to build competitive advantage in SMEs, we develop a mixed methods approach in this study (Figure 4). The data collection was gather through a focus group and analyzed with a systematic content analysis.

3.1. Focus group

Focus group discussions is a flexible research method and it is particularly effective for exploratory studies and to observe diverse experiences and perspectives on a topic study. Moreover, the focus group provides the opportunity to stablish a discussion between participants and get wider information than in surveys (Hennink, 2014).

For the focus group, nineteen (19) participants were invited to participate, with a rate of acceptance of 63%. This focus group was carried out via experts of researchers and practitioners from recognized universities (4), sustainable SMEs (4), and consultancy firms (4) from Spain. The moderators were researchers who have been practitioners in industrial companies. Their fields of study are industrial engineering, environmental management, quality and logistics. Then, three groups were organized thinking about creating diversity, gender balance and easy communication language, according to the profile, age and experience of each participant. Every group had at least one male or one female, one researcher, one practitioner, and one consultant.

The experts' focus group was carry out through a workshop to generate interaction. The participants had to identified the most important stakeholders to implement the CE in SMEs. Then they proposed strategies and indicators regarding the CE fields of action. During the workshop three activities were developed:

1) The first activity was designed to stimulate the participants and facilitate the integration. The moderator invited them to hear the production process description of the practitioner of their groups and to draw the process in a big paper, without thinking about improvements they could do. This activity took 15 minutes.
2) Then, the moderators make a brief presentation about the circular economy(CE) purpose, stages, advantages for companies and examples. At that point, the participants had to propose the most important stakeholders, strategies and indicators for each CE stage. Besides, in this section, the participants expressed the internal and external factors that support strategies which may help SMEs to implement the CE. This activity took 90 minutes.
3) The final activity was oriented to think about the processes that groups draw at the beginning of the workshop and propose to the practitioners, new ways to improve their business. The aim of this task was to make participants develop new concerns about the external and internal factors in their own context. This activity took 20 minutes.

The focus group facilitated the integration of the researchers' theoretical knowledge with the practitioners' experience. During the workshop audiovisual and written materials were analyzed through a systematic content analysis.

3.2. Systematic content analysis

During the focus group the audiovisual and written material was gather to develop a systematic content analysis. The content analysis involves organizing large quantities of textual or visual data into many fewer and representative content categories (Krippendorff, 1989; Weber, 1990). The video recording of focus group discussions is not usual, although it can give additional information of participants' body language or information that was not caught in the moment (Hennink, 2014). Additionally, the video was useful to transcribe the discussion or analyze it with researchers that were not present. However, the presence of a video-recorder can influence participants' contributions (Hennink, 2014), consequently, we try to decrease its influence by using a little camera and allocating it into a not invasive place of the room.

As follows, the information was recorded in a systematic way by creating a set of codes that define items observed in data and regarding the literature review (Figure 4). This analysis was developed in ATLAS.ti, a software which support the qualitative research or qualitative data analysis.

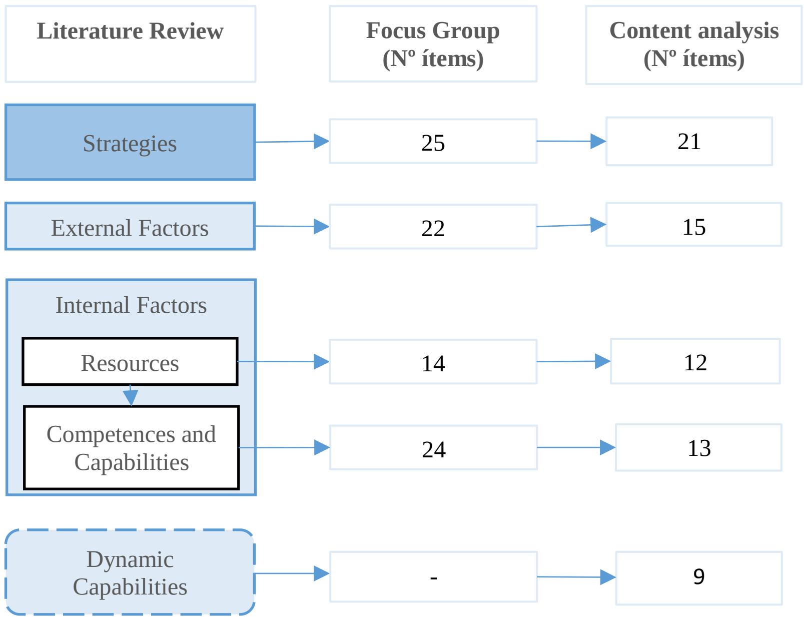

Figure 4. *Results obtained during the data analysis regarding the literature review concepts.*

4. Results and discussion

This part of the paper discusses the findings which emerged from the focus group analysis and the systematic content analysis. First, the main objective of the study is covered by the presentation of the key strategies and indicators to incorporate the CE paradigm in SMEs. Then, the study revealed the main internal and external factors that support that kit of strategies. Finally, an unanticipated finding is presented; a group of useful dynamic capacities to implement the CE in SMEs.

4.1. Strategies and indicators

The SMEs should design the CE strategies that fit with their available RRC and of course their environmental management maturity, consequently they can build a proper corporate strategy which let them build a competitive advantage in coherence with nature.

A group of strategies were proposed concerning the CE action cycle and listed in the Table 1. In the "take" phase the strategies are mainly oriented to manage the materials provision which can be assessed according to the materials toxicity, the suppliers' certifications and the life cycle assessment. However, the corporate social responsibility strategy is important in this part because it is associated with workforce conditions and the social sustainability of the firms, participants explained that it defines the coherence of the organization. This collective agreement contrast with author (Murray et al., 2015) who question the social dimension of the CE paradigm.

In the *Make* stage, the strategies pretend to trigger the design of circular and sustainable products and get financial advantage based on circular and efficient processes. Moreover, in this section a useful strategy is the design of coaching policies and career scheme according to the organization change for CE. As (Forstater, 2006) claimed, "The ongoing -jobs versus the environment- mindset needs to be replaced with a -jobs and the environment- attitude". Thus, the sustainable SMEs may create new "green jobs" in but the traditional jobs are going to be transformed but people should not be fired, people should be coach with the environmental knowledge they need (Renner et al., 2008).

In third place, the distribution stage can be improved with strategies related to the supply chain management and its optimization through collaboration initiatives. Then, *Use* strategies are focused on communicate the value added by the SMEs through green marketing tools like the Ecolabelling and Zero Waste certifications. Besides, the market segmentation is a key strategy because not all the green customers are the same green consumers (Ginsberg and Bloom, 2004) and not all my customers care about the environment (Paço and Raposo, 2010). And, as we mention above, SMEs may adopt a Product system service (PSS) business model to sell their service instead of products.

Table 1*. Strategies and Indicators to implement CE in SMES.*

Stages	Strategies (21)	Indicators (21)
Take	1. Audit focused on materials 2. Suppliers certification requirement 3. Materials traceability 4. Process and product transparency 5. Corporate social responsibility	(1) Materials toxicity (2) Suppliers certification (3,4) Life cycle assessment (5) Review of working conditions and its social sustainability
Make/Transform	6. The design of circular and sustainable products which can be reintroduced 7. Use of sustainable energy sources 8. Efficient use of water 9. Collaborative product design 10. Company digitalization 11. Coaching policy and career scheme regarding the organization change for CE 12. Industrial Symbiosis 13. Standardization of some products	(6) Costs % of circular products and number of improved processes (7,8,18,20) Materials Flow analysis (12) Volume or number of products available for refurbishment (9) Customer interactive platform and catalog (10) Number of processes or type of information digitalized (11) Satisfaction surveys and Number of coaching hours
Distribution	14. Local market promotion 15. Optimization of stock, routes and space 16. Collaborative reverse logistics	(14) Δ% sales in local region (15,16) Annual logistics costs, Annual km, and mode of transport
Use/Consume	17. Communicate the environmental vision of the firms to show its value added through green marketing tools 18. Market segmentation 19. Product system service (PSS)	(17) Environmental certification achievement such as Ecolabelling and Zero Waste certifications. (18) Number new segments and customers (19) % of the business in PSS
Recovery	20. Valorization of waste and energy 21. Industrial Symbiosis	(20) Volume of waste and energy recovered (21) Number of new agents in the industrial symbiosis

4.2. External and Internal Factors

The focus group identified internal and external factors that may be useful to develop the SMEs environmental strategy and implement the CE. The external factors were directly analyzed by the focus group in the second activity, and they were associated with each CE stage too (Table 2). However, the scope of this section of the study was limited to the stakeholders' exploration.

In the *Take* stage the participants considered that suppliers and competitors are the most important stakeholders. The participants explained that the industry resources suppliers are not usually interested in the development or exploitation of sustainable materials and they should give more information about their activity. On the other hand, they realized that if leader competitors have environmental criteria or not, that attitude has a high influence in the whole market.

Then, CE requires knew knowledge and eco-innovation processes that are not always developed inside firms (internal factors) (Teece et al., 1997). In this way, the focus group identified spontaneously that Universities, Research centers and Design Schools are key stakeholders to facilitate the SMEs eco-innovation. Preliminary work on this issue was undertaken by Horbach et al. (2013), who have proved that firms require more external sources of knowledge and information to develop eco-innovative processes and products compared to other kind of innovations. They found that the external sources may be the businesses' suppliers, consulting firms, research and public institutions; their weight vary according to the local context. Moreover, the focus group also remarked the importance of the workforce profile and values to carry out sustainable initiatives, even one of the practitioners said: "I pretend to introduce the environmental consciousness among my employees' DNA and make it part of our culture".

In the third CE stage (*distribute*), participants considered that logistic suppliers have a central role because they are related to pollutant process such as transport. Then in the *Use* stage the focus group present multiple agents: the shopper who buy the product, the consumer, the second-hand user, the grouped consumers or consumers that group their orders to increase their negotiation power, and the 'product-responsible organization', if the consumer is not the owner. In general, all of them compose the demand side which can pressure the sustainable production. After that the *Recovery* stage is closely linked to agents that can manage or transform wastes such as waste managers and landfills. Two of the participants represent SMEs which are legally accredited as waste managers because their business model requires the direct access to materials that can be valorized such as batteries and electronic waste. In addition, they enhance that the low prices for landfills services is a barrier to the CE.

Finally, table 2 revealed four transversal agents which can promote the CE implementation in all stages. Evidently, in first place are the investors and organizational leaders. As Rizos et al. (2015) points out, the leaders in SMEs should be engaged with the environmental values and understand the circular business model as a way to be more effective and efficient in the long term. As expected, government was recognized as the agent that can change the rules of the game (Horbach, 2008; Reisch et al., 2016), an example of this is the European Union roadmap to achieve the CE (European Commission, 2015). Then, the focus group realized the high influence of standards organizations such as BSI and AENOR in the environmental management in the industry because they both are developing zero waste standards to certified companies locally and globally (AENOR, 2016; BSI Group, 2017). Last but not least, there are Industrial or trade associations who can help SMEs to develop industrial symbiosis (Ormazabal et al., 2016) and may play the role of innovation intermediaries (Alfaro et al., 2017).

***Table 2**. Stakeholders to implement CE in SMES.*

<table>
<tr><td>Stages</td><td colspan="2">Stakeholders (15)</td></tr>
<tr><td>Take</td><td>1. Suppliers
2. Competitors</td><td rowspan="4">12.Investors and organizational leaders
13. Governments
14. Standards organizations such as BSI, AENOR etc.
15. Industrial or trade associations</td></tr>
<tr><td>Make/Transform</td><td>1. Universities and Research centers
2. Design Schools
3. Workforce</td></tr>
<tr><td>Distribution</td><td>4. Logistic suppliers</td></tr>
<tr><td>Use/Consume</td><td>5. Shoppers
6. Consumers and final users
7. Second hand users
8. Grouped consumers</td></tr>
</table>

	9. The 'product-responsible organization'	
Recovery	10. Waste manager 11. Landfills managers	

Then, the internal factors were identified in a tacit way; it means without direct questions because the moderators encouraged participants to express what kind of resources, competences and capabilities should support the CE implementation in SMEs. The most useful resources, competences and capabilities to implement the CE and identified by the focus group are listed in Table 3. Moreover, they were organized regarding the five fields of action of CE, explained in the literature review.

In the first stage, the resources required by SMEs are a qualified procurement department oriented to look for sustainable supplies and a materials database according to those criteria. Practitioners from SMEs, expressed a high interest in specific innovations to improve the "taking" CE stage and they criticised the low availability of sustainable materials in the market, in order to produce green products. Moreover, practitioners consider that design and creativity are critical to develop competitive, green and circular products or services. Unexpectedly, all participants agree in the need of a human resources department with the ability to attract talent with environmental values.

Then in the *make* stage the resources are clearly associated with the production process and systems, it means machinery and equipment, include the users designs to enrich the process, and look for the geographical proximity in the same company (be at least in the same building if it is possible) and with suppliers to build the industrial symbiosis by creating synergies with compatible organizations. In addition, the project management is a valued competence because it let the creation of products and services that fits with market needs. For the *Distribution* stage SMEs require traceability systems to performance reverse logistics, share logistics operations with other organizations, and of course, to manage traceability. After that, for the *Use* stage, practitioners also suggest the employ of market Analysts and the use of business intelligence platforms (e.g. Omnichannel) to review the demand behavior and to correct the production plan. Therefore, if the company has a product service business model it needs a maintenance services platform to have the ability to offer those services. In addition, in this stage, an effective communication channel is essential to develop effective green marketing to open new markets and to include consumers in their products design. Finally, the *recovery* stage require access to reusable and recyclable products to work in symbiosis in the firm and with others, and to design circular process and products.

Table 3. *Resources, competences and capabilities to implement CE in SMES.*

Stages	Resources (12)	Competences and capabilities (13)
Take	1. Procurement department 2. Materials database 3. Design and creativity 4. Human resources department	1. To develop successful, green and circular products or services 2. To understand the competitor strategy 3. Ability to attract talent with environmental values
Make/Transform	5. Machinery and equipment 6. Users Designs 7. Geographical proximity in the same company and with suppliers	4. To create synergies with compatible organizations 5. Project Management
Distribution	8. Traceability systems	6. To performance reverse logistics 7. To share logistics operations with other organizations 8. To manage traceability
Use/Consume	9. Market Analysts-Business intelligence (e.g. Omnichannel) 10. Maintenance services platform 11. Communication channels	9. Maintenance services offer 10. To develop effective green marketing to open new markets 11. To include consumers in their products design
Recovery	12. Reusable and recyclable products	12. To work in symbiosis in the firm and with others 13. To design circular process and products

4.3. Dynamic capabilities

One unanticipated finding was that this study facilitated the identification of some useful dynamic capacities to implement the CE in SMEs. According to Teece (2007) “dynamic capabilities enable business enterprises to create, deploy, and protect the intangible assets that support superior long- run business performance”, consequently, dynamic capabilities enable firms to be adaptable and responsive to dynamic environments. Likewise, Teece (2007) suggested that there are three kinds of dynamic capacities: 1) to sense and shape opportunities and threats, (2) to seize opportunities, and (3) to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise’s intangible and tangible assets.

According to above, those three kind of dynamic capacities may help entrepreneurs and SMEs to achieve and maintain a competitive advantage according to the CE challenges. First, in order to sense and shape opportunities and threats participants consider that SMEs have to: increase their access to stakeholders’ information to understand their needs and increase their research and development programs to identify better technologies and opportunities to close the resources and materials loops.

Then, the incremental improvement of the business models, the ability to create a “green” culture and boost it inside the SMEs and the formation to increase workers’ awareness to propose improvements are identified as three dynamic capabilities to seize opportunities. In addition, SMEs should develop the capability to transform obsolete jobs into new employment with coach and without redundancies. In this last part, the participants considered the social implications of the modernization of companies and threat that it can mean to elder employs in any industry.

Finally, the focus group enhance the leaders’ vision and their environmental awareness to maintain competitiveness. Moreover, SMEs should develop the capacity to design and reconfigure sustainable business models according to the CE opportunities and challenges. Lastly, the participants considered that knowledge management and development should be continuously fed by future/potential users through virtual platforms.

5. Conclusions

The central goal of the current study was to identify the key strategies which may favor the CE paradigm in Small and Medium Enterprises (SMEs). Consequently, this work contributes to existing knowledge Circular Economy implementation by providing a kit of strategies (21) that could help SMEs to mature and orient their corporate strategy towards the circular economy. The strategies are classified regarding the five CE fields of action identified through the literature review and we propose the indicators to measure their development. Moreover, this kit of strategies is supported by a group of internal and external factors organized according to the CE fields of action too. These findings suggest that in general, the SMEs can follow these strategies, and correspondingly they can assess their own situation to understand what resources, competencies, and capability they should develop towards the CE implementation and be sustainable in the long term.

Likewise, we consider that further research should be done to investigate the key role of consumers to the change of paradigm since the focus group was concerned about the importance of including them in the make and recovery CE fields of action and the importance of including their needs or future expectations in the CE implementation process.

The second major finding was the highlight of some useful dynamic capabilities that may help SMEs or any company, to that build a sustainable competitive advantage. More research is needed to better understand the dynamic capabilities which cannot be limited to the ones we proposed and vary according to the internal and external factor of each organization.

Finally, this focus group was formed with representative experts of Spain, thus, it could be useful to duplicate this experience in different countries and economic sectors to facilitate the change of paradigm to CE in different contexts.

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Circularity assessment in companies: conceptual elements for developing assessment tools

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Abstract

Circularity assessment is a relatively new term that started to be used by organisations promoting the circular economy, but that has not been adequately defined in the scientific literature yet. Different actors have recently developed proposals for circularity assessment at the company level. Having an assessment tool that could be used as a measuring stick against which companies can compared themselves has been suggested as the first step in the transition towards a circular economy. Existing proposals for circularity assessment tools have different approaches to what should be evaluated, risking their potential for meaningful comparisons. To contribute to minimize the gap between tools, this paper provides a general framework of what a circularity assessment at the company level should include, based on input from expert sources. The framework was used to evaluate four existing circularity assessment proposals at the company level (Circle Economy and PGGM, Ellen Macarthur Foundation, Viktoria Swedish ICT and VBDO) resulting in the identification of alignments and misalignments. From this examination, it is possible to conclude that the main disagreements relate to what principles and criteria of circularity are used in the proposals, while scale and purpose of the assessment are the most agreed upon elements. Our results suggest that there is still room for improvement of existing circularity assessment tools for companies if they aim at supporting the implementation of a comprehensive circular economy strategy.

Keywords: Circular economy, companies, circularity assessment

1. Introduction

Circularity assessment is a relatively new term that started to be used by different entities promoting the circular economy the past four years. As of 2015, Circle Economy (Circle Economy & PGGM, 2014), VBDO (VBDO, 2015), the Ellen MacArthur Foundation (Ellen MacArthur Foundation & GRANTA, 2015) and, Viktoria Swedish ICT (Viktoria Swedish ICT, 2015) had launched initiatives to measure or assess circularity in a company context. Other initiatives include Geng et al. (2012) who provide indicators for evaluating the circular economy program in China at the country level and Haas et al. (2015) who offered a way to measure how circular the global economy is by using material flow analysis. More recently, the British Standard Institution released the BSI 8001 standard for implementing the circular economy at organisations in May 2017[1].

IMSA & Circle Economy (2013) suggest a circularity assessment tool as the first step in the transition towards a circular economy. In their report, they lay down a set of milestones that need to happen to move into a circular future, from bottom-up and top-down perspectives. The report calls for an "index of circular performance [that] the maximum of companies can join" (p. 20), i.e. a general metric that can be used by different organisations to assess their performance and that of their partners. Such measurement would allow them to make informed decisions about procurement and incentives. From a government

[1] https://www.bsigroup.com/Sustainability/BS8001_Executive_Brief.pdf

perspective, it could assist them in deciding what front-running companies to support. The report also encourages companies to develop their metrics to evaluate their achievements while the index is developed.

After a rapid review of the proposals developed as of 2015, a lack of agreement was evident about the scope, relevant scale and criteria used to assess circularity in companies. It is suggested that such discrepancies exist because of an incomplete understanding of what the circular economy means at the company level. If such tools are going to be used for comparisons between companies, it is important to minimise such disagreement. This paper aims at contributing to such task by answering the following questions regarding the existing proposals:

- What critical elements are required to assess the circularity of companies?
- What factors have been considered by existing circularity assessment tools?
- What gaps exist between what experts suggest and what current proposals include?

By answering these questions, this article wishes to provide a common basis for understanding circularity at the company level that would allow for more coordinated evaluation of performance. The rest of the paper is divided into four sections, methods, results, discussion and conclusions and areas for future research.

2. Methods

Several steps were taken to answer the research questions. First, a framework or scorecard was developed, based on expert input, consisting of the following building blocks:

- Purpose: the aim that a circularity assessment has, what is the objective of implementing it.
- Principles: guiding values or ideas that support the evaluation proposal and help identify what criteria are need to be included or not.
- Scale: the system level at which the tool should be applied;
- Criteria: refer to the different features that are evaluated by the assessment;

Second, four different circularity assessment proposals were reviewed and organised following the categories mentioned above. Third, the proposals were compared against the reference framework developed in the first step, to find alignments and misalignments.

Information was collected through literature review and semi-structured interviews with both experts[2] and stakeholders[3]. Experts refer to people from academia and private sector, working on issues related to the circular economy. Stakeholders refer to the organisations developing circularity assessment proposals. To develop the scorecard, fifteen (15) expert sources were reviewed, including eight (8) peer-reviewed articles and seven (7) business documents and reports. Four (4) proposals from stakeholders were considered. Documents included internal working papers and presentations facilitated by the contact individual in each organisation. These reports are not peer-reviewed and were being developed at the time of the study.

In addition to the literature review, ten (10) interviews were conducted with experts and four (4) with stakeholders between March and May 2015. A brief description of the research project and questions to be asked was sent via email to the potential interviewees. Interviews were conducted via Skype, phone and personally. Each interview lasted between 45 and 60 minutes. Interviews were recorded, or the researcher took notes that were later included in the systematisation matrix alongside the notes from the recordings.

The definition of the topics to be addressed and the questions to be asked through interviews was done based on the following elements:

[2] Seminal papers from the founding disciplines of the Circular Economy, Industrial Ecology, Cradle to Cradle and the Sustainability principles and business reports providing input on what the circular economy is.
[3] Organizations that have developed circularity assessment proposals at the time of this study (May 2015).

- The type of actor to be interviewed (Expert or Stakeholder)
- Their area of work
- The sector they belong to
- Their previous work on the topic

Table 1. *Expert interviews by sector.*

Sector	**Interviewed**	**Recorded**
Government	1	0
Academia	8	6
Private	5	5
Total	**14**	**11**

3. Results

Based on the data collected and analysed, this section presents the proposed general framework for evaluating circularity at the company level; it also includes an evaluation of existing proposals against such framework, and the analysis of alignments and misalignments between the existing proposals and the suggested framework.

3.1 Critical elements for a circularity assessment tool: a general framework

The resulting framework has four (4) blocks, purpose, principles, scale and criteria. For each block, a group of elements is derived from the expert sources and are summarised in the following paragraphs.

<u>Purpose</u>

From an academic perspective, two aspects are relevant when discussing the purpose of a circularity assessment, according to experts interviewed: it should contribute to closing the material loops and keep resources for future generations. Sources from the private sector indicated that a circularity assessment should allow companies to understand what natural resources they depend on and what internal opportunities they have from waste streams. Other actors from the same sector mentioned that this kind of assessment could be essential to encourage strategies towards circularity and to communicate the importance of the transition. In sum, the purpose of a circularity assessment tool at the company level is three-folded: resource stewardship, a management tool for decision-making and engagement tool.

<u>Principles</u>

Principles are derived from the fields of industrial ecology and cradle to cradle is provided. A first issue highlighted by the Industrial Ecology authors (Gallopoulos, 2006; Garner & Keoleian, 1995; Lifset & Graedel, 1997), is the need for a system approach to understanding problems. A second issue raised in the literature refers to the need to recognised that human systems are dependent on the ecological environment, also known as strong sustainability (Frosch, 1992; Gallopoulos, 2006). They emphasised that since ecosystems should be models regarding cycling, community and diversity, environmental concerns should be considered before; making a business decision (Lifset & Graedel, 1997). Another important element suggested by all of the authors reviewed is the need for closing the loops by moving from a linear approach to a cyclical one to reduce waste, achieve dematerialization and environmental impact reductions (Frosch, 1992; Gallopoulos, 2006; Garner & Keoleian, 1995; Lifset & Graedel, 1997). In addition to this, they also stressed the need for a future-oriented perspective or forward-looking type of analysis (Garner & Keoleian, 1995; Lifset & Graedel, 1997). In summary, common principles from the literature in Industrial Ecology can be recapped as systems thinking, strong sustainability, closing the loop, resilient systems and future orientation.

The Cradle to Cradle literature also provides guidance on what elements should orient the development of business and solutions that can be used in the circular economy. In their pivotal book McDonough & Braungart (2002) add four principles, first the idea of creating safe objects with a long-term value; second, the need to rely on natural energy flows (e.g. renewable); third, they promote the idea of positive footprint. And finally, the importance of sharing knowledge and understanding the limitation of single fields. These principles were coded as maximise value, use renewable energy sources, positive footprint and collaboration.

Resulting from this analysis, the categories of principles presented in ***Table 2*** are thus proposed.

Table 2. *Principles suggested by the expert sources*

Principle	**Explanation**
Closing the material loops	refers to the need to close the material loops by decoupling growth from materials, transforming waste into valuable streams and managing non-renewable material flows in such a way that do not leak.
Systems thinking	Refers to the need of understanding the economy as a system within other systems and consequently of acknowledging the complexity that entails. This principle requires that any circularity effort incorporates a systems approach.
Resilient system	establishes the need to consider both efficiency and resilience as goals of the economic system, to achieve its ultimate aim of satisfying human needs sustainably.
Maximize value	deals with the need of the economic system to maximise returns from all types of capitals (natural, financial, human, social, etc.)
Collaboration	Refers to the need for a new approach to interaction between economic agents based on cooperation rather than competition to maximise all types of values.
Renewable energy sources	Addresses the need to rely on renewable energies including labour for all economic processes.
Positive Footprint	Calls for the aspirational aspect of the economic system regarding being capable of restore and regenerate what is depleted by the system instead of only mitigating.
Strong sustainability	Requires economic agents to acknowledge sustainability from a top-down perspective where the economy depends on society, which in turns depends on the environment, instead of a bottom-up perspective where all dimensions are equally relevant.
Future based orientation	which refers to the need of conducting analysis that looks into the future and provides solutions that are free from lock-in and path dependence effects.

Scale

The suggestions here were quite varied, depending on the type of organisation of the interviewee. Academic experts suggested that the value chain was an adequate level, taking into account the need for a life cycle perspective. However, product offerings and components were also mentioned as important; nonetheless, another source from academia contradicted this last argument by stating that the smaller relevant scale for assessing circularity was the company and not the product if a systems perspective was to be considered. In the case of the private sector, different scales and approaches were proposed: life cycle, value chain, the business model and the product. Thus, circularity assessment is considered as a multi-scale tool that needs to address the component level, the product level, the value chain, the business model and the company as a whole and should have a life-cycle perspective.

Criteria

The experts consulted also provided input about what the relevant aspects to assess are when evaluating the circularity of a company. Representatives of academia mentioned recycling, refurbishment, closing loops in a strict sense, reuse, smartness, energy use, costs, dependency on future materials, ability to retain value and waste reduction. Another expert from the same sector mentioned that these aspects are not general but depend on the product offerings. From the perspective of the industry, the relevant criteria include the number of times the product is used, the level of renewability, the origin of inputs, the type of business model, material intensity and waste generation.

In ***Table 3*** the different criteria are presented with an explanatory question companies should ask to assess their level of circularity, according to the sources consulted. An additional step was conducted to group the different criteria under wider categories regarding scale. The criteria were clustered under product if they were referring to the components, material aspects; processes when they referred to how the company creates the product or delivers it; business model when discussing how the value was created and, a more general group dealing with the role of the company at the system's level. This classification is arbitrary and is only suggested for the purpose of clarity.

Table 3. *Criteria for circularity, suggested by expert sources.*

Criteria	Explanation	Scale
Use intensity	How many times is the product used per unit of time?	Product
Recycling	How much of the value proposition is derived from recycled inputs?	Product
Refurbishment	How much of the value proposition is derived from refurbished products?	Product
Remanufacturing	How much of the value proposition is derived from remanufacturing processes?	Product
Renewability	How much of the energy/material inputs is derived from renewable sources?	Process
Repairing	How much of the value proposition is derived from repairing processes?	Process
Reusability	How much of the value proposition is derived from reused materials, components or products?	Business model/Product
Waste generation	How much waste is generated to deliver a unit of value?	Process
Waste reduction	How much waste is reduced as a result of the value proposition?	Process
Raw materials	How much of the value proposition comes from raw materials?	Product
Dependency of future materials	How much of the value proposition depends on materials that are going to be needed in the future?	Product
Costs	How much do costs increase by implementing circularity?	Business model
Retained value	How much of the value proposition returns to the company in a specific period of time?	Business model
Smartness	How tight do materials, components or products of a company circulate?	Process
Hazardousness	How much of the materials used to deliver the value proposition are toxic?	Product
Energy use	How much energy is used to deliver the value proposition?	Process
Material intensity	How much material inputs are needed to deliver a unit of value?	Process
Efficient use	How efficient is the use of materials and energy to deliver the value proposition?	Process
Circulating of materials	How much does the company contribute to the closed circulation of materials at a society level?	System

Type of business model	How much of the value proposition comes from circular business models?	Business model

Circularity assessment scorecard

Table 4 summarises the findings from the expert interviews and literature review in the form of a general framework to assess circularity for companies or "scorecard". It consists of the four building blocks evaluated, each of them with a set of components that help understand how circularity is embedded at the company level.

Table 4. *Circularity assessment framework*

THE CIRCULARITY SCORECARD V. 01

Included explicitly | Included implicitly | Not included

1. PURPOSE

- Close material loops
- Dependency knowledge
- Decision making tool
- Resources for future generations
- Waste opportunities
- Communication tool

2. PRINCIPLES

- Close material loops
- Maximise value
- Strong sustainability
- Systems thinking
- Collaboration
- Positive footprint
- Resilient system
- Renewable energy sources
- Future-based orientation

3. SCALE

- Value chain
- Company
- Business model
- Product /component
- Life cycle

4. CRITERIA: process

- Efficient use
- Energy use
- Material intensity
- Renewability
- Repairing
- Smartness
- Waste generation
- Waste reduction

4. CRITERIA: product

- Hazardousness
- Refurbishing
- Need for future materials
- Remanufacturing
- Raw materials
- Reusability
- Recycling
- Use intensity

4. CRITERIA: others

- Circular business model
- Costs
- Retained value
- Circulating materials

3.2 Existing circularity assessment proposals

Given the attractiveness of the circular economy, different stakeholders have developed initiatives to assess circularity in recent years:

- Circle Economy (Circle Economy & PGGM, 2015)
- VBDO (VBDO, 2015)
- The Ellen MacArthur Foundation (Ellen MacArthur Foundation; Granta Design; 2015)
- Viktoria Swedish ICT (Viktoria Swedish ICT, 2015)

These proposals have different approaches, levels of development, targets and goals, but all have the aim of assessing circularity at the company level. The summary of the proposals is presented in ***Table 5***.

Table 5. *Summary of circularity assessment proposals*

Dimension	Circle Economy	VBDO	EMF	Viktoria ICT
Purpose	To evaluate organisations based on how well they are upholding circular economy principles and implementing their policies and intentions to move towards a circular economy.	To measure to what extent a company is taking concrete steps towards a circular business.	To develop a methodology that measures how well a product or company performs in the context of a circular economy in order to help companies design more circular products, compare different products for internal reporting or procurement purposes, or to compare departments/companies.	To help companies progress along a path towards CE. It could be used mainly internally to focus business strategies, calculating potential cost savings. It can be used to benchmark and compare companies and products to encourage a race to the top. It will also quantify costs of different degrees of circularity.
Scale	Organisation/system	Organisation/system	Product/Organisation	Business Model/ Product offerings
Aspects	Materials, energy and labour: Renewability, recyclability, criticality, geopolitical risk, locality, competition.	Strategy and governance: which includes how circular thinking is embedded in the strategy, the long-term strategy, targets and accountability.	Inputs: virgin, re-used or recycled	Materials: LCA or MFA are tools relevant to assess the material use and environmental impacts.
	Activities: smart, efficiency, modular, extended lifetime, degradability,	Implementation: revenues from circular products and services, product design and procurement.	Use: length and intensity	Costs: cost savings due to reduction of material costs

	hazardousness, precaution.			
	Practices: transparency, collaboration, integrity	Innovation: circular business models, innovation budget and strategic partnerships.	End-of-life: landfill, reuse, recycle	Value retained: portion of added value that comes back to the company
	Impact: global impact on land, water, atmosphere and society	Communication and engagement regarding circular economy customer, stakeholders, raising awareness	Complementary indicators for assessment: Energy use, CO2, water use, cost, price variation, toxicity,	Recirculation: costs of input coming from reuse, recycle, remanufacturing

3.3 Gap analysis

Each of these proposals was analysed regarding the elements proposed in the circularity assessment framework or scorecard presented in the previous section. The question asked here was whether an item of the scorecard was present in the proposal or not. Three answers were allowed, included explicitly, included implicitly or not included. Then this information was translated into arbitrary scores: "included explicitly" being 1 (green), "Not included" a 0 (grey) and "included implicitly" 0,5 (light green). Normalised scores were used to find levels of alignment. As illustrate in ***Table 6***.

Table 6. *Example of a comparative analysis for Circle Economy*

From an overall perspective, none of the proposals is entirely aligned with the framework suggested as it can be concluded from ***Figure 1***. Circle Economy's assessment tool integrates most of the elements followed by VBDO and Viktoria ICT, while the Ellen MacArthur Foundation seems to be the least aligned initiative. Regarding the particular building blocks, perspectives regarding 'purpose' are relatively aligned with what the framework. In contrast, 'principles' is the category which exhibits less agreement among stakeholders. 'Scale' is the aspect over which stakeholders most agree upon, considering at least 50% of the elements suggested by experts. Criteria to evaluate circularity does not strictly follow experts' suggestions.

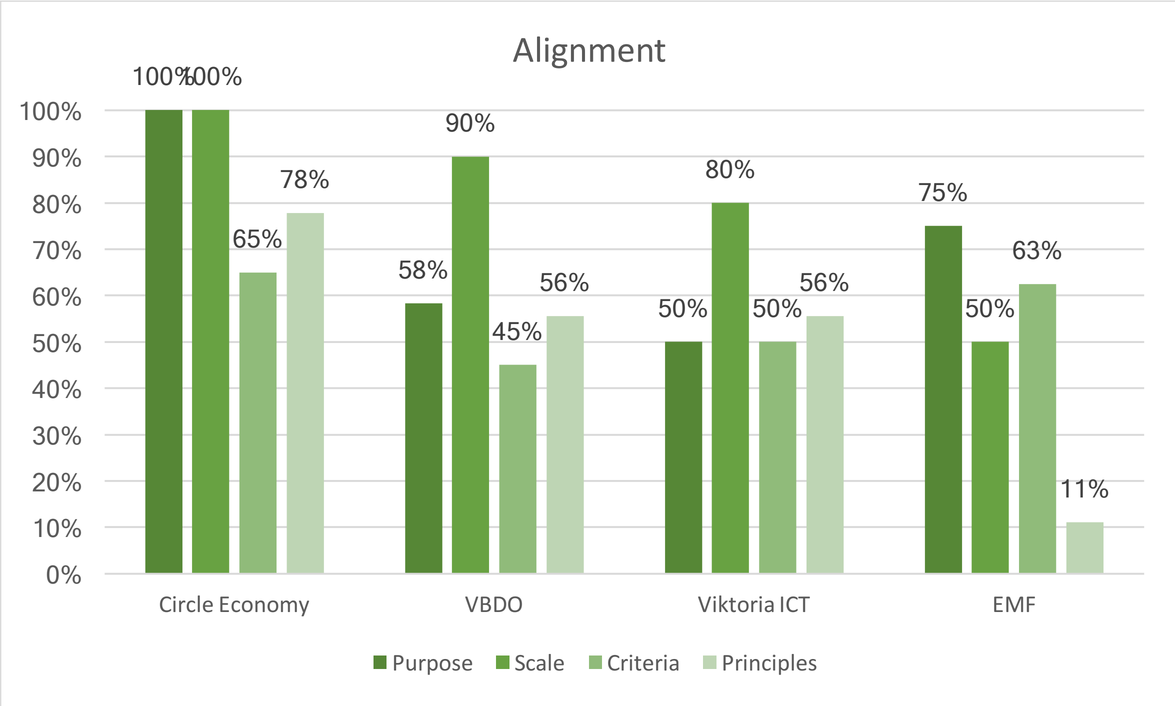

Figure 1. *Level of alignment between the stakeholder´s proposal and the framework by building block.*

Looking into more detail, regarding purpose 'Keep resources for future generations' is the least included item, while the most prevalent one is 'To encourage decisions towards circularity'. As it is evident, most of the purposes offered by the expert sources are integrated into the different proposals as presented in ***Figure 2***.

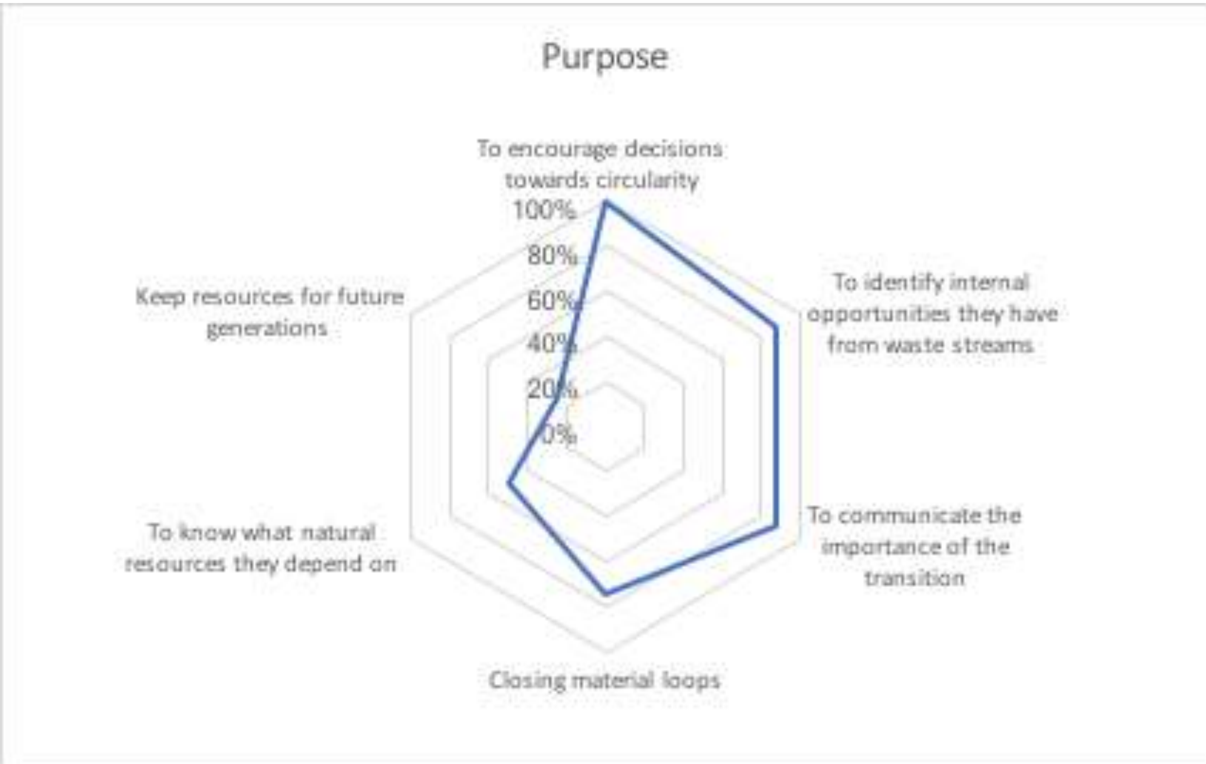

Figure 2*. Level of alignment for different purposes of a circularity assessment tool*

Regarding the principles, none of the proposals considered all the principles identified. Moreover, the principle named as 'Future-based orientation' was not added in any of the proposals. All other principles were included in one or more proposals. After this principle, the two less considered were 'Strong sustainability' and 'Collaboration'. Most of the proposals agreed that 'Closing the material loops' was a principle to be considered, while the least agreement is connected to the principles 'Systems thinking', 'Resilient System' and 'Positive Footprint.'

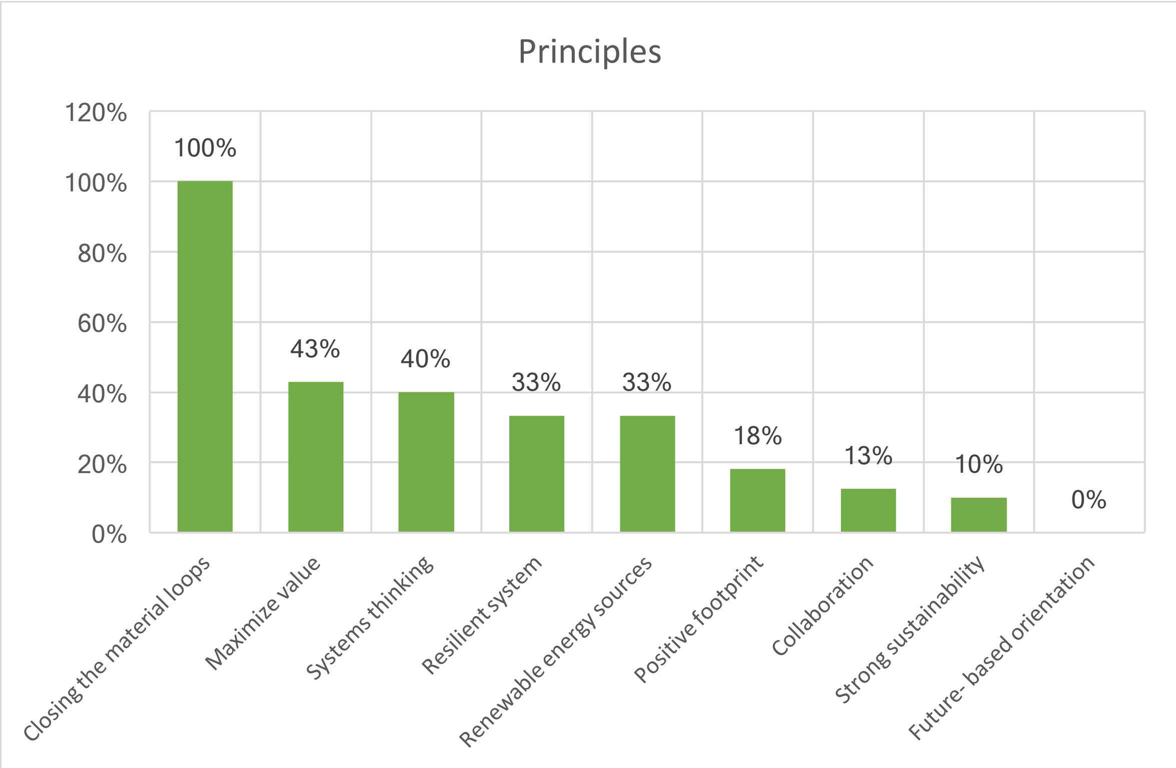

Figure 3 *Level of agreement regarding principles.*

Regarding the scale at which the assessment should be implemented, only the Ellen MacArthur Foundation does not include the business model and lifecycle perspectives while all other proposals have a multi-level approach, which was strongly suggested by the expert sources. It is important to highlight that the value chain and product/offerings perspectives are predominant, with all stakeholders agreeing that these levels have to be included in the assessment, while the lifecycle perspective was not so strongly advocated for.

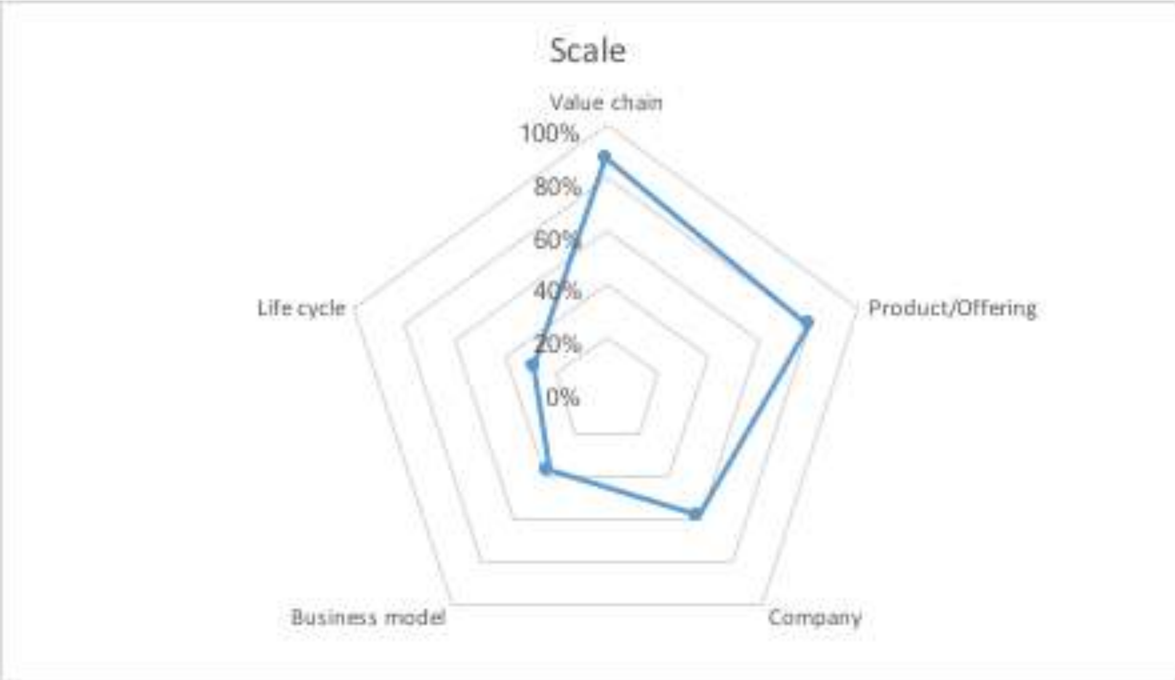

Figure 4. *Level of alignment for different scales relevant for a circularity assessment tool*

Finally, Figure 5 illustrates different criteria considered by the stakeholders' proposals. Retained value and recycling were included in all the proposals. Less mentioned aspects are the value proposition, smartness, refurbishment, dependency on future materials and remanufacturing.

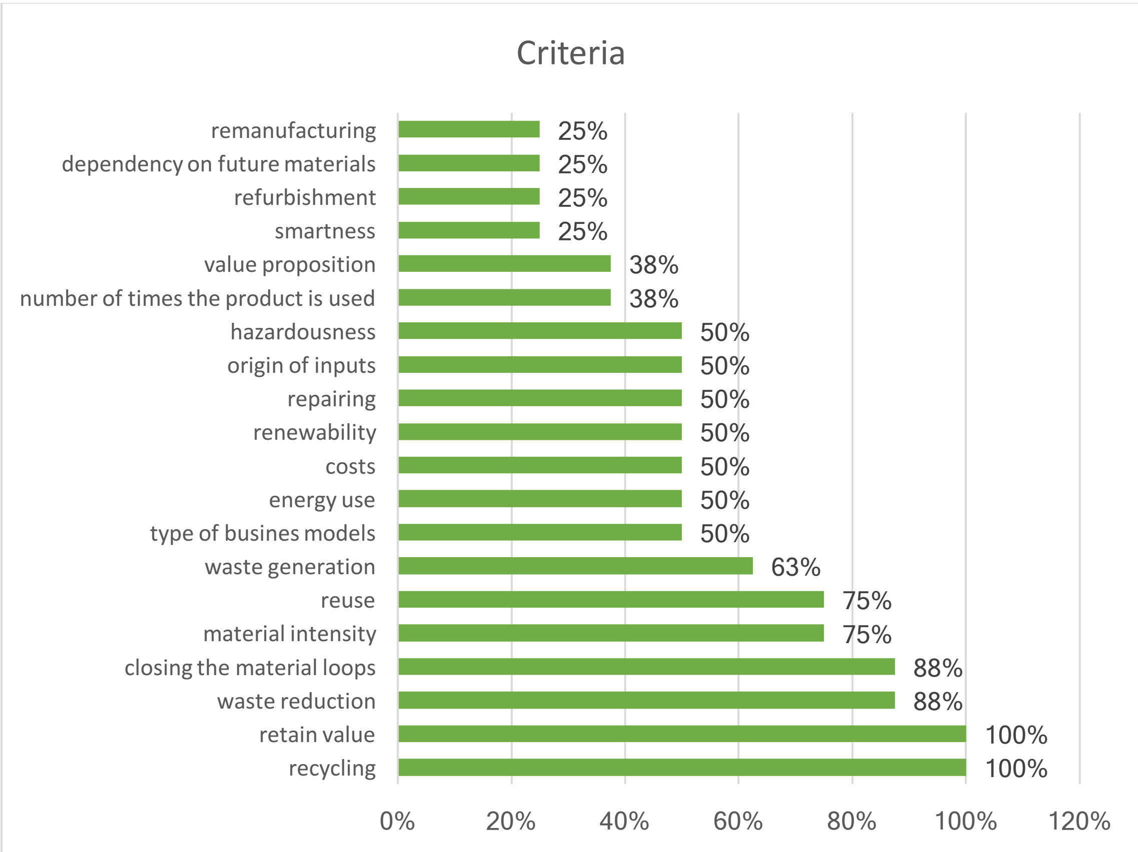

Figure 5. *Level of alignment for each criterion of circularity*

To conclude, regarding purpose, proposals acknowledge that it is important that assessment tools help companies plan for the future by identifying dependencies and sustainability issues. However, current proposals focus more on current challenges than future ones reflecting the second main finding of this evaluation, that none of the proposals uses 'Future-based orientation' as a principle. In addition to this, the principles 'Strong Sustainability, 'Collaboration' and 'Positive Footprint' are only partially integrated. Concerning scale, the business model and company level are less considered, and the life-cycle perspective is still missing from the proposals. Finally, concerning criteria refurbishing, remanufacturing, smartness and dependency on future materials are less recognised by existing tools while closing the loops is the most relevant aspect to be assessed.

4. Discussion

In this section, significant findings that were not explored in detail and would offer opportunities for further inquiry are presented. A first element that affects the evaluation conducted here is the understanding of assessment in itself. Although throughout the text the concepts of assessment, measurement and appraisal were used as equivalents, they are different, and this may affect comparisons between the various proposals. Moreover, the lack of agreement between sources about the relevant scale for a circularity assessment might come from the diversity of backgrounds and the novelty of the circularity assessment concept. Additionally, different experts raised the question about the relationship between circularity assessment and tools such as Life Cycle Assessment or Material Flows Analysis. This issue was slightly mentioned by the stakeholders in two opposite senses: on the one hand, the Ellen MacArthur Foundation and Viktoria Swedish ICT proposed that their circularity measurement can be part of Life Cycle Assessment. On the other, Circle Economy and VBDO expressed that these tools can, in turn, be part of the circularity assessment. In sum, if circularity assessment is understood as only concerning circulation of materials, it will be part of broader tools, and if it is defined as more than just materials, for example, organisational aspects, it will use these tools for its evaluating process.

Finally, a key aspect brought up by academics is the role of context in the assessment process. This aspect was not introduced in the framework as it was only mentioned once, but it would be important to address it. This issue, the role of site-specific conditions, is also cited as a key point to take into account for sustainability assessments. In sum, the framework suggested here is specific to the type of expert sources consulted. Moreover, both the interviewees' context and the interviewer background shaped the information and resulted in this report, making it necessary to recognise this influence and to read the results and conclusions under this light.

Also, the definition of the questions to be asked also affected the contribution received and therefore, the results obtained. In this sense, this research has been more a process of interpreting what the sources of information provided rather than just registering them so they could be understandable and useful for answering the research questions. Another key element was the questions that guided the analysis process in itself yielding the categories and basic elements of the suggested framework. Taking into account the above-mentioned factors, several particularly interesting findings were identified: first, circularity cannot happen just at one scale, mirroring the complexity of this phenomenon; second, stakeholder proposals are different and rather complementary, which could be explained by their different aims at measuring and assessing circularity. Third, a gap was identified between what the expert literature suggests as principles and what the experts consulted consider as relevant aspects, but this was not further explored. Finally, a significant challenge lies on how to incorporate context specificities into an assessment tool. These findings offer opportunities for further research if the issue of circularity assessment is to be explored and strengthened.

5. Conclusions

The aim of this inquiry was to establish the fundamental elements of a circularity assessment framework that effectively contributes to improving resource efficiency. Such a framework was structured based on experts input from literature sources and interviews. Perspectives from academia, the private sector and civil society were combined to identify the purpose, principles, scale, and criteria that should guide a circularity assessment. This framework was used to evaluate existing efforts for developing tools to assess circularity at the company level and identify alignments and misalignments. The proposed framework has four building blocks: a purpose for circularity assessment; what principles need to support the assessment; the relevant scales at which it should be implemented; and, the criteria that allow defining if a company is circular or not.

Regarding the purpose, a circularity assessment assists companies in addressing their role in society as resource stewards, in making management decisions and in engaging with a wider audience. Circularity is about reducing resource use and negative environmental impacts and creating value as much as making our economic system resilient, and future proved while delivering wellbeing. Regarding scale, circularity does not happen only within the boundaries of the company; it is a property of the broader system in which the company is embedded. In this sense, circularity assessment has to be multi-scale and have a life cycle approach.

Existing efforts to assess circularity consider these aspects partially; in some cases, like in the case of the Circle Economy and VBDO proposals, they are closer to the framework proposed here than the proposals suggested by the Ellen MacArthur Foundation and Viktoria Swedish ICT. The first group has a more comprehensive approach to the assessment, while the other two are more focused on measuring circularity. Thus, it is concluded that the different proposals are complementary and elements of all could be combined to have a basic proposition that follows more closely the suggestions made by the experts.

In sum, the main contribution of the circular economy is the systems' approach to understanding the economy, which in turn requires a change in mindset by key actors in society. This is only achieved if the operationalization of the idea follows the principles proposed by its foundational disciplines. It is not enough to just mention the principles and acknowledge them, but it is mandatory to translate them into measurable practices.

Circularity, like any social phenomenon, is not a technical fix or a management solution; it is a multifaceted approach that requires a sophisticated understanding and complex solutions. In this sense, a circularity assessment requires collaboration between experts from academia, private and government areas. Additionally, it demands integrating approaches from other sectors of society, like consumers, civil society and unions. Current proposals come from either technical or management experts; some organisations have incorporated input from civil society (companies and business associations), but this needs to be taken further if complexity is to be addressed.

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Society-nature relations in the context of mechanized and semi-mechanized illegal gold mining in the Department of Chocó - Colombia.

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Abstract

The dynamics of the relations between society and environment exposes the success or the lack of effective actions of social sustainability. The continuous and complex relationship of the society (which includes public and private, economic, political and social institutions) and the natural systems reveals the human dimension as one of the key aspects of sustainability, given the different connections developed throughout the development of the social system (cultural, religious, economic, political, amongst others). The aim was to identify to what extent the environmental impacts, as reported in the literature, may constitute potential factors and sources of change, conflict or social impacts. To this, the paper follows the initial stages of Social Impact Assessment – SIA– (scoping and profiling) in context of mechanized and semi-mechanized gold mining of illegal character in the municipality Río Quito - Department of Chocó - Colombia, using literature review and document analysis, identifying the ecosystems that shelter the municipality and determining the effects of environmental impacts on ecosystem services affected thought causal - effects matrix. The Department of Chocó is characterized by its natural and ethnic wealth, with 90% of the territory composed by indigenous and afro-descendent communities, recognized by its collective and traditional territories where the artisanal mining is an ancestral practice. Oppositely, this region presents the highest poverty rates in the country in municipality Río Quito, according to official data. In current days, the presence of mechanized and semi-mechanized illegal gold mining is another concerning factor that causing impacts in local communities, in the modification of ecosystems and their services, which are the basis of traditional subsistence and compromise the well-being of these communities. The literature demonstrates a wide range of environmental impacts arising from the illegal mining of gold, such as Mercury pollution, which affects miners and communities through ingestion and inhalation pathways. The research concludes that this type of mining is a driver of changes in the biophysical and social contexts of the municipality of Río Quito, with repercussions on traditional activities, and those considered as part of the foundations of a society: food, access to water and income generation. Based on the outcomes, we suggest that SIA is a tool that exposes changes and impacts that affect the relationship between society-nature, as well as promoting the knowledge of socio-environmental contexts in the proposal of sustainable measures that respond to the realities of communities, increase their social acceptance and the probabilities of being more successful.

Keywords: Society-nature relations, mechanized and semi-mechanized illegal gold mining, Social Impact Assessment, environmental impacts, social impacts.

1. Introduction.

The Mechanical and Semi-mechanical gold Mining of Illegal Character (MSIGM) it is a practice in Colombian territory stimulated by high international gold prices. It is characterized by aggressiveness in its development with a high capacity of displacement of the territory, associated with lack of the social conditions and low indices of attendance of basic needs in the mining regions.

The impacts on the environment and health aspects are usually related to the MSIGM. There is a gap between the evaluation of the social impacts resulting from this type of exploitation without considering the deep and complex relations of social systems (political, social, economic, etc.), with biophysical systems (natural and environmental resources) which can generate Ecosystem Services (ES) that are enjoyed by social systems (Berkes et al., 2000; De Groot, 1992; Slootweg et al., 2001; Vanclay, 2002). Therefore, this process generates new pressures and impacts in the biophysical system reflected in social well-being and in the consequences of social decision-making and much more (MILLENNIUM ECOSYSTEM ASSESSMENT, 2005a, 2005b).

This paper seeks to identify how the environmental impacts reported in the literature can be form in potential factors and sources of change, conflicts or social impacts in the context of MSIGM in the city of Río Quito, Department of Chocó, in Colombia, identifying the potential contribution of the Social Impact Assessment (SIA) in the recognition of the socio-environmental context.

2. Methods

In order to identify how the environmental impacts reported in the literature may constitute potential factors and sources of changes, conflicts or social impacts in the context of MSIGM in the Department of Chocó, in Colombia, were adopted as a guide tool for impact Assessment the first phase of SIA. The SIA is a Systematic Tool for Impact Assessment, specialized in understanding the conflicts and factors that drive social change, which can turn into direct or indirect impacts of a social nature and, consequently, affect the well-being of communities (Esteves et al., 2012; Vanclay, 2002, 2003; Vanclay and Esteves, 2011).

Following the structures proposed by Burdge, 1994; Taylor et al., 2004; Vanclay et al., 2015, in Fig. 1, it is presented the phases of SIA developed in the article: Description of the facts to be assessed, delimitation of time and description of the type of mining; the Scoping or Understanding of relevant issues, whose purpose is to clearly delimit the focus of the research by identifying the environmental aspects with which MSIGM interacts; Profiling, which provided an overview of the historical, economic, and social contexts of the research area and the Identification of Environmental Impacts reported in the literature and their implications for the use of ecosystem services following the list by Landsberg et al. (2013).

These phases were conducted through an Exploratory Survey that was guided by bibliographic and documentary review and analysis in several formats: books, scientific articles, official reports, normativity, photographic records, cartography and interviews (Creswell, 2014, Gil 2008, Neuman, 2013), and aided by cause and effect matrices that allowed us to identify how MSIGM interacts with ecosystems, availability and quality of SE and human well-being.

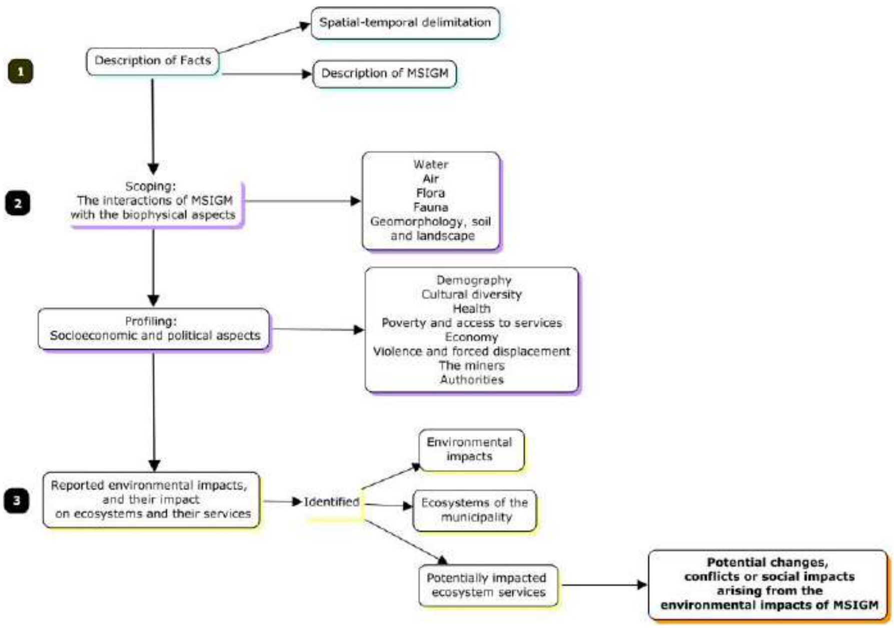

Figure 1. Phases of the scientific research. Source: Own elaboration based on SIA.

3. Results

3.1. Description of Facts

3.1.1. *Spatial-Temporal Context:* The study focused on the municipality of Río Quito, located at 5 ° 25'N and 76 ° 40'W, in the central sub-region of the Department of Chocó, in the Tropical Humid Forest ecosystem, with an annual rainfall that oscillates between The 8,000 and 10,000 mm and average temperatures of 28 and 33 ° C. Recognized as ethnic-collective territory under the 1991 National Constitution and Law No. 70 of 1993, where 87.12% of the lands belong to Afro-Colombian communities and 12.78% to indigenous communities, comprised of 8 districts and 4 indigenous reserves (Alcaldía de Río Quito, 2012a), see fig. 1.

In 2005, the city was declared the poorest in Colombia, with 98.81% of basic needs unsatisfied, including factors such as inadequate housing, unavailability of public services, high density of housing, school drop-out and economic dependence (DANE, 2005a), exposing a panorama of precariousness and social injustice.

The temporal cut of the research includes the year of 1997, year in which the phenomenon gains visibility until nowadays.

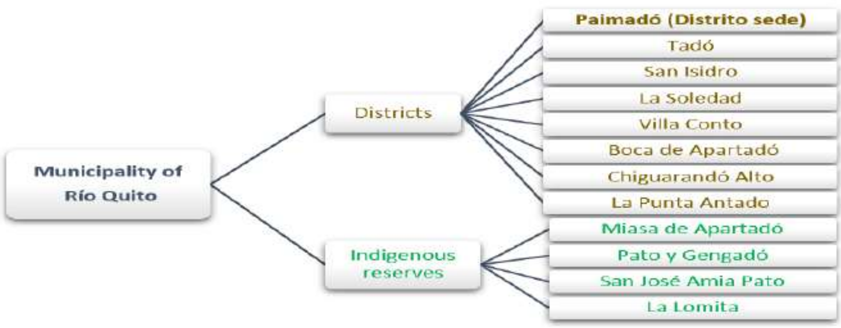

Figure 2. Administrative system. Source: Territorial Planning Plan (Alcaldía de Río Quito, 2012a).

3.1.2. *Description of the mining developed in the study area:* The MSIGM used in Colombian territory motivates a devastating scenario in the country's environmental, social and economic spheres (Cordy et al., 2011; Cordy and Lins, 2010; De Miguel et al., 2014; Lacerda, 2003; Marrugo-Negrete et al., 2007, 2008; Olivero et al., 2002; Olivero-Verbel et al., 2011, 2011, SPDA, 2014, 2015; Veiga et al., 2006). The activity developed within water bodies and in flooded areas is considered illegal because it does not have the mining-environmental, social and economic requirements (Ministério de Minas e Energia, 2013), and is characterized by socio-environmental aggressiveness in its development and by the high displacement in the territory with factors related to violence (Sabogal, 2012).

The use of heavy machinery (backhoe loaders and river dredges) in a mining exploration with small-scale and artisanal mining bends (ASM) makes it impossible to classify it within the national and international parameters. As posed by Hinton (2005), ASM is characterized by an incipient level of mechanization, requiring a wide use of labor, and low environmental and safety standards at work, but the insertion of heavy machinery expanded the extraction areas, the production capacity and water demand, (Instituto Nacional de Salud and Observatorio Nacional de Salud, 2016; Vargas, 2012). In the year of 2012, the Department of Choco considered that the percentage of mechanized mining was to be 21.60%, semi-mechanized to 46.4% and artisanal to 32.6% (Sabogal, 2012).

In the years 2015 and 2016, illegal gold mining was present in approximately 21 of the 32 departments of Colombia, with a large presence in the departments of Antioquia and Chocó (Espectador, 2016; Semana, 2015; Tiempo, 2015). Due to this scenario, the National Unity Against Criminal Mining (UNIMIC) task force was created, articulated by the public forces, the control entities and the Ministries of Defense, Interior, Environment, Mines and Energy (Urna de Cristal, 2014).

According to Judgment No. 01953 (Tribunal Administrativo de Cundinamarca. Sección Primera. Subsección B, 2015), this type of mining has been present in the territory of Chocó since 1999 with the arrival in the region of nationals and foreigners attracted by the increasing value of Gold and the recognized mining vocation, developing working days of more than 20 hours per day, with productions between 300 and 500 grams of gold.

The ruling also exposes socioeconomic arrangements established between some landowners with the new explorers, such as rent of land and agreements that allow, for a part of the community, to take advantage of the tailings of sands and stones extracted from the river to carry out artisanal mining. These agreements over the years did not generate the profits that the landowners expected, because the percentage that corresponded to them was low. Besides, the severe modifications in the territory and the attribution of functions that compete only to the environmental and mining authorities, generating some conflicts, strengthening the scope of illegality (Contraloría General de la República., 2016; Instituto Nacional de Salud and Observatorio Nacional de Salud, 2016).

> “We would not allow them to take the gold without leaving us anything, yet these people are protected by dangerous people, so either allow themselves or allow themselves. Now the government says we are an accomplice to the miners. Accomplice? When neither the police nor the army hold these activities. Nobody protects us and we have to put up with armed groups, and we are not criminals" Testimony of an inhabitant of the district of San Isidro (Cuevas Guarnizo et al., 2015).

3.2. Scooping

3.2.1. *The MSIGM interactions with the biophysical aspects:*

Water: Considered the key element for the mechanical concentration of metal particles in the river banks, meanders, riverbeds and river flood areas, due to their erosive and transport properties (IIAP, 2005). Water is one of the main elements in the collection of the metal, used in the washing of alluvial sands and is again fed to the rivers with: fuels and lubricating oils from the machinery; with chemicals used as a means of collecting the gold content in exploited alluvium such as cyanide and mercury and large sediment concentrations (CODECHOCÓ, 2012; National Institute of Health and National Observatory of Health, 2016).

Vargas (2012) determined that water consumption for semi-mechanized mining is 699,544 l/day and for mechanized mining of 2'241,721 l/day, contributing between 10'315,052 and 186'062,400 kg of total solids per year, Generating high levels of sedimentation and turbidity.

The areas of the water bodies already exploited are abandoned with sterile waste stocks and with the edges of degraded bodies of water with the intention of covering areas of metal deposition, generating deforestation and hydrodynamic and hydrodynamic changes (Contraloría General de la República., 2013; Instituto Nacional de Salud and Observatorio Nacional de Salud, 2016). This situation exposes the local communities to flood risks in rainy seasons, as has already occurred in the years 2011, 2012 and 2013 (OCHA Colombia, 2013; UNGRD, 2015). In addition, it also provokes low navigability of the water body, considering that the fluvial environment is the main source of transportation in the Department of Chocó, which may affect the supply of water and food (CODECHOCÓ, 2012; Defensoría del Pueblo de Colombia, 2014).

A recent characterization of the quality of the Quito River and 7 of its tributaries presented physical-chemical variables above the permissible parameters for the development of aquatic life, as a direct consequence of the mineral development along the river (IDEAM et al., 2015b, 2015a).

Air: Considering the rural character of the municipality of Río Quito, MSIGM introduces noise as an unrelated factor to the ecosystem. This scenario, far from being occasional, exposes a considered number of production units of the mining activity impacting the dynamics of the environment, in the which refers to the migration of species (part of the enjoyment and beauty of the landscape) and on the diet of Afro-Colombian and indigenous communities (Contraloría General de la República., 2016; IDEAM et al., 2015a; Vargas, 2012). In 2005, according to CODECHOCÓ reports, in the department there were 80 production units aided by 160 backhoes and dredgers. In 2015, in Río Quito, 100 production units were reported (Contraloría General de la República, 2016; IDEAM et al., 2015a). According to the National Institute of Health (2016), the incidence of noise in the health of communities and miners is not commonly reported, without denying its existence, taking into account workdays of more than 20 hours/day.

Emissions of air pollutants can be cataloged in those generated in the combustion of hydrocarbons and those generated in the burning of mercury-gold amalgams. The sources of combustion of hydrocarbons are derived from the operation of the heavy machinery (Contraloría General de la República., 2013) and from police operations, which are covered by Decree No. 2235 (Ministerio de Defensa Nacional, 2012), before which is regulated by art. 6 of Decision No. 744 (Comision de la Comunidad Andina, 2012) which decrees the in-situ destruction of heavy machinery used in illegal mining activities.

The emissions from the burning of mercury-gold amalgams in the final process of obtaining the gold, is a widely-reported problem (Cordy et al., 2011; Cordy and Lins, 2010; De Miguel et al., 2014). Developed in the area of exploration of the metal as well as in populated centers, jewelry stores or in the mining house itself, it raises health risks of intoxication by inhalation of mercury vapor for both miners and the neighboring population. The result of the report "Una mirada al ASIS y análisis en profundidad" (Instituto Nacional de Salud and Observatorio Nacional de Salud, 2016), exposes a health system in the Department of Chocó so precarious that it prevents detection and treatment of related diseases Mining activities.

Flora: The Department of Chocó is recognized for its diversity and high degree of endemism. Río Quito is characterized by the presence of riparian vegetation which includes several subtypes, among them ciliary forest, gallery forest and woodland. Deforestation is a phenomenon related to the illegal exploitation of gold, which affects the water and forest ecosystem generating a rupture in the habitats of the region (Contraloría General de la República., 2013).

The IDEAM et al., (2015a) analyzed the flora of the Quito River and identified the decrease of forest species. There are eight predominant families' forest species in the tropical rainforest. In the municipality have predominantly the presence of only one. It also reports that abandoned areas by gold mining presents little or no presence of organic soils, hindering the development of pioneer vegetation.

Deforestation affects the customs of indigenous and Afro-Colombian populations, as regards the loss of access to medicinal plants, animals and the enjoyment of the landscape (Defensoría del Pueblo de Colombia, 2014; IDEAM et al., 2015a). The loss of ciliary forest diminishes the resilience of the ecosystem when confronting floods, exposing communities that are mostly living on the riverside (Alcaldia de Río Quito, 2012b; UNGRD, 2015).

Fauna: The disturbances caused by semi-mechanized and mechanically illegal gold mining modify the dynamics of feeding, reproduction and refuge spaces of many organisms (IDEAM et al., 2015b). The characterization of the fauna in the Quito River basin by IDEAM et al. (2015a), shows migration and reduction of herpetofauna and birds due to the fragmentation of habitats and states that "*the transformations in the environment were so rapid, deep and intense, which fundamental elements such as habitats, microenvironments and trophic availability, are deeply modified, making the fauna, sensitive to disturbances, migrate looking for new ecosystems*".

In the same study, the characterization of the ichthyofauna in the municipality of Río Quito was shown by the relevance of the food customs of the Chocoan communities, identifying that the abundance and richness of the collected samples decreased in relation to other studies of the years 2007 and 2012. The study evaluated the chain of bioaccumulation and biomagnification of the mercury in the trophic chain as a consequence of the discharge of this heavy metal in the bodies of water. From the 10 species collected, 100% of them contain levels of total mercury, with concentrations vary from 0.76 and 0.07 μg Hg/g that, according to De Miguel et al., 2014; Marrugo-Negrete et al., 2007; Olivero et al., 2002 and Olivero-Verbel et al., 2011, depend on the level in the trophic chain, being directly proportional, the highest level in the food chain, the highest concentration of total mercury.

Geomorphology, soil and landscape: These three aspects were framed in the same item by the implications that generate the mining activity in the constituent links of the terrestrial ecosystem. According to the Territorial Planning Plan of the Municipality of Río Quito and the Report on the State of the Environment and Natural Resources (Alcaldia de Río Quito, 2012a, IDEAM et al., 2015a), the municipality is located in a sedimentary littoral unit of marine origin of more than 10 km of thickness, that contains the alluvial deposits of Quaternary (Qal) with important concentrations of metals such as gold, platinum and silver, which is why the Department of Chocó has a large artisanal mining history (IIAP, 2005).

The planning of this type of mining focuses on the economic-productive. As for environmental planning, the literature does not report any type of measure developed on the initiative of the miners with the intention to affect less the environment.

The effects in the soil and landscape are the changes most easily recognized by the population, due to the presence of production units on the banks and in the middle of streams and rivers, fuel spills, increased turbidity, water damming in gaps and the provision of sterile materials, among others (Contraloría General de la República, 2013, 2016; IDEAM et al., 2015a; Instituto Nacional de Salud and Observatorio Nacional de Salud, 2016; Rivas, 2015).

3.3. Profiling

3.3.1. <u>*Socioeconomic and political aspects:*</u>

Demography: The life expectancy in the country is 73.95 years but in the Department of Chocó is 69.3 years (Instituto Nacional de Salud and Observatorio Nacional de Salud, 2016) which may represent the marked social differences of the department, as well as the factors linked to violence. According to population projections, in the municipality of Río Quito, there were 8,849 people (Defensoria del Pueblo de Colombia, 2014): 94.9% of the total population represents Afro-Colombian communities and 5.1% of indigenous communities. About 60% of the population is concentrated in the districts of Paimadó, San Isidro and Villa Conto. Approximately 25% of the population are children under 10 years of age; 54% of the population is under 24 years of age, what features as a young population (Rio Quito, 2012a). In 2005, the department had the highest fertility rate in the country, at 4.35% (DANE, 2009).

Cultural Diversity: With the Law N° 70 (Congreso de la República, 1993) about 90% of the Department of Chocó was recognized as collective property of communities with Afro-Colombian ancestry, land declared inalienable, imprescriptible and non-releasable. The Law N° 21 (Congreso de la República, 1991), recognizes the country's indigenous reservations and constituted legal tools in the pursuit to maintain cultural particularities and an environment relation. The property titles bring to the scene a broad debate, given that the process has been widened in time by the violence that has taken place in the region and the mining interests of the national governments in the last 11 years. This situation has helped the emergence of illegal mining in the department (Defensoría del Pueblo de Colombia, 2014; Instituto Nacional de Salud and Observatorio Nacional de Salud, 2016).

Health: The most common diseases of the municipality of Río Quito are related to water, among them are dermatitis, malaria, dengue, malaria and various infections (IDEAM et al., 2015a; Instituto Nacional de Salud and Observatorio Nacional de Salud, 2016). The retention of water by mining and the climatic nature of the region generate the perfect conditions for the proliferation of pathogens, a phenomenon that helps to achieve the highest rates of infant mortality in the country, 82.20% (DANE, 2009).

The impacts of MSIGM on the health of miners and communities are related to mercury through different routes of exposure, with ingestion and inhalation being the most common (De Miguel et al., 2014). One study pointed to the level of mercury contamination to which residents of 10 municipalities in the department are exposed, reporting 87 people at risk of mercury intoxication. From this group, 70 had mercury in their blood, hair and urine, of which 56 were reported with mercury contamination; 4 Presented acute intoxication and 1 person chronic contamination. The highest mercury contractions were in owners of jewelers and miners (Medina Mosquera et al., 2011). The effects on the health of mercurial intoxication involve central nervous system effects, teratogenic incidences, weakness, memory loss, and tremors among others (Instituto Nacional de Salud and Observatorio Nacional de Salud, 2016).

The access to health facilities is limited by the mobility difficulties that the department presents and the capacity of attention of the Headquarters District, Paimadó, with only one unit service of first level. (Alcaldia de Río Quito, 2012a).

Poverty and access to services: Despite being recognized for its natural wealth, Chocó is also recognized for having the highest poverty rates in the country, a situation that can be related to the country's armed conflicts, corruption and illegal mining (ABColombia et al. Al., 2015).

The precarious living conditions in the districts of the municipality are evidenced by the lack of public water and sewage services, the energy service supplies only 80% of the districts of the municipality and few institutional services such as one cemetery and police station (Alcaldia de Río Quito, 2012a). The rate of people in poverty in the rural area of the municipality of Río Quito is 52.03% and in the Headquarters District of 34.60% (DANE, 2005a), which has generated a feeling of state abandonment (ABColombia et al., 2015).

The municipality of Río Quito does not have a public water and sewage service (Alcaldia de Río Quito, 2012a; DANE, 2005b). Former mayor José Isabelino Becerra, in an interview with the television channel (Los Informantes, 2015), explains that although it is a constitutional right, the municipality does not have the economic conditions to build an aqueduct, and says: *"We collect the Water from a nearby stream, but it is yellow"*. The journalist adds "*No one in the municipality knows the plan* *for the construction of the aqueduct, everyone drinks, cooks and bathes with the water that flows down the river, which has mercury"*.

The water bodies of the municipality are the fluvial network, building the main channel of communication with the other municipalities and cities of the department, does not count on companies that offer services to the population that mobilizes in the boats that carry sales products among the Municipalities (Alcaldia de Río Quito, 2012b, 2012a; Procuradoria General de la Nación., 2011).

Economy: The extractive model fomented by the national development plans brought an exponential increase in the volumes explored in the municipality, an activity that should generate an economic retribution to the populations. But this scenario is not evident in Chocó due to the illegality of the gold explorations and by the corruption in institutions, deepening social inequalities (Göbel and Ulloa, 2014). See fig. 3.

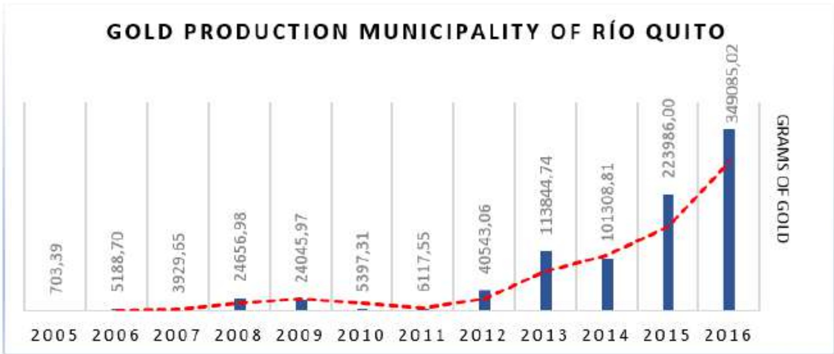

Figure 3*. Banco de la República, Ministerio de Minas y Energía, Minercol, Ingeominas (2004-2011), ANM (2012 en adelante) ANM, (2016).*

The illegality of gold production violates the department's economic dynamics, supported by the ease of gold laundering and the volumes of illegal mining (more than 82% of the country) are easily mixed with legally constituted holdings (Time, 2016).

The traditional activities such as fishing and agriculture were displaced by MSIGM (ABColombia et al., 2015, IDEAM et al., 2015a). Even artisanal mining invests more time in collecting gold than in the past (Cuevas Guarnizo et al., 2015). Fisheries, the basis of livelihood for the community that lives on the riverside, have been affected, both by the low supply of species traditionally fished and by the danger of mercury contamination.

> "These, people do not want to buy, they say that it is contaminated... look, I had a customer who used to buy half an arroba, which is 5 packages of these, but no longer buys... We say ´May I help you? Will you take the fish?' And they say 'No, I no longer eat fish because it is poisoned'. Now it is very difficult to sell fish, there are times that I think it is true that it is contaminated, people do not want to buy it... Sometimes I say it is a lie [laughs]". Testimony of Ana Mosquera, fish seller of Río Quito (Cuevas Guarnizo et al., 2015).

> "Today people are eating fish that are from breeding, and I am from here and I really like the Bocachico, but in the last 6 months that it came out ... that this ... chemical was affecting that, I'm eating more Cachama and Tilapia, to avoid eating the Bocachico because of what I told you" Javier Mosquera, Consumer of Río Quito (Cuevas Guarnizo et al., 2015).

The effects on agriculture due to mining are linked to the loss of organic matter and the quality of the water with which they irrigate, reporting losses in their economies (IDEAM et al., 2015a).

> "The plantations have been damaged and many have stopped sowing because they are going to harvest. People who have money buy food in Quibdó, the rest eat what is in the municipality. We are on the verge of a crisis. And every moment there are people announcing studies and studies, nobody else does anything for us ... so we are going to misery". Testimony of Manuel González, Farmer of Villa Conto (Cuevas Guarnizo et al., 2015).
>
> "We've always been poor, but we've never been hungry." Testimony of Tina Mosquera, inhabitant of Paimadó (Cuevas Guarnizo et al., 2015).

Violence and forced displacement: 392,447 people were victims of forced displacement in Chocó. These data were reported by the government between 1990 and 2005, due to disputes over the territory of armed groups (guerrillas, paramilitaries and criminal gangs), control of routes Illicit crops, illegal gold mining, murders, kidnappings and massacres (Instituto Nacional de Salud and Observatorio Nacional de Salud, 2016).

The hope of experiencing peace on its territory, after the peace process advancing with the FARC guerrillas, it is getting lost. In March there was a displacement of more than 500 people in clashes between armed groups (Pacifista, 2017). Pressures in communities increase when reporting the links that can be generated between MSIGM and outlaw groups, according to the World Drug Report (UNODC, 2016) the reported income from this activity is more profitable than drug traffic (El Mundo, 2017).

Miners: The origin of the miners is wide. The promise of "easy" gold brought citizens from different parts of the country as well as foreigners, especially those of Brazilian origin, who according to official sources were those who introduced the levels of mechanization in the extraction of gold (Colombian, 2016). Sabogal (2012) defined the profile of the miner who takes care of the logistics in a production unit as men with average age of 43 years, with low educational levels and families composed on average by 5 individuals. These miners reports mining work of Relatives: parents, siblings, children and wives. Its experience in mining fluctuates in the 21.5 years with a monthly income (depending on the position in the chain of command) between US $ 13.00 to 1,974.00; In Chocó 87.7% of the miners have debts generated in the acquisition of inputs.

The authorities: Sabogal (2012) reported the presence of MSIGM in 5 departments of Colombia, including Chocó. About 89% of the consulted authorities reported that since 2005 migration has increased due to gold, which has generated a shock with the traditional mining of some departments. In addition, 61% of the interviewees perceive social changes as the increase of alcoholism, prostitution, drug addiction, violence, labor and child prostitution.

3.4. Environmental impacts reported and their impact on ecosystems and their services

The relation between nature and society recognizes the mutual influence of the parties; a nature that provides and a society that enjoys and manages its social structure and the services that nature provides, a product of the functions developed by the ecosystems (Berkes et al., 2000; Landsberg et al., 2013, Slootweg et al., 2001). ES depend on the full state of the environment, in quantity and quality, presenting their relevance to human well-being (Millennium Ecosystem Assessment, 2005a, 2005b).

In order to identify the potential of the environmental impacts of MSIGM to constitute factors and sources of changes, conflicts or social impacts, were identified in the literature 22 negative environmental impacts, the operational characteristics of mining activity and its procedures in ecosystems, aquatic, forest and anthropic systems (exhibiting agropastoral interventions) of the municipality of Río Quito. The ecosystems identified cartographically, as recommended by Landsberg et al. (2013), in IGAC et al., (2012) and IIAP (2011); where the aquatic and forest ecosystems reported a greater number of impacts in the literature, as seen in table 1.

In sequence, the ES potentially impacted by MSIGM, from the cause and effect establishment, were identified between the environmental impacts and the ES. Although the classification of ES in the literature is broad (De Groot et al., 2002, Haines-Young and Potschin, 2013, Millennium Ecosystem Assessment, 2005c, Rosa and Sánchez, 2016), The Indicative List of Ecosystem services was adopted, proposed by Landsberg et al., 2013, due to the definitions and examples provided by the analysis. The criteria selected in the cause and effect analysis were: (i) the impact can generate some kind of change in the ecosystem that provides the service? (ii) does the impact prevent the usufruct or access to ES? See table 2.

Table 1. *Environmental impacts of the MSIGM on the ecosystems of the municipality of Río Quito, reported in the literature.*

<table>
<tr><th rowspan="3">Natural components of environment</th><th colspan="4">Mechanized and semi-mechanized illegal gold mining, municipality Río Quito - Department of Chocó - Colombia</th></tr>
<tr><th rowspan="2">Environmental impacts reported in the literature</th><th colspan="3">Ecosystem affected</th></tr>
<tr><th>Aquatic ecosystem: rivers and streams</th><th>Forest ecosystem: Tropical humid</th><th>Anthropic systems: agro-pastoral interventions</th></tr>
<tr><td rowspan="10">Hydric</td><td>Sediment poured: between 3.100 and 186.000 tons/year per unit of production</td><td>CODECHOCÓ, 2012, pg 78; Vargas, 2012</td><td></td><td></td></tr>
<tr><td>Hydromorphological changes of rivers and streams</td><td>CODECHOCÓ, 2012, pg 79; Instituto Nacional de Salud y Observatorio Nacional de Salud, 2016; Vargas, 2012</td><td></td><td></td></tr>
<tr><td>Hydrodynamics changes of rivers and streams</td><td>CODECHOCÓ, 2012, pg 59; Contraloría General de la República., 2013, pg 16</td><td></td><td></td></tr>
<tr><td>Erosion along riverbanks</td><td colspan="3">CODECHOCÓ, 2012, pg 59</td></tr>
<tr><td>Risk of floods</td><td colspan="3">Alcaldía de Río Quito, 2012b; UNGRD, 2015</td></tr>
<tr><td>Lubrication oils spills from production units: approx. 1283 liters/year per production unit</td><td>CODECHOCÓ, 2012, pg 79; Instituto Nacional de Salud y Observatorio Nacional de Salud, 2016; Vargas, 2012</td><td></td><td></td></tr>
<tr><td>Mercury releases: 36 Kilograms/year per production unit</td><td>CODECHOCÓ, 2012, pg 79</td><td></td><td></td></tr>
<tr><td>Proliferation of animal/disease vectors (yellow fever, dengue, etc.) water stagnation</td><td colspan="2">CODECHOCÓ, 2012, pg 79</td><td></td></tr>
<tr><td>Migration and/or loss of species of ichthyofauna</td><td colspan="2">CODECHOCÓ, 2012, pg 79; Vargas, 2012</td><td></td></tr>
<tr><td>Change in the physico-chemical characteristics of water</td><td>CODECHOCÓ, 2012, pg 79; Vargas, 2012</td><td></td><td></td></tr>
<tr><td rowspan="3">Air</td><td>Emission of gaseous pollutants in the burning mercury-gold amalgam</td><td></td><td>CODECHOCÓ, 2012, pg 105; Contraloría General de la República., 2013, pg 17; Medina Mosquera et al., 2011</td><td></td></tr>
<tr><td>Emission of gaseous pollutants from the combustion of heavy machinery</td><td></td><td>Contraloría General de la República, 2013, pg 17</td><td></td></tr>
<tr><td>Emission of noise generated by the use of heavy machinery.</td><td colspan="2">Contraloría General de la República., 2013, pg 17</td><td></td></tr>
<tr><td rowspan="5">Fauna and Flora</td><td>Riparian forest loss</td><td colspan="2">Contraloría General de la República., 2013, pg 18</td><td></td></tr>
<tr><td>Decrease of dominant forest species in rain forests</td><td></td><td>IDEAM et al., 2015a, pg 156; Rivas, 2015, pg 139</td><td></td></tr>
<tr><td>Fragmentation and alteration of habitats</td><td></td><td colspan="2">Contraloría General de la República., 2013, pg 17</td></tr>
<tr><td>Migration and decrease in fish supply and bird diversity</td><td colspan="2">IDEAM et al., 2015a, 2015b, pg39</td><td></td></tr>
<tr><td>Mercury bioaccumulation in fish</td><td>Ministerio de Ambiente y Desarrollo Sostenible, 2012, pg 241; IDEAM et al., 2015a, pg 164 e 173; Instituto Nacional de Salud y Observatorio Nacional de Salud, 2016; Medina Mosquera et al., 2011</td><td></td><td>Ministerio de Ambiente y Desarrollo Sostenible, 2012, pg 241; IDEAM et al., 2015a, pg 164 e 173; Instituto Nacional de Salud y Observatorio Nacional de Salud, 2016; Medina Mosquera et al., 2011</td></tr>
<tr><td rowspan="2">Soil</td><td>Alteration and loss of organic soil by conformation of alluvial terraces.</td><td></td><td>Contraloría General de la República., 2013, pg 17; Instituto Nacional de Salud y Observatorio Nacional de Salud, 2016, pg 200</td><td></td></tr>
<tr><td>Generation of degraded areas</td><td colspan="2">Rivas, 2015, pg 141</td><td></td></tr>
<tr><td rowspan="2">Geomorphology and landscape</td><td>Changing the landscape</td><td colspan="2">IDEAM et al., 2015a, pg 158; Instituto Nacional de Salud y Observatorio Nacional de Salud, 2016, pg 200</td><td></td></tr>
<tr><td>Inadequate disposal of sterile materials and solid waste</td><td colspan="3">Contraloría General de la República, 2013, pg 17; Instituto Nacional de Salud y Observatorio Nacional de Salud, 2016, pg 200</td></tr>
</table>

Source: Own elaboration based on bibliographical and documentary revision.

Table 2. *Matrix cause and effect of the environmental impacts of MSIGM on Ecosystems Services.*

Ecosystem Services / Environmental impacts reported in the literature	Provisioning services: The goods or products obtained from ecosystems														Regulating services: The contributions to human well-being arising from an ecosystem's control of natural processes											Cultural services: The nonmaterial contributions of ecosystems to human well-being			Supporting services: The natural processes that maintain the other ecosystem services			
	Crops	Livestock	Capture fisheries	Aquaculture	Wild foods	Madeira produtos florestais	Fibers and resins	Animal skins	Sand from corals	Ornamental resources	Biomass fuel	Freshwater	Genetic resources	Biochemicals and natural medicines	Regulation of air quality	Regulation of climate regional	Regulation of climate global	Regulation of water timing and flows	Erosion control	Water purification and waste treatment	Regulation of diseases	Regulation of soil quality	Regulation of pests	Pollination	Regulation of natural hazards	Recreation and ecotourism	Ethical and spiritual values	Educational and inspirational values	Habitat	Nutrient cycling	Primary production	Water cycling
Sediment poured: between 3.100 and 186.000 tons/year per unit of production																																
Hydromorphological changes of rivers and streams																																
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Generation of degraded areas																																
Changing the landscape																																
Inadequate disposal of sterile materials and solid waste																																

Source: Authors' own work, based on the work of Landsberg et al. (2013).

The matrix shows that all ES (provision, regulation, cultural and support), according to the criteria of appreciation, are plausible to be modified and generate a limitation in the usufruct or access by the populations of the municipality, due to the environmental impacts generated by MSIGM.

It also showed that services related to Cultural Services are more likely to be affected by the environmental impacts reported in the literature due to their non-material nature, related to the enjoyment of the environment, the cultural heritage of Afro-Colombian and indigenous communities, as well as Intrinsic values of religious and spiritual character (Landsberg et al., 2013). The limitations to access and/or usufruct of the Provision Services reported in the literature show changes in the customs of the municipality's communities, in the economic and food aspects due to the unavailability of food or the exclusion of traditional economic activities such as fishing and Agriculture (Vanclay et al., 2015). Regarding the Regulation and Support Services, the literature reports the aggressiveness of the processes developed by MSIGM, affecting the ecosystemic functions of regulation: water quality, soil quality, floods, ecosystems in the municipality of Río Quito (see table 1). In the same way, the Support Service of habitat presents greater causality regarding the modification by loss of natural spaces that provide specific characteristics of reproduction and maintenance of species (Biggs, 2015), see fig. 4.

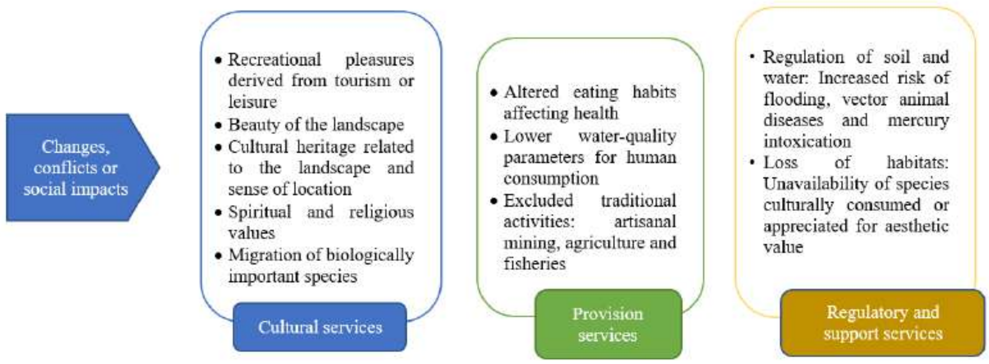

Figure 4. *Potential changes, conflicts or social impacts arising from MSIGM´s environmental impacts*.

4. Discussion

The relationships between nature and society are narrow. Created on a daily basis, in the experiences with the environment, transmitted between generations, influenced by the economic, political and institutional context, among others. Berkes et al. (2000) understand these relationships as socioecological systems, in which different types of processes and interactions between the biophysical and social systems are developed in order to obtain benefits for man, recognizing the mutual influence, but delimited by the ecosystems in which they are inserted. The components of human well-being go through these society-nature relationships (Narayan et al., 1999), not only in the availability and quality of the ecosystem services provided by the environment, but also in the different security, political and economic measures that the society develops (Millennium Ecosystem Assessment, 2005d).

Slootweg et al. (2001) add that governments, through institutional agents, political instruments, trade agreements and other mechanisms, must mediate the imbalances generated by social demands on ecosystems. These imbalances, in the context of the MSIGM, the lack effective institutional management in relation to the active presence in the municipality poverty, the largest in the country; Lack of basic access to services such as potable water and sewage; Conditions of insecurity; The restricted opportunities of income generation, where MSIGM presents itself as the only source of effective and rapid income in the municipality.

Berkes et al. (2000); De Groot et al. (2010); Millennium Ecosystem Assessment, (2005d), establish that biophysical degradation is a cause of conflicts and losses with reflexes on the communities well-being. As reported, the decrease in quantity and quality of access to food traditionally consumed, the exclusion of ancestral practices (artisanal mining, agriculture and fisheries); the diseases reported in exposure to heavy metals; the morphological, hydrodynamic and quality modifications of water bodies, among others (see table 1), are situations that lead to cycles of poverty and degradation in order to recover lost services.

The environmental impacts of MSIGM raised in the bibliographic and documentary research, in the socioeconomic and political contexts described in the profiling stage and in the characterization of this mining activity, bring to the analysis of cause and effect developed in table 2, key elements to determine the potential of this mining activity as a driver of change or social conflicts (Figure 4). These key elements can be created, initiated, empowered and/or exacerbated by the mining activity and the materialization of social impacts experienced or sensed, perceptually or corporately, by an individual or social unit (Vanclay et al., 2015).

5. Conclusions

The research recognizes MSIGM potential to generate changes, conflicts and social impacts as a result of the environmental impacts reported with the socioeconomic context of the municipality: high poverty rates, social inequality, feelings of governmental forgetfulness, broad levels of violence and perception of having a bad quality of life, among others.

The ability to modify ecosystems and decrease the quantity and quality of the ESs, presents an aggressive mining activity whose focus is the exploration of the metal and the fast income. The generation of income in a fast way can improve the well-being of the miners, that can be part of the Communities or migrants, who are exposed to the same risks of communities (diseases, intoxications and disasters as floods), as well as the risks of work, and also perceive the changes that are being generated in the environment.

According to the information collected for this research, there are dimensions of the welfare of the communities of the municipality of Río Quito committed, as the freedom of school and action, for example. The MSIGM coerces communities to accept development in their territories. It can also be quote the good social relations, as the conflicts generated with outsiders, which can be intensified by the difference of languages and customs; Material goods, changes in their food traditions, lack of access to drinking water and sewage services and the physical well-being affected by diseases, vector products and heavy metal poisoning.

The Social Impact Assessment is presented as a tool that exposes changes and impacts that affect the relationship between society and nature and the human well-being (present and future). It also promotes the knowledge of socio-environmental contexts and gives relevance to the human dimension as one of the main actors of sustainability in the implementation of measures that respond to the realities of the communities, increasing the social reception and the probability of being more successful.

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Facilitating spaces for co-creating microfinance models in conservation areas

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Abstract

As part of the project of the conservation of dry forests, sponsored by the United Nations Development Programme (UNDP) and Fondo Patrimonio Natural, we were asked to explore the microfinance practices of a local region in Colombia to define a microfinance model that would help them engage in sustainable practices. Together with seven master degree students in Design, we traveled to Natagaima, Tolima to spend a week with the inhabitants of Yaví and Pocharco. During the exploration, we used different participatory design tools, such as social cartography and generative sessions. The design team presented three proposals. Trust and solidarity inspired the first one. The second one was a network of local producers that were able to access to information about offer and demand for their products, as well as the reputation of the buyer. The third one is a saving and investment system using animals.

Keywords: Social innovation, Finnovation, Design, Participatory design.

1. Introduction

Innovation is a popular term used these days. It seeks for novel solutions that can create value for an individual, community, a company, or a process among other things. Different researchers, consultants, and corporations have developed models that allow them to do so. Some models focus on problem-solving, in which a solution is presented to meet an individual problem; others, are opportunity-driven, in which different possibilities emerge from the process, and not necessarily have to solve a problem. There are long processes that follow certain phases or are cyclical, these emphasize on iterations and experimentations. Some methodologies put the user in the center of the process, but not necessarily include them all along, while there are participatory approaches that contemplate different stakeholders at every step of the process. There are disruptive innovation processes that seek a paradigm shift, augmented innovation that intend to improve something, corporate innovations that build from inside an organization, or social innovation that creates value in a community (Dubberly, 2004). In this paper, we present a case study of a Social Participatory Innovation approach that took place in an indigenous cabildo in Colombia. Social Participatory Innovation stands for the idea of working with communities including them in all the stages of the innovation model. It intends to create a bond between the team and the community to bring about solutions based on their knowledge and values.

2. Background

(i) Facilitating spaces for co-creation.

The key to innovation is to have a thorough understanding of the context. Beckman & Barry (2007) proposed an innovation model consisting of four phases that include observation, frameworks, imperatives and solutions, going from concrete experiences and abstract conceptualizations to reflective observation and active experimentation. However, this model doesn't specify that users should be taken into account in all phases, but mainly in the real ones, which include observation and solutions. On the one hand, Participatory Innovation puts together all stakeholders and their expertises to be able to articulate solutions that are based on their practices and can create value (Buur, J. & Matheus, B., 2008; Sander, E. B. N., 2002). On the other hand, Social Innovation takes into consideration community needs over individual needs (Manzini, E., & Coad, R., 2015; Mulgan, G., Tucker, S., Ali, R., & Sanders, B., 2007). So, to provide a proper environment for innovation it is important to deep dive in the context, interact and learn from local people and ultimately articulate spaces for co-creation.

These spaces for co-creation aren't necessarily bottom-up approaches, neither top-down. In which according to Easterly, W. (2008) bottom-up comes as emerging entities from social, cultural and technological norms, while top-down is the imposition of certain rules and laws to assure the development of something. However, co-creation has to flow from the center of the community and with the active participation of all the stakeholders, including the design team. Social Participatory Innovation is a process of learning and reflecting on practice, and recognizing the other as part of the process and the solution. Generating empathy and ownership for what is proposed.

(ii) Designing finances and micro-finances.

There has been a significant shift in rural finances since the mid-1980's. It changed from subsidizing credit to sustainable financial systems with the introduction of Micro Financial Institutions (MFI). These new models attempt to change from higher transaction costs and risks for clients and intermediaries to empowering users by increasing their financial participation, ability to purchase and ability to make their decisions (Zelle, M. 2003). Financial Innovation has also helped to improve people's experiences with MFIs. For example, launching context-wise solutions that make products and services more accessible to users or acquiring new technologies that promote financial growth and social entrepreneurs (Mugo, J. G., 2012).

Nevertheless, designing for micro-finances has its challenges. According to Banerjee, A.V. (2010) people with low income behave with a strong preference of consuming today, rather than tomorrow. This behavior implies activities such as borrowing money at extremely high rates, saving minimum resources and living on a daily based budget. However, this doesn't mean that low-income citizens aren't capable of managing their resources. They just do it differently. Misconceptions about their decision-making

generate a misguidance regarding the way they operate. Also, low-income citizens can't save because they don't have proper mechanisms to do so. Dupas & Robinson (2011) tested simple saving tools and tracked the continuity over time. A simple intervention like a safe place to put money aside proved the commitment of the members of the community to their goals and increased their intention to save money.

So then, why forcing existing products when it is possible to design ones that can adapt to people's practices and concerns? Every community has its needs, resources, and practices. It is important to emphasize that the intention should not be to copy an individual model and replicate it on a different context but rather create the right solutions for specific situations.

(iii) Design and conservation.

Correspondingly, in his book "How to thrive in the next economy" Thackara, J. (2015) explains that natural environments consist of three primary levels: practical, cultural and ecological. Those levels include the land and the people living on it. Those people, are probably the ones that have more knowledge about the territory, they have been part of it, they are in constant interaction with it. So to come to solutions that can help the protection and conservation of the land and its resources, we need to work together with the community at all levels and through all stages.

That is the case of Patrimonio Natural. They are a mixed fund that is in charge of managing the resources intended to promote conservation in Colombia (2016, Retrieved from http://patrimonionatural.org.co/). One of their projects is the 'Landscape Conservation Program' in the Caribbean. It focuses on protecting the dry tropical forest under a model of production-conservation centered on the inhabitants of the region. This program involved a contextual research phase to investigate the culinary traditions and cooking techniques of the local communities. It was followed by a series of co-creation workshops that resulted in the design of an eco-efficient stove, PRIMA, adapted to their cooking practices that reduced wood consumption by 60% and carbon emissions by 90%, it is simple to assemble and transport. Following the holistic nature of the program, Patrimonio Natural supported the creation of a local women's association that sells and manages the repair services of the stoves in the region (Fondo Patrimonio Natural, 2016). Thus, encouraging the appropriation of the stove in the area aiming at empowering the local community to integrate it as part of their economy, which gave way to the case study of the current paper.

3. Case study – Yaví and Pocharco

(i) The context.

Colombia is considered to be one of the most biodiverse countries in the world (UN Environment World Conservation Monitoring Centre, 2017). In 1995, the country became part of the Biological Diversity Agreement that proposes the conservation and sustainable use of the biodiversity, as well as the fair and equitable sharing of the benefits derived from the use of it. As a result of this agreement, the National System for Protected Areas (SINAP) was established. This system has summoned different groups and entities to be part of it, managing and executing resources to follow the objectives proposed by the

agreement. One of those entities is Fondo Patrimonio Natural. In 2014, the United Nations Development Program (UNDP), started the project Sustainable use and conservation of biodiversity of dry ecosystems by Fondo Patrimonio Natural. It aimed to "improve the quality of life of vulnerable communities, through the reduction of the current tendency of deforestation and desertification of dry forests, the conservation of biodiversity, a sustainable use of the soil and carbon fixation, in prioritized places in Colombia" (UNDP, 2017), like Natagaima. The program wanted to evaluate the possible insertion of the Prima stoves into the community. The challenge of the design team was to define a microfinance model that would help them engage in sustainable practices, regarding the use of the natural resources in their area, by ensuring the accessibility to clean technologies. However, replicating this approach in different Colombian regions, as Manzini (2015) explains, is a matter of "how different groups of people may recognize, adopt and localize" the idea. To scale the model to a new Colombian region, going to the field to understand local practices and engaging local communities was essential.

As a matter of fact, working with people in rural areas in Colombia is an enjoyable experience, especially if we allow ourselves to learn from them. Their wisdom, generosity, and resourcefulness to do things are invaluable and unimaginable. The field trip led us to met the people from Yaví and Pocharco, two "veredas" from the municipality of Natagaima, in the department of Tolima, in the center of Colombia. Only a week spent in the area gave the hope and energy needed to believe that change is everyone's business. On this short stay in Natagaima, we learned that a few years back the woman running the only local store sold, on credit, to most families in the community for eight months in a row, through the time when laborers were not getting paid their daily wages. We discovered that when someone gets sick, they call Jaime, one of the neighbors. He drives them to the doctor; it doesn't matter if they call at 3 am, he will not ask for money. He knows that they will find the way to acknowledge his act either with money, mangos or avocados. We discovered self-sufficient farms that proved the resourcefulness of the inhabitants, like the one owned by Santos (Figure 1), a happy local farmer that has been building his life project on his plot for ten years and has achieved a fully productive hectare that allows him to maintain his family. He is the proof of a network that interacts with the market by selling its goods outside of the community. The members of the community often attend a weekly market in a village about one and a half hours away to sell their produce. However, most of the operations within the community are fulfilled without any money exchange based on non-written rules of loyalty and reciprocity.

Figure 1. *Santos' family.*

(ii) Articulating the alliance.

After succeeding with Prima in the Caribbean region, Patrimonio Natural was initiating the endeavor of replicating the model: to produce, commercialize and repair the stoves; with two indigenous communities –Yaví and Pocharco– in Natagaima, Tolima, a Colombian region where the tropical dry forest is at risk of extinction as well. The project approach was to go in an initial fieldwork trip to conduct research around two main areas: the local culinary practices and microfinance habits within the communities. Research on these topics would set the ground for future work in the area. While two design-researchers from Patrimonio Natural would explore the local cooking practices, in parallel a design team by seven master students and three professors from the Design Department of Universidad de los Andes would focus on studying microfinance and productive practices. The project was part of the course "Innovation for education and financial inclusion" offered by the Design Master Program.

The goal set by Patrimonio Natural was to facilitate a microfinance model that facilitates access to clean technologies for vulnerable communities taking as flagship example the project of the Prima stoves.

(iii) Our approach – closeness and transparency

We based our project approach on the framework proposed by Beckman & Barry (2007) that understands innovation as an iterative learning process in which adaptation is essential to create meaningful solutions that address real needs. For each stage we tailor made our own tools drawing from design ethnography (Barab, S. A., Thomas, M. K., Dodge, T., Squire, K., & Newell, M., 2004), social cartography (Navarro-Sanint, M., 2013) and cultural probes (Gaven, B., Dunne, T., & Pacenti, E., 1999)

To illustrate this case study we will discuss in more detail the process we followed in the exploration phase of the project during our fieldwork trip.

(iv) The fieldwork experience

During the time we spent in the field, planning the activities, collecting data, and analyzing was crucial. Before going there, the students did a desk research about the community, their practices and the way their economy works. When the team arrived at the territory, the students visited different contexts with some members of the community, in which they were interviewing them while they carryied on with their daily routines.

We visited the Sunday market, milked a cow, helped to hoe and shovel a communal garden, among other activities. While we were visiting the people, we were trying to understand how each household worked by conducting ethnographic interviews (Spradley, 2016) and using diagrams that helped us visualize how and which elements enter and leave the house (Figure 2).

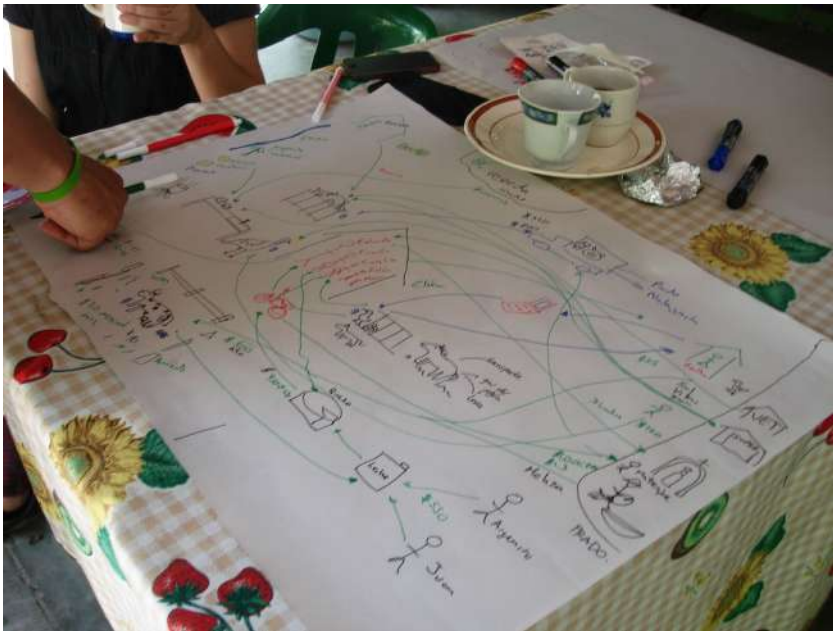

Figure 2. *'Our home' input and output diagram from a visit to one families from Yavi.*

Once we had mapped people's practices we gathered the community to create a social cartography (Navarro-Sannint, 2013). At that point, we had learned about the practices of each family, but we wanted to figure out how were the dynamics in the territory and how people interact with each other beyond their family members. We divided the group into three smaller groups to we assure the participation of all of them. We started by asking them to place the known landmarks: rivers, mountains, school, among others. Then we asked each of the participants to locate their houses (Figure 3) and then we suggested to spot the ones that were absent or were in the other groups.

In the end, each group presented the resulting map to the whole community. Each map highlighted aspects that were important for the ones participating, but also helped to visualize meaningful interactions and relations among people in the community. From that, roles of leaders emerged, as well as characteristics of individual people that were key to the community.

Figure 3. *One person from Yavi, showing where her house was located in the map.*

In the middle of field trip, we took some time to analyze what we had gathered so far.. We had to do it fast so that we could draw some valuable insights from the interviews and sessions. We compiled all the observations and ideas on a wall. Once we had all, we clustered them into topics and began to interpret what we had. Parallel to that, we began to define profiles of the key persons (Figure 4). By the end of the analysis session, we had determined five topics that would be the insight seeds for possible design directions.

Figure 4. *In the process of analyzing Santo's profile, one of the most inspiring people of Yaví.*

Before we left, the design team wanted to have one last session with the people of Yaví. For that, the students prepared a generative session that consisted on evoking the last big project that a person had done, and how they managed to do it, what kind of resources, assistance, or decisions they had to take. Afterward, they would ask for the next project, and based on the reflection of the first part of the exercise, the person had to propose the most efficient way of doing it. For that, the design team prepared some material to build a house to support locals tangibilize their ideas while they were talking (Figure 5). This tool allowed us to understand their decision-making process and let us identify paramount themes to start defining design proposals.

Figure 5. *Generative session of previous and future projects.*

As part of the documentation of the project, the students created a video that summarized the insights of the work with the community (2016, April 12. Retrieved from https://youtu.be/vidcevDO0b4)

(v) Proposals

To meet the requirements of Patrimonio Natural, the students presented three proposals. Trust and solidarity inspired the first one. It was a flexible credit system that allowed people to ask for bank loans in groups and according to the time of their harvest. The members agreed to look after the others and support one of them when delayed with the payment. The second one was a network of local producers that were able to access to information about offer and demand for their products, as well as the reputation of the buyer. The third one was a saving and investment system using animals. The users of this system will raise a pig, during the process they will attend workshops to expand their knowledge on animal care, as well as productive, financial and social topics. At the end of each raising cycle, the user will exchange the animal, and in return, they can get another small one, money or vouchers to spend on clean energy products. This last project was deployed to the community for further testing.

4. The results

At the beginning of the course, the students had difficulties trying to grasp the project brief. Even though they had meetings with Patrimonio Natural, did a background research of the community, and studied all the documents available about the region, they had doubts about what was their role as designers and what kind of contribution they were able to offer. This kind of projects need to take into consideration all

variables, and one of those is to be in the context, experiencing face to face what is the daily routine of the people in their community. However, it demands more that just observing; it is about interacting with the community,sharing, learning, and collaborating. It is about taking responsibilities for what you do.

When the students had to deal with this situation, the perspective of the project changed dramatically. They started to feel the project as if they were part of the community. They created a bond so that they became interested in the community, beyond the project brief. This method opens the possibility to interact with communities and develop a more empathic way of working. Where everyone has the chance to contribute, and every solution is shaped to create value.

Facing a complex project demands a deeper understanding of the context, people, and interactions, especially, when the design team doesn't know the context first hand. One of the first impressions that we had when approaching to the community is that they were expecting that we were going to tell them what to do. This kind of behavior is related to top-down approaches which impose certain types of solutions without acknowledging what the community needs and the knowledge they hold. Using Social Participatory Innovation enabled the design team to get involved in the context, learn from the local community and plant a seed for co-creation in the community.

5. Conclusions

It is too hasty to conclude that this method is the answer to all complex projects. However, it broadens the spectrum and creates possibilities that are promising when facing multidisciplinary and multi-layered projects. Facilitating spaces for co-creating microfinance models was the excuse to prove the Social Participatory Innovation approach. Involving the community through the exploration phase of the project, beyond observation, by using tools such as the household mapping exercise or the collective social cartography, was essential in raising the community’s self-awareness regarding their practices. This awareness proved to be crucial in generating the self-reflection necessary for the community to feel empowered to actively co-design solutions that impact them.

Surely, this is not the only possible approach, but it is one that would allow the research or design team to engage, interact, share, and learn from all the stakeholders. Moreover, this model might contribute to driving innovation in a broader variety of contexts, such as private organizations, government entities, and, of course, communities of different nature.

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Don't Throw It All Away:
Innovative recycling solutions to waste management in tourism communities

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ABSTRACT

Costa Rica's tropical beaches attract millions of tourists annually, yet increased waste generated by growing tourism threatens the environment tourists seek. Recycling removes large quantities of reusable materials from the waste stream and reducing disposal directly into the environment. While Costa Rican law requires municipal trash and recycling collection, remote tourism areas lack recycling programs. Using GIS mapping of litter and residential surveying, this research aims to evaluate at the social-environmental interface in relation to waste management solutions in the context of tourism communities on Costa Rican's Nicoya Peninsula. This study argues that social impact assessments can play a key role in evaluating regional development strategies and fostering effective community response. Examination of residents' role in developing waste management solutions indicates that a recycling program will likely mitigate social and environmental risk but local skills and knowledge are still largely undefined or incorporated. A partnership with a garment manufacturer to collect recovered ocean and post-consumer plastics for use in apparel may provide a socially agreeable solution in the face of government inaction. However, low levels of bonding among diverse residents and low participation in civil organizations indicates that further investment in social capital formation is necessary to produce positive outcomes.

Keywords: sustainable tourism, marine plastics, Costa Rica, social impact assessment, public-private partnerships

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Introduction

Over the past 25 years, Costa Rica's economic revenue stream has switched from primarily agricultural exports to service industries. Now a full 40% of revenue is generated from service industries, including tourism. The natural beauty and political stability of Costa Rica made it well placed to host 2.9 million of the 1.140 billion global tourists in 2016 (La Nación, 2016). Many of those tourists self-report interest in environmental protection and sustainable travel. According to the Center for Responsible Travel, 42% of Costa Rica travelers consider the environmental and social impacts of their travel and 10% cited sustainability as the main factor in selecting a holiday destination (CREST, 2015). Despite attracting self-reported environmentally conscious tourists and the private efforts of some hotels, Costa Rica faces many logistical challenges when addressing the negative environmental impacts of tourism, especially solid waste management (SWM).

The United Nations has declared 2017 the International Year of Sustainable Tourism for Development, making this discussion on sustainable waste management in tourism areas especially timely. The United Nations Environmental Program has identified solid waste production as one of the main threats to environmental protection, estimating that during 2011, 4.8 million tons of solid waste was generated worldwide from international tourism alone, representing about 14% of the total municipal solid wastes generated annually (UNEP, 2012).

Concern over environmental issues related to 'sun and sand tourism' has become a serious problem of rising magnitude (Williams, et al., 2002). Costa Rica, like many other nations, is in danger of degrading the potentially sustainable form of revenue through ill-planned tourism, particularly regarding waste management. These matters are compounded by the demands of ecotourism, which generates more waste in isolated communities and are the least likely to have SWM programs able to address such demands. Though marketed as ecofriendly, unplanned, unsustainable tourism can jeopardize the very environment that attracts tourists and sustains communities.

The Costa Rican *Integrated Waste Management Law* (*Ley para la Gestión Integral de Residuos*, No. 8839, 2010) requires municipalities to collect both trash and recyclable materials, although recycling collection is rarely implemented outside main metropolitan areas. In Santa Teresa, a tourism town situated on the southern tip of Costa Rica's Nicoya Peninsula, the waste infrastructure system is insufficient to deal with local waste, let alone that produced by the growing tourism population. Local residents indicate that the largest portion of trash is plastic. Litter is also primarily plastics, as confirmed by mapping of waste along the main road. While residents agree that waste management and recycling must improve, challenges to plastic collection include high bulk and low retail value. The migratory nature of touristic consumption and resulting contamination encourages evaluation of the social components of those communities left holding the figurative trash bag. This paper serves as a case study of the role of social participation in addressing SWM issues in coastal tourist towns hosting greater numbers of visitors. Using social impact assessment (SIA) as a gauge, this research considers the role of social capital in influencing environmental protection outcomes.

Social impact assessment to improve community outcomes

All social change brings positive and negative consequences, but in the case of unplanned tourism growth, local community members have little say in the direction of grow or response to negative impacts. Recognizing how social issues are understood, experienced and addressed is essential to ensuring that development initiatives are accepted and have the desired positive outcomes (Vanclay, 2015). Addressing the local communities' concerns can ensure that positive outcomes are socially sustainable, generating a "social license to operate" (Dare et al. 2014).

The key to any successful sustainable development solution is cooperative engagement with the influenced community (Webler et al., 1995). Coproducing knowledge can build community resilience to enhance outcomes (Noris et al., 2008). This is particularly necessary when addressing the negative social, economic or environmental impacts that are perceived as common problems (Imperiale &Vanclay, 2016b).

Implementing a sustainable intervention to a social problem requires skills and commitment to understand, manage and improve the social aspects of environmental impacts. Social impact assessment (SIA) is a valuable tool for enhancing community resilience. SIA is a field that looks to address all social aspects of project development (Vanclay, 2016). The theory is applicable to tourism planning and addressing the unintended consequences of unsustainable practices. This study will exhibit how principles of SIA can be used to evaluate and enhance a coastal tourism waste management initiative. The case study will use the following SIA principles to identify steps and evaluate the strengths of this recycling initiative.

1. Identify and mitigate the social risks and vulnerabilities that characterize the social context;

2. Acknowledge local needs and desires for, and perceptions of, past, present, and future development;

3. Recognize the local knowledge and local capacities that need to be engaged and strengthened;

4. Build deliberative spaces and facilitate deliberativeness in order to enhance social development (Vanclay et al 2015).

SIA is concerned with the process of identify and managing social aspects of development projects to bring about a more socially sustainable outcomes (Esteves et al., 2012). While often implemented to assess large scale infrastructure projects, SIA is not typically used in small scale community projects. Rural tourism communities need tools to develop greater capacity to address negative impacts of waste, water management and climate impact, among others. This study demonstrates how applying SIA to a coastal ecological project has the ability to increase positive outcomes, including project scope and continuity while building community resilience. This study will overlay the SIA methodology with the recycling project to evaluate of positive social outcomes and strategies to alleviate potential negative impacts.

Impacts of tourism in Costa Rica

The National Board of Tourism reported a 12.8% increase in tourism from 2015 to 2016, continuing an uninterrupted trend of growth since 2010 (Fallas, 2017). With 100,000 jobs directly tied to tourism in 2013, and another 250,000 indirect jobs, most people support the economic growth model driven by tourism (WWTC, 2014). However, little discussion about the negative externalities of growth occurs at a national or local level. Tourism growth is assumed to be positive by most parties since it provides jobs and boosts Gross Domestic Product. This attitude is exemplified in a statement by Isabel Vargas, president of the Costa Rican Institute of Tourism (Instituto Costarricense de Turismo, ICT). “We always consider any increase in the number of visitors as positive, but we can’t say we’re satisfied – it’s not enough. Costa Rica has the natural conditions and a tourist product to attract more travelers than those who are coming now.” (ICT, 2017).

As a measure to safeguard resources while trying to capture an ever larger portion of the tourism market, Costa Rica has encouraged responsible tourism as a measure to safeguard resources, primarily through a Sustainable Tourism Certification program (Instituto Costarricense de Turismo). Ecotourism applies the three pillars of the “sustainable development triangle”, a balance of social, economic and environmental protection, to travel, as promoted at the United Nations Conference of on Environment and Development in Rio de Janeiro, Brazil (Munasinge, 1992). Sustainable tourism attempts to minimize negative impacts to nature and culture while maximizing economics benefits to local communities (Fennell, 2015). Waste management is a crucial issue often overlooked in the examination of sustainable tourism. Improper waste disposal undercuts sustainable tourism initiatives by contaminating water, harming wildlife, and increasing the spread of diseases such as dengue. Tourism has now generated more revenue than the three main agricultural crops, banana, coffee and pineapple, combined (Leitón, et al., 2016).

There are significant impacts involved in hosting 2.4 million tourists in a country with a population of only 4.5 million. According to the most recent national census data, Cobano municipality, the site of this case study, has a local population of approximately 10,000 residents with 150,000 tourists visiting annually (Instituto Naciónal de Estadística y Censos, 2011). The implications are particularly serious where the country has been unable to develop SWM infrastructure to adequately address the demands of its own citizens. Roughly 2,400 tons of waste is generated daily in Costa Rica, with 250 tons dumped illegally into streets and rivers (Frankie, 2004). Dumping and burning of trash occurs because of proper waste collection, though a responsibility of the municipalities, is inadequate or absent in many rural areas. These are the same areas that see the highest rates of ecotourism.

The point at which tourists intersect with Costa Rican waste management systems only exacerbates existing problems. Those who visit small towns near national parks and beaches also most often demonstrate high consumer patterns and generate more waste. Residents of the United States, on average, produce at least twice as much waste (2.2 kg per day) as people in Latin America (1.1 kg) (Hoornweg, D. et al., 2012). In addition to initially high levels of waste production, people often increase their consumption when on vacation.

Unable to rely on inefficient or even corrupt municipalities, some communities are developing site-specific solutions. Residents of Santa Teresa have identified an environmental risk, acknowledging the need for a solution at the local level and are in the process of deliberately including the community to achieve a socially and environmentally sustainable solution. This paper serves to evaluate progress and remaining challenges to effective implementation. The case of this community's efforts to implement reuse, recycling and proper trash disposal in their tourist town highlights the challenges and possible transferable solutions to improved waste management.

Right to a healthy & clean environment under international and national law

What obligation does the Costa Rican government have to provide waste management to its citizens? There are strong national and international duties to provide a clean and healthy environment. The core forum to which American States can bring cases regarding human rights violations is the Inter-American Commission and Court of Human Rights, created by the American Convention, which was adopted in 1969 and entered into force in 1978. The Convention provides rights which can be related to environmental protection, including the rights to life (Article 4), humane treatment (Article 5), personal liberty and security (Article 7) and use and enjoyment of property. The Inter-American Commission has found that "The realization of the right to life, and to physical security and integrity is necessarily related to and in some ways dependent upon one's physical environment. Accordingly, where environmental contamination and degradation pose a persistent threat to human life and health, the foregoing rights are implicated" (Inter-Am. Comm'n H.R., 1997).

Costa Rican national law confers the environmental and human rights mantle by enshrining the right to a healthy environment in the National Constitution of 1949. Article 50 of the Costa Rican Constitution states that “(a)ll persons have the right to a healthy and ecologically balanced environment. For that, they are legitimated to denounce the acts that infringe on this right and to claim reparations for the damage caused” (Costa Rican Constitution, 1949). This guarantee demonstrates that the Costa Rican government identifies a healthy and ecologically balanced environment as a human right, going further than regional instruments that invoke environmental rights under the right to health.

The *Integrated Waste Management Law*, No. 8839 of 2010 determines the responsibilities of waste management and recycling to preserve this right to a healthy and ecologically balanced environment (Integrated Waste Management Law, 2010). This law sets high standards for landfills and requires local recycling plans, but no sanctions when they are unmet. Municipalities are only likely to face penalties for failure to provide a healthy and ecologically balanced environment when large numbers of people are diagnosed with serious illnesses (Barquero, 2016). Since sanctions for failure to follow the waste management law are not a likely means of protecting this right, innovative forms of enacting environmental justice are emerging.

Waste management in Costa Rica

Traditionally, urban Costa Rican’s have paid a trash collector to drive their waste to municipal open-air dumps while those living in rural areas have buried or burned waste on their own properties. There is also a strong practice of reusing compostable materials in gardens and repurposing goods, as incomes were low and towns far away. Solid waste has increased in rural areas as incomes rise and consumption of goods increases. Higher incomes increase the opportunity to purchase snack foods, which are problematic due to their packaging in plastic bottles and bags. This packaging is often dumped along roadsides as litter. Without combative action the problem is likely to escalate, as people are more likely to litter where they find existing waste, as opposed to well-maintained areas (Weaver, 2015). Under the Integrated Waste Management Law (*Law 8839*) the government is obligated to provide these services and safeguards via the local municipal government.

Local Waste Management

Rural waste collection and processing practices frequently fall short of legal requisite to maintain a healthy environment. In Santa Teresa, as in other rural areas, some residents resort to burning or burying trash because of irregular trash pick-up by the municipality. Other residents leave the trash at the roadside, where it is opened by dogs and dispersed into streams and the ocean. The waste problem is exacerbated by littering, to which there is little social negative response. Research suggests that the presence of litter creates an impression that little value is given to maintaining a clean environment which elicits more littering by others (Lui & Sibley, 2004). Mapping of the area (see Fig. 3) shows that nearly all of Santa Teresa/Malpais main road is covered in litter and larger debris.

Community waste management response

A group of local residents and organizations in Santa Teresa has risen to challenge the local government’s inaction in relation to waste and water management. Businesses and residents have long identified the negative impacts of recyclable materials in trash and the natural environment. Small groups have initiated collection of recyclables by a local trash collector, though without clear information most people were unaware of the program or collection days. An attempt to place recycling bins outside businesses that sell packaged foods failed because people dropped off garbage bags and construction waste, highlighting the ineffective collection system and causing the bins to be removed. These efforts indicate a desire for social change to address negative social and environmental risks of poor SWM coupled with a high willingness to participate among some residents. However, a lack of centralized planning to involve various members of the community and informational outreach has blocked the social sustainability of this project.

Figure 1: Lack of maintenance and community dumping rendered local recycling bin project ineffective, Playa Carmen, Santa Teresa, Costa Rica.

Methods

Data for waste management and recycling practices in the Santa Teresa area was collected in four, week-long site visits from November, 2014 to April, 2016. The research was conducted with the assistance of Nicoya Peninsula Waterkeeper. Each research session consisted of evaluating topics of SWM, including current waste disposal methods, recycling practices over time and mapping of waste "hotspots", areas with high concentrations of loose trash or large waste objects.

Spatial data was collected between April 25 and April 27, 2016 to determine the severity of litter and waste contamination along the main road to identify high-waste concentration zones. Mapping was conducted along the main road of Santa Teresa to determine whether any correlation between quantities of litter and location of commercial outlets existed. Tracks and waypoints were recorded using a handheld Garmin GPS device. Points were obtained from the

GPS device through DNRGPS. Using QGIS, a map was produced to display the distribution of waste hotspots along the road in relation to the markets and plazas.

Throughout the research periods, surveys were conducted with local residents in Spanish and English to identify primary environmental concerns, barriers to participation in existing recycling schemes and what factors would best facilitate participation in a local WM program. Convenience sampling was employed to gather responses from residents within 100 meters of the main road. Interview responses were analyzed for most frequent responses to identify perceived environmental impacts, determine barriers to participation and willingness to participate in recycling programs.

Results

This study of waste management in the Santa Teresa/Mail País area began by gauging local residents' awareness of the issues and self-identified primary concerns. This question was designed to evaluate community identification of social risk and dangers within Phase 1 of the SIA framework. Interview subjects' perception of behavior indicates an awareness of the negative impacts of certain waste disposal behavior, especially littering. When 124 residents, defined as people who live in the area at least 6 months of the year, were asked if they believed their community had health or environmental issues related to solid waste, 88.7% of residents surveyed responded positively. The most common responses included litter on beaches, streams or streets (45%), contaminated water (29%), illness (28%), problems with urban or wild animals opening bags and spreading trash (17%) and other environmental contamination (6%). Notably, 25% of respondents reported uncollected trash filled with rain water contributes to a rise in the mosquito-vectored disease dengue fever, which could constitute a violation of the right to a healthy environment.

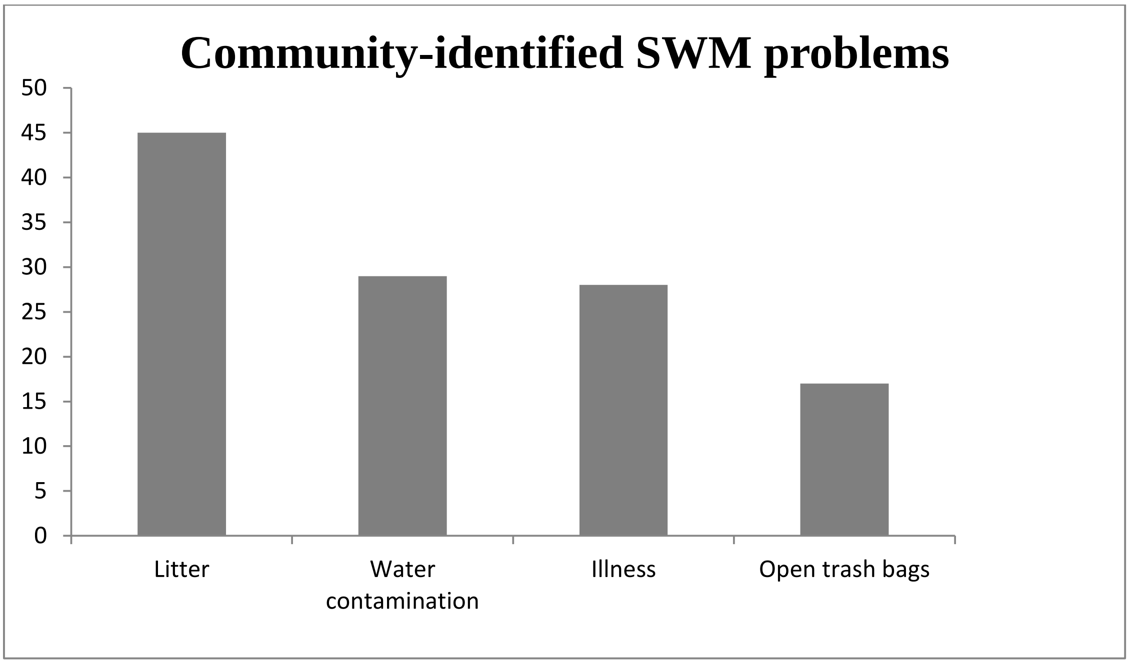

Figure 2: Most frequent responses of community members of Santa Teresa, Costa Rica, when asked to identify problems caused by trash in their community. Data collected from November 4-7, 2016.

It is not surprising that residents identify litter as a main concern. Creating a map of trash overflow and litter along the main road helps clarify the biophysical risk in Phase 1 of the SIA. Results demonstrate the extent of solid waste contamination in the zone. GIS tracking was conducted along the central road on which all business and traffic flow. Waste hotspots were documented as high concentration of loose trash and open garbage bags with scattered waste while nontraditional trash is large waste objects that are not collected by municipal garbage vehicles. Food markets and shopping plazas were recorded as waypoints to determine whether shops impact litter dispersal. Plazas were classified as buildings or plots with three or more businesses.

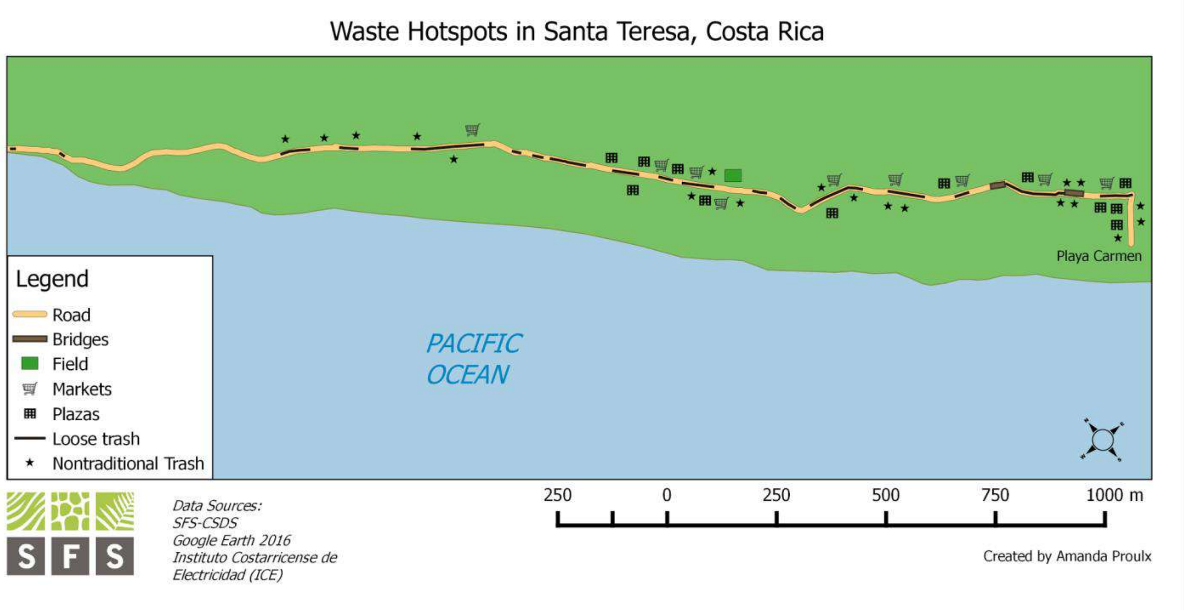

Figure 3: Distribution of nontraditional and loose trash waste hotspots relative to shopping plazas and markets. Data collected on April 25, 2016 and April 27, 2016.

Phase 2 of the social impact assessment calls for recognition of the local reception and perspectives. To further this agenda, surveys concerning which recycling solutions best address local needs were conducted. The majority of participants responded that plastics both make up the majority of litter and are the most difficult to recycle because of combined lack of economic value and large volume/low weight.

Information collected on perceived obstacles to participation in recycling and community reported solutions correspond to Phase 2 of the SIA analysis. Several themes arose when residences reported on barriers to recycling. A quarter of participants cited a lack of motivation (24%) or a lack of education (26%) as primary obstacles to participation. When asked specifically about desire for education, 77% of participants responded positively to wanting more information about recycling in the future, though most participants reported having “some knowledge of recycling” or being “very familiar with recycling” (*avg=3.44 on a scale of 0-5, 0 being no knowledge and 5 being a high level of knowledge*). Residents also noted that the volume of materials they needed to recycle, lack of transportation, and lack of storage space between local, monthly collections posed significant challenges. Lack of time or transportation to bring recyclable materials to the collection center during collection days was noted by 31% of residents, with an additional 9% explicitly citing the lack of a pickup program prevented them from recycling. Twenty-four percent of participants expressed frustration with the lack of a government-sponsored program. Only 8% of respondents cited lack of economic incentive (8%), and an even smaller number, 4%, reported being unwilling or unable to sort their recycling.

When asked specifically what recycling arrangement would best facilitate their participation in a local program, 42% of residents expressed a desire for more information about how and where to recycle. Twenty-eight percent also expressed a need for collection near their residences, with 7% citing the need for a local collection center. Fig. 4 illustrates community-identified problems with the current recycling system and local respondents' suggested solutions.

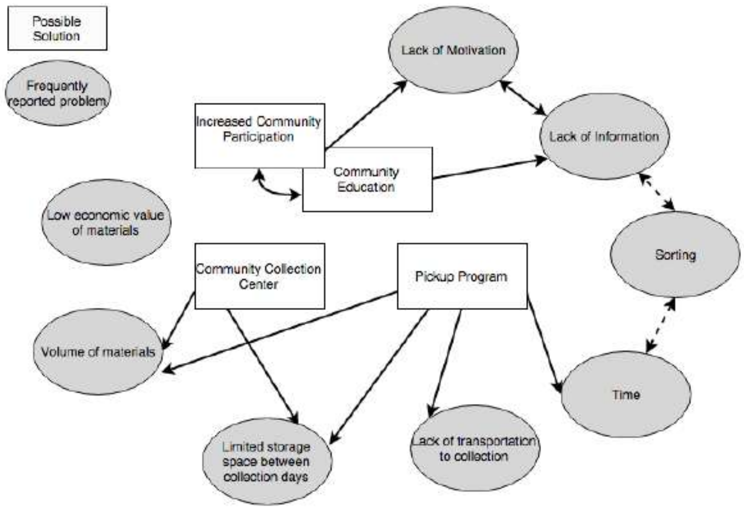

Figure 4: The interaction of frequently reported barriers to participation in recycling and frequently suggested solutions of interviewed community members of Santa Teresa, Costa Rica.

Discussion

Lack of public waste system inevitably leads to negative implications for residents' health and economy which are tied to environmental well-being. These findings indicate that residents are aware of these consequences, which may be useful in generating participation and building social capital around future recycling schemes. The effects of three problems most commonly identified by local residents, litter, dengue and water contamination, can have a most serious impact on the lives and livelihoods of residents.

Health implications

The lack of a fully functioning waste management system creates a web of interconnected health, economic and environmental hazards. Human infection with dengue and dengue hemorrhagic fever generates a cycle involving humans and *Aedes aegypti*, the most common mosquito vector (Knudsen, 1995). Jose Pablo Delgado, President of the Camara de Turismo de Malpaís y Santa Teresa, reported Santa Teresa had one of the highest per capita number of cases in Costa Rica during 2015, with 250 treated cases (Delgado, J. P., President, Camara de Turismo de Malpaís y Santa Teresa, personal communication, April 23, 2016). Research by Getachew, Tekie, Gebre-Michael, Balkew & Mesfin, (2015) demonstrates that *Aedes aegypti* breeds in rainwater that collects in a wide range of artificial containers. The lack of effective SWM systems means that litter continues to provide ample breeding habitats and denies citizens their rights to a healthy environment, as guaranteed in Article 5 of the Costa Rican Constitution.

Economic Development Implications

Waste management directly impacts the local economy in many ways, including the contamination of land and marine areas which attract ecotourists. While the local economy was once based on ranching and fishing, up to 95% of economic activities is now directly or indirectly tied to tourism (Delgado, J. P. President, Camara de Turismo de Malpaís y Santa Teresa, April 23, 2016).

Researcher have found that a key factor for tourists when selecting a beach is the absence of litter (Ballance, Ryan, and Turpie, 2000 (Ballance, Ryan, & Turpie, 2000). It is a factor that can be managed and controlled but has been neglected by the government and can seem overwhelming to unassisted communities. As demonstrated in the map (Fig. 3), it is currently impossible to avoid litter and waste on the main road. Beaches are strewn with debris, which is occasionally collected in beach clean-ups carried out by hotels that belong to the environmental certification program, Bandera Azul (Blackman, Naranjo, Robalino, Alpízar, & Rivera, 2014).

Environmental implications

Solid waste has a particularly negative impact on waterways, which are of great concern in this coastal area. Litter and trash enter streams, which discharge into the ocean. Research by Cózar, et al. estimates the amount of plastic in the open-ocean surface to be between 7,000 and 35,000 tons (2014). This epidemic of ocean waste, primarily plastic, is due to ever increasing human consumption, glacial biodegradation of petroleum-based products combined with the lack of proper waste systems on land. Some ocean plastics return to the land, washing up on the shore where they further injure wildlife, while driving away lucrative tourism.

Considering the failing local WM system in Santa Teresa, reducing waste is an ideal option for minimizing the likelihood of entering the ecosystem. Interviews with local residents show that there is a willingness to recycle but it has been difficult since there is no municipal recycling program. Since 2015, the local NGO Nicoya Peninsula Waterkeeper conducts monthly recycling collection. They have collected approximately 20 tons of recyclables since the initiation of the program but participation is limited to those who can bring their own materials to the site, as there is no collection service (Chavarría, C., Nicoya Peninsula Waterkeeper Executive Director, January 12, 2017).

Community action – Towards a Bionic solution

Municipal governments face challenges that pose obstacles to meeting waste management obligations, including broad geographical zones and inadequate budgets. In Santa Teresa, a group of local residents and organizations has risen to challenge the local government on its inaction in relation to waste and water management. Communities around the world facing similar challenge have devised means of addressing and even profiting from trash. Pioneers in community waste collection and repurposing include Ocean Soles, an organization started in 1997 to transform discarded flip flops into animal sculptures and other merchandise. This model of direct repurposing of materials, usually as souvenirs, has spread and positively impacts the environment with improving participants' livelihoods (Abdelhamid, 2014). The actual quantity of waste collected and used can, however, be limited. And the market is restricted to those interested in purchasing these specific goods and souvenirs.

There is increased awareness of the negative environmental impacts of waste generation from packaging and action to recycle those materials, despite considerable use of energy and the often inferior quality materials, known as *downcycling* (McDounough & Braungart, 2012, p. 56). There is less awareness surrounding the environmental damage from producing clothing and the waste generated from the disposal of textiles. Retailers encourage customers to purchase and eventually discard, more clothing at an ever increasing rate in a phenomenon known as disposable fashion. In the U.S., textiles make up 9% of the 251 tons of municipal waste (United States Environmental Protection Agency, 2012). Innovative textile manufacturers have developed a closed loop recycling system which breaks down the raw materials in post-consumer waste to be used in new products. This production process releases fewer environmental contaminants and ensures that textiles are not being made from virgin raw materials (Payne, 2015).

The non-profit organization Thread had devised a non-profit solution which involves paying local Haitians to collect plastic bottles and turning them into thread for garment production. This provides income for bottle collectors while removing waste from the environment (Tierney, 2014). Limitations of this model include 1) the plastic type is limited to PET 2) the type of polyester thread produced from bottles is only suitable for certain fabrics and 3) while ideal for an area with high unemployment, this model would be difficult to replicate in areas with fewer people willing to work in plastic collection.

Bionic® has proposed as different combination of market-based, socially responsible production to incorporate plastic waste that enhances instead of downgrading the quality of recycled plastics. This New York-based company aims to incorporate post-consumer plastic into fashion while increasing environmentally responsible demand by making conscious consumption desirable to a larger demographic. Bionic® started by developing high strength threads that are a blend from recovered plastic. The thread can be used to produce a wide range of goods, from to surfing board shorts to formal wear (Laposky, 2014). The start-up was developed with a social mission to recover marine plastic from coastal areas in Central America and Asia. Regions without recycling infrastructure are targeted to enhance environmental impact. Recycling centers are created in the communities so the materials are locally collected and processed (Toussant, 2015). Simultaneously, the company is working to greatly increase accessibility to these products by partnering with the international retail chain H&M on a line of clothing produced from Bionic® thread. They will collaborate with the fashion outlet in their mission to use 100 per cent recycled or sustainable materials by 2030 to ensure a growing international market for salvaged plastic materials (Singer, 2017).

Bionic® and NPWK's shared objectives of reducing plastic waste that clogs the oceans and improving local community participation in environmental action led to a recycling system collaboration in Santa Teresa. Bionic®'s mission to collect marine plastic was particularly well-suited to address the marine waste issues faced in this area. This marine plastic is often not accepted by other recycling operations due to low material quality. Santa Teresa is also a popular surfing destination, tying Bionic® products to marine protection which appeals to environmentally concerned customers. Bionic® agreed to construct a recycling center and provide a collection truck to the project, which will address residents' and businesses' need for frequent material collection. NPWK will coordinate information and education campaigns and community beach plastic collection. As managers of local operations, NPWK will also work with residents and businesses to determine collection dates, times and routes. These initiatives to involve community members in planning and awareness-raising could serve as an essential initial phase in creating social capital around this environmental action.

This innovative reuse of a wider range of plastics in garment production still raises certain concerns. If the objective is to remove materials from the waste stream, how long-term is this solution? Since most of their threads are a hybrid of two or more materials, what challenges does recycling these combined materials pose? Additionally, might shoppers consume more “fast fashion” once their guilty consciences are soothed, simple shifting the waste problem from one sector to another? More to the point of this study, does this partnership empower participatory planning that enhances the likelihood of uptake and project success at the local collection site?

Social impact assessment evaluation

SIA model is a set of actions that can be implemented by local communities to achieve improved social outcomes through enhanced understanding and better management of social issues (Imperiale & Vanclay, 2016a). The 4 phases of the framework are 1) understanding the local context 2) recognizing local concerns and capacities, 3) engaging local communities and 4) empowering sustainable transformation (Future Earth, 2014). These steps of the impact assessment are applied to the WM case study of Santa Teresa/Mal País to evaluate community consultation, involvement and empowerment. The hope is that identifying the strengths and areas for additional community cooperation will lead to improved social outcomes for this and similar local sustainable development projects.

Phase 1 – Understanding the local context

A full understanding of the local, social issues should serve as a guide for a sustainable development plan. Identifying the social area of influence and biophysical parameters of the issue helps to define the breadth of the response. An understanding of other central factors such as the impacts on affected demographics impacts and levels of local trust is necessary to mount this type of sustainable project.

The MW issue in Santa Teresa has been identified as an area of great local concern for years. Community members have expressed discontent over the current situation through official channels and local action. NPWK pivoted from strictly water quality related work to include solid waste because of local requests and apparent environmental degradation. A more complete evaluation of the problem was done through attending municipal waste disposal planning meetings and community meetings on garbage collection and alternative solutions. Collective recycling options were tried, indicating strong community support. Monthly recyclable drop off collection has grown consistently.

Creating a complete understanding of the objectives, needs and desired outcomes of the local population is challenging phase in most SIA planning. The area is very demographically diverse, with locals, Costa Rican’s who have moved to the area and foreign residents from many countries. There are educational and environmental awareness/concern differences between these groups. Fully understanding these differences will be crucial for engaging and empowering these different sectors. Particular demographic groups were also less likely to participate in meetings because of physical and time restraints, as shown in the survey data. Taking the understanding process to them in the form of surveys helped reduce exclusion from the process. This recognition helped clarify the recycling goal to include truck collection.

Phase 2 – recognizing local concerns and capacities

The recognition phase involves analyzing the impacts of the proposed intervention to make adjustments to better meet local needs. Considering local capacities is essential for effective implementation and involvement. In Santa Teresa, the first step was informing active community members and local business of the plan to build a recycling center with the help of Bionic®, which included building the center on municipal land. Stakeholders expressed concern that the municipality could determine the hour and manner of operation without community input. The municipal government, another stakeholder, was also concerned that the recycled materials would be sold at a profit. Recognizing and trying to address these concerns allowed the plan to change to placing the center on a donated piece of land, thus avoiding potentially project threatening disagreements.

The trust deficit is not limited to residents and the local government. The attempt at various private, inconsistent recycling efforts has left many locals less willing to invest their time and effort in another project. Recognizing these worries demonstrates the importance of simple and effective program that is demonstrably functional and effective.

The surveys collected over a two-year period from 124 residents helped create a program that was responsive to the needs and desires of the population. This data allowed NPWK to negotiate that other materials, in addition to plastics, be collected and recycled at the center. These surveys revealed that there is a local practice of separating organic matter that may lead to a communal composting area to further reduce material from the waste stream.

This process of listening, through multiple avenues, was crucial to acknowledging varying attitudes. The problems mentioned by participants include low levels of awareness on how to properly recycle, exclusion of some constituents, and a cultural polarization between local residents and foreign/new residents. Identifying these issues creates cognizance of areas to address and how local resources might be deployed. Teachers expressed willingness to hold recycling workshops on how to participate in the recycling program, plus send information to families with students. Businesses offered to post material on the program and sponsor collection sites, once an effective collection serve is established.

Phase 3 – engaging local communities

The “engagement” phase supports mitigation of issues by creating community lead social development strategies. The process helps local communities move from collecting information about problems and desired outcome to building shared solutions built on cooperation (Imperiale and Vanclay, 2016a). Inadequate waste disposal is an apparent problem, which many loosely organized groups have tried to address. Active social engagement offers the benefits of incorporating more stakeholders, thus reducing missteps that led to exclusion or backlash against externally designed responses.

In the Santa Teresa area, NPWK has actively sought to generate spaces and invite all blocks of society to discuss their vision of waste solutions. These have included a community liaison creating spaces of businesses and residents to discuss place-based, collaborative solutions. Each year NPWK holds an annual sustainable solutions community fair to recognize the work of local community members, hold workshops on sustainable practices and provide an open forum for new concepts, complaints and contributions. The partnership with this researcher provides an additional avenue to convey options and needs, which local organizations would not have time our resources to gather. A final example of creating lines of communication with the community involves is the use of social media. There are few mediums of local news dispersal so the NPWK Facebook page is a high traffic forum that can research all groups of residents including those living in more isolated areas.

While these efforts have laid a foundation for full community involvement, generating community participation is especially challenging. The director of NPWK likened many locals' attitude to doing the organization a favor by participating in sustainable activities, such as cooking grease collection or recycling. The community must feel ownership of the projects to create motivation and socially appropriate responses. A sense of ownership is facilitated by local involvement. Coordination by organizations like NPWK is crucial to creating forums for directed action. They must work with the community to find the balance between coordination while leaving space for locals to lead.

Working with the local municipality to address waste needs did not result in a cooperation agreement, or any commitment to provide recycling by the public entity. Seeking a more productive response, NPWK connected the community with the sustainable textile producer to provide recycling collection and removal. Acting as a bridge between the municipality, an outside company and local residents, may be highly productive but runs the risk making residents feel less engaged. If external solutions are imported, this could perpetuate the perception that local contributions are not wanted or needed. This raises the question how to facilitate local participation while empowering self-directed decision making.

Phase 4 – empowering socially sustainable transformation

The "empowerment" phase ensures that programs and tools are in the hands of local communities. This strengthens a sense of responsibility and collective direction as programs need to be adapted to meet new needs. This phase also solidifies a sense of legitimacy within and facilitates upkeep and offshoot improvement projects. The stage is ongoing, as it allows for evaluation of the costs and outcomes of a project plus the opportunity to recalibrate and improve existing plans.

Agreement with local business, local municipalities and NGOs are secured during this phase so the local community is involved in co-designing and monitoring the program. In this case, an understanding of local concerns was incorporated into the plan for a recycling center that collects both post-consumer goods and beach plastic, but there was little room for cocreating those operations. There is an opportunity moving forward to provide tools to collectively evaluate the transformation created by the current project. Because of the ecological vulnerabilities of the area, it is crucial to monitor and modify local action plans to enhance skill building and participation.

An agreement with local entrepreneurs to maintain recycling containers outside businesses is one step in empowering locals to shape the program and expand local and tourism participation. Residents have also proposed small buildings within each neighborhood where recyclable materials can be deposited before collection days to address dispersal into the environment before collection and dengue threats.

One of the expected outcomes of revisiting plans is increased social cohesion around waste issues. The recycling center will be a central component and symbol of local problem solving capabilities. This research team is also developing a Social Impact Management tool to obtain information on the recognizing and engaging phases that can be revised over time.

Conclusion

Non-governmental private partnership offers a creative solution to removing plastics from the waste stream and resulting ocean contamination while generating products that finance the collection efforts. A social impact assessment demonstrates that this program is posed to mitigate residents' self-identified challenges to participation in recycling, mainly the volume of materials, difficulty storing material between collection and lack of transportation to collection sites. Local transport needs and desire to include beach plastics in the recycling collection have been incorporated to address the specific social and environmental needs of this community. Low social capital influenced by distrust of local government, low bonding levels with the larger community and failure or incompleteness of former recycling programs remain challenges to involvement. There is a need to build space for collective action to enhance social participation and build trust among the various community actors.

Environmental organizations have an important role to play in investment in social capital formation and facilitating effective ecological preservation. Social impact assessment indicated that community concerns have been addressed when generating this local recycling solution. However, much of the planning was done without inclusive collaboration. To assure participation involving various segments of the community will be critical in implementation and adaption. This study suggests that community empowerment could successfully be used convert potential willingness to participate in direct local action. Incorporating local participants in management and improvement of the recycling program will expand the scope of participation, support continuity over time and build community resilience needed to face other looming environmental challenges including land and water use issues.

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Figure Captions

Figure 1: Lack of maintenance and community dumping rendered local recycling bin project ineffective, Playa Carmen, Santa Teresa, Costa Rica.

Figure 2: Most frequent responses of community members of Santa Teresa, Costa Rica, when asked to identify problems caused by trash in their community. Data collected from November 4-7, 2016.

Figure 3: Distribution of nontraditional and loose trash waste hotspots relative to shopping plazas and markets. Data collected on April 25, 2016 and April 27, 2016.

Figure 4: The interaction of frequently reported barriers to participation in recycling and frequently suggested solutions of interviewed community members of Santa Teresa, Costa Rica.

Waste not, want not: social innovation in the food sector

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Abstract

The wasteful management of food resources is an important phenomenon characteristic to both developing and developed countries. According to the Food and Agriculture Organization of the United Nations, about one third of the food produced in the world for human consumption is lost or wasted – approximately 1.3 billion tons, which amounts to roughly USD680 billion in industrialized countries and USD310 billion in developing countries (FAO, 2011). Food wasted in Latin America alone could feed 300 million people. At the same time almost 1 billion people stay undernourished and another 1 billion suffer from hunger[1].

The issue of food waste has relevance from several different perspectives including food security, environmental governance, resource efficiency, hazards to health and equity between different social groups (Stenmarck et al., 2016). As a result, programs aiming at the reduction of the amount of food waste take many different forms and the Sustainable Development Goals (SDGs) of the United Nations addresses the issue under at least three different domains: poverty, hunger and sustainable consumption and production. While policymaking has been active around the world in raising awareness and promoting best practices, its success to date has been limited. Meanwhile, the fast development of the information and communication sector (ICT) has led to the emergence of a number of new, innovative business models, which have the potential to handle social and environmental issues, such as the problem of food waste. Our research aims at identifying and analysing innovative economic and social practices for sustainability in the food sector. An inventory of different approaches to the utilization of food waste will be introduced, as well as the results of an analysis of these initiatives from both a sustainability and business model perspective.

We evaluate private, voluntary and combinatory initiatives based on the experiences of existing recent examples using mainstream management theories (such as the resource based view of the firm and transaction cost theory) to draw conclusions regarding their long term viability. Initiatives such as the Leftover Swap (a smartphone app to help barter or give away food leftovers), Foodsharing.de (established in 2012 in Germany and run with the participation of individuals, supermarkets, restaurants, bakeries, and food stalls, to be closed by Berlin authorities in 2016) and the solidarity fridges in Galdakao will be examined regarding their environmental and social impacts. Our research includes both European and Latin American examples and differences and similarities will be pointed out.

Conclusions resulting from the research will cover suggestions for policymakers regarding the promotion of social innovation in the field as well as advice to practitioners based on failure and success stories.

Keywords: food waste, food supply chain, social innovation, sustainable business models, UN Sustainable Development Goals

[1] http://www.un.org/sustainabledevelopment/sustainable-consumption-production/

1. Introduction

The wasteful management of food resources is an important phenomenon characteristic to both developing and developed countries. According to the Food and Agriculture Organization of the United Nations, about one third of the food produced in the world for human consumption is lost or wasted – approximately 1.3 billion tons, which amounts to roughly USD680 billion in industrialized countries and USD310 billion in developing countries (FAO, 2011). Food wasted in Latin America alone could feed 300 million people. At the same time almost 1 billion people stay undernourished and another 1 billion suffer from hunger.

The issue of food waste has relevance from several different perspectives including food security, environmental governance, resource efficiency, hazards to health and equity between different social groups (Stenmarck et al., 2016). As a result, programs aiming at the reduction of the amount of food waste take many different forms and the Sustainable Development Goals (SDGs) of the United Nations addresses the issue under at least three different domains: poverty, hunger and sustainable consumption and production.

While policymaking has been active around the world in raising awareness and promoting best practices, its success to date has been limited. Meanwhile, technological development, especially in the information and communication sector (ICT) has led to the emergence of a number of new, innovative solutions, which have the potential to handle social and environmental issues, such as the problem of food waste.

Research activities to be introduced in this article aim at identifying and analysing innovative social and business practices for sustainability in the food sector. To this end, we first identify and define the most important phases of the food supply chain (FSC) and their characteristics. Second, based on secondary data available in the literature, we examine the nature of food loss (with regard to both quantity and nutritional value) in both developed and developing countries (pointing at the similarities and differences between them). Finally, we concentrate our attention on innovative, radical solutions to the food waste problem utilizing social innovation including novel business models at the different phases of the food supply chain.

As a result of our research we are able to create an inventory of different approaches to the utilization of food waste and to draw up some early conclusions regarding this new, unfolding field.

2. The food supply chain and the problem of food waste

2.1 Characteristics of food supply chains

Supply chains providing people with nutrition around the globe, i.e. food supply chains (FSCs) are set apart from other supply chains by the underlying principles of food consumption (see e.g. the fundamental needs of humans), the complexity of these chains (e.g. the number of regions involved, the long distances between producers and consumers etc.) and the nature of products supplied (e.g. sensibility of products to environmental characteristics, condition of suitability for consumption, etc.).

Variances of the availability of food and the question of malnutrition link food supply chains to the global issues of hunger and inequality (Stuart, 2009; Parfitt et al., 2010; FAO, 2011; FAO, 2014; Stenmarck et al., 2016). Better management of FSCs may contribute to closing the gap between supply and demand, which will only gain more and more importance with growing world population (Lipinski et al, 2013 in FAO, 2014).

Demand for food is income inelastic, i.e. growing income does not necessarily increase demand for specific food items. Rather, a change in the structure of food consumption (e.g. from cereals to meat) is evident in countries with growing incomes. Further, food consumption does not grow over a certain level and additional income is spent on other commodities (FAO, 2011; FAO, 2013; FAO, 2014).

Food supply chains must be able to cope with huge geographical differences regarding the concentration of demand (i.e. distributing goods to highly populated areas as well as to vast areas inhabited by very few people) and the seasonal nature of agricultural production, which may result in processers and retailers sourcing from a large number of producers, in many cases small-holders, from a wide diversity of climates (Rueda et al., 2017). Furthermore, the ecological impact of farming varies across different climates, regions and ecosystems.

Herrmann (UNCTAD, 2009) notes the high level of market concentration in food trading, while according to Rueda et al. (2017) the importance of the place of origin (terroir) ascends even though the production processes (agriculture) can visibly influence the quality and safety of the product.

The most important challenge remains the vulnerability of food products: unlike most other commodities, food consists of organic substances subject to degradation, and different food stuffs have different nutritional values (FAO, 2007; Stuart, 2009; Parfitt et al., 2010; FAO, 2011; FAO, 2013; FAO, 2014). Li et al. (2014) describes modern supply chains collecting and delivering products worldwide and linking manufacturers and consumers far from each other possibly across thousands of miles. Food items harvested and manufactured in a typical area are purchased and shipped to all over the world. The transportation process exposes food products to different climates and weather conditions (i.e. physical and environmental stresses), handling activities and logistics processes including warehousing and packaging. Due to the vulnerability of food, recycling is of critical importance, which has ethical aspects (Parafitt et al., 2010): for example whether food waste is used to meet human needs directly or is diverted into feeding livestock or the production of biofuels and other materials consisting of organic compounds (e.g. packaging materials).

As a result of the special features of food supply chains, authors pay an increasing attention to their features and their consequences. Van der Vorst et al. (FAO, 2007) address the main characteristics of FSCs and interpret the general features of supply chains calling attention to the importance of supply chain management. To achieve their objectives they introduce a number of example food supply chains (e.g. the beer supply chain, the pork chain in China, the fresh vegetables chain in Thailand, the supply chain for beans in Central America in specific and horticulture in the Netherlands in general), but they do not provide a general scheme for FSCs. On the other hand, Parfitt et al. (2010) who examined FSCs on a global scale, provide a scheme containing 11 phases. Contrary to this detailed scheme, most of the relevant literature identifies five or six phases of the Food Supply Chain: (1) agricultural (or primary) production, (2) postharvest handling and storage, (3) processing and packaging, (4) distribution, (5) household consumption and finally, (6) end of life (FAO, 2011; FAO, 2013; MAGRAMA, 2013; FAO, 2014). Table 1 shows the relationship between this classification of FSC phases and the more detailed classification by Parfitt et al. (2010). The table also highlights the distinction of upstream and downstream phases as identified by Gustavsson et al. (FAO, 2011).

Table 1. *Phases of the Food Supply Chain*

Phases of FSC – Gustavsson et al. (FAO, 2011)		Phases of FSC - Parfitt et al. (2010)
'Upstream'	Agricultural production (1)	Harvesting—handling at harvest
		Threshing
	Postharvest handling and storage (2)	Drying—transport and distribution
		Storage
'Downstream'	Processing and packaging (3)	Primary processing: cleaning, classification, de-hulling,
		pounding, grinding, packaging, soaking, winnowing,
		drying, sieving, milling
		Secondary processing—mixing, cooking, frying
		moulding, cutting, extrusion
		Product evaluation—quality control: standard recipes
		Packaging—weighing, labelling, sealing
	Distribution (4)	Marketing—publicity, selling, distribution
	Household consumption (5)	Post-consumer—recipes elaboration: traditional dishes, new dishes product evaluation, consumer education, discards
-	End of life (6)	End of life—disposal of food waste/loss at different stages of supply chain

2.2 Food waste: definitions and classification

Among the many introduced characteristics of food supply chains, we focus our attention on the topic of food loss and waste emerging along the different phases of the FSC. Recently, a number of reports (e.g. by FAO, the European Environmental Agency and the European Union) have aimed at uncovering the problem and identifying its main features. Some national programs go even further and identify tasks for the different stakeholders of FSCs, such as the Spanish 'More food, less waste' program (MAGRAMA, 2013) or the waste prevention program of England (DEFRA, 2013).

In 2011, FAO published a report titled 'Global food losses and food waste' demonstrating that each year, one-third of all food produced for human consumption in the world is lost or wasted (FAO, 2011). The aim of the report is to raise awareness of global food losses and wastes, their impact on poverty and hunger, as well as on climate change and on the use of natural resources. The report adopts definitions from the publication of Parfitt et al. (2010), where food loss refers to the decrease in food quantity or quality, which makes it unfit for human consumption (Grolleaud, 2002 in Parfitt et al., 2010). From an FSC viewpoint food losses take place at the production, postharvest and processing phases of the food supply chain, while the term food waste is applied at the later phases of the FSC where they can be traced back to behavioural issues. Parfitt et al. (2010) define the terms of food loss and food waste, but in their report they refer to both as food waste.

In the FAO report the terms 'food loss' and 'food waste' are used exclusively for goods that are produced for human consumption thus excluding animal feed and non-edible product ingredients (FAO, 2011). The report states that the causes of food loss vary across the world and are very much dependent on the specific conditions and local situation of a given country or region. Food losses are subject to crop production choices and patterns, internal infrastructure and capacity, marketing chains, channels of distribution and consumer purchasing and consumption behaviour. The authors distinguish the characteristics of food loss in developing and developed countries. In developing countries – due to a lack of adequate infrastructure – food is lost mostly during the early and middle phases of the supply chain, while much less food is wasted at the consumer level compared to developed countries where food is wasted at the final distribution (retail) and consumption phases. The report adds that food losses represent a waste of resources used in production such as land, water, energy and inputs and producing food that is not consumed leads to unnecessary CO_2 emissions in addition to a loss of economic value. In 2013, a new study published by the FAO titled 'Food wastage footprint. Impacts on natural resources' focused on the environmental impacts of food waste and the main sources of these impacts from the point of view of regions, commodities, and phases of the food supply chain involved. The survey identified seven regions and a wide range of agricultural products – representing eight major food commodity groups – has been considered. The analysis showed that large variances exist in food consumption and waste-generation patterns as well as regarding the intensity of impacts of different agricultural commodities depending on their region of origin. The document uses the definition of food loss as identified by Grolleaud 2002, in Parfitt et al., 2010, but adds some components reflecting the reasons behind the phenomena. Food loss refers to a decrease in mass (dry matter) or nutritional value (quality) of food that was originally intended for human consumption due to inefficiencies in the food supply chains, such as poor infrastructure and logistics, lack of technology, insufficient skills, knowledge and management capacity of supply chain actors, and a lack of access to markets. As the document adds, natural disasters play a role as well. Parallel to the definition of food loss, food waste is defined in a more detailed manner: food waste refers to food appropriate for human consumption being discarded, whether or not after it is kept beyond its expiry date or left to spoil. Reasons for the generation of food waste include: spoilt food, oversupply, and individual consumer purchasing and consumption habits. The report introduces the term food wastage which refers to any food lost by deterioration or waste, thus encompassing both food loss and food waste. According to Gustavsson et al. (FAO, 2011) the analysis of the food supply chain phases by regions reveals that on one hand losses occurring at agricultural production phase appear homogenous across regions representing about one-third of each region's food wastage; on the other hand downstream, wastage occurring at consumption level is much more variable, with wastage in middle and high-income regions at 31–39 percent, but much lower in low-income regions, at 4–16 percent. These results resonate with the findings of Parfitt et al. (2010): the downstream phases of the FSC waste generally relate to behavioural issues.

The FAO studies represent a refinement regarding the definition and classification of food waste and call attention to the importance of food supply chains in solving the food waste problem, as well as to the differences between developing and developed countries.

Compared to these reports, the European Union uses a different approach and defines food waste as the loss of raw or cooked food material before, during or after meal preparation in the household, as well as food discarded in the process of manufacturing, distribution, retail and food service activities. Hence, food waste comprises of materials such as vegetable peelings, meat trimmings, and spoiled or excess ingredients and prepared food, as well as bones, carcasses and organs (EC, 2011).

The following table provides an overview of the types of food loss and waste at the different phases of the FSC (based on Parfitt et al., 2010).

Table 2. *Types of food loss and waste at the different phases of the FSC*

Phases of FSC	Phases of FSC - Parfitt et al. (2010)	Typical forms of food loss and waste	Food loss	Food waste
Agricultural production (1)	Harvesting—handling at harvest	• edible crops left in field, ploughed into soil, eaten by birds • crop damaged during harvesting, loss due to poor harvesting technique • out-grades at farm • loss in food quality due to that the timing of harvest is not optimal	X	
	Threshing	• loss through poor technique	X	
Postharvest handling and storage (2)	Drying—transport and distribution	• poor transport infrastructure, loss owing to spoiling/ bruising	X	
	Storage	• pests, disease, spillage, contamination, natural drying out of food	X	
Processing and packaging (3)	Primary processing: cleaning, classification, de-hulling, pounding, grinding, packaging, soaking, winnowing, drying, sieving, milling	• process losses		X
	Secondary processing—mixing, cooking, frying, moulding, cutting, extrusion	• process losses		X
	Product evaluation—quality control: standard recipes	• product discarded/out grades in supply chain		X
	Packaging—weighing, labelling, sealing	• inappropriate packaging damages product (grain spillage from sacks) • attack by rodents		X
Distribution (4)	Marketing—publicity, selling, distribution	• damage during transport: spoilage • poor handling in wet market • losses caused by lack of cooling/cold storage • products discarded		X
Household consumption (5)	Post-consumer—recipes elaboration: traditional dishes, new dishes product evaluation, consumer education, discards	• plate scrapings • poor storage/stock management in homes: discarded before serving • poor food preparation technique: edible food discarded with inedible • food discarded in packaging: confusion over 'best before' and 'use by' dates		X
End of life (6)	End of life—disposal of food waste/loss at different phases of supply chain	• food waste discarded may be separately treated, fed to livestock/poultry, mixed with other wastes and landfilled		X

2.3 Food waste in numbers

A report published by the European Union in 2011 regarding food waste estimates that approximately 89 million tons of food (179 kg per capita) is lost and wasted every year in the 27 countries of the European Union (EC, 2011). According to the report, approximately 42% of food waste originates from households, 60% of which is avoidable, while 39% occurs during processing, most of which is considered unavoidable. 5% of food waste arises during distribution and 14% comes from catering and catering services. In 2016, a new study was published: 'Estimates of European food waste levels' in the framework of the 'FUSIONS EU project (Reducing food waste through social innovation)', which provides estimates for food waste in the EU-28 countries (the estimate is for 2012 and includes both edible food and inedible parts associated with food). According to the study the sectors contributing the most to food waste are households (47 million tons ± 4 million tons) and processing (17 million tons ± 13 million tons). As the study describes these two sectors account for 72 percent of EU food waste, although there is considerable uncertainty around the estimate for the processing sector compared to all the other sectors. The study comes to the conclusion that food waste levels vary to a high extent across countries. The remaining 28 percent of food waste is distributed among food services (12%), primary production (10%) and wholesale and retail (5%).

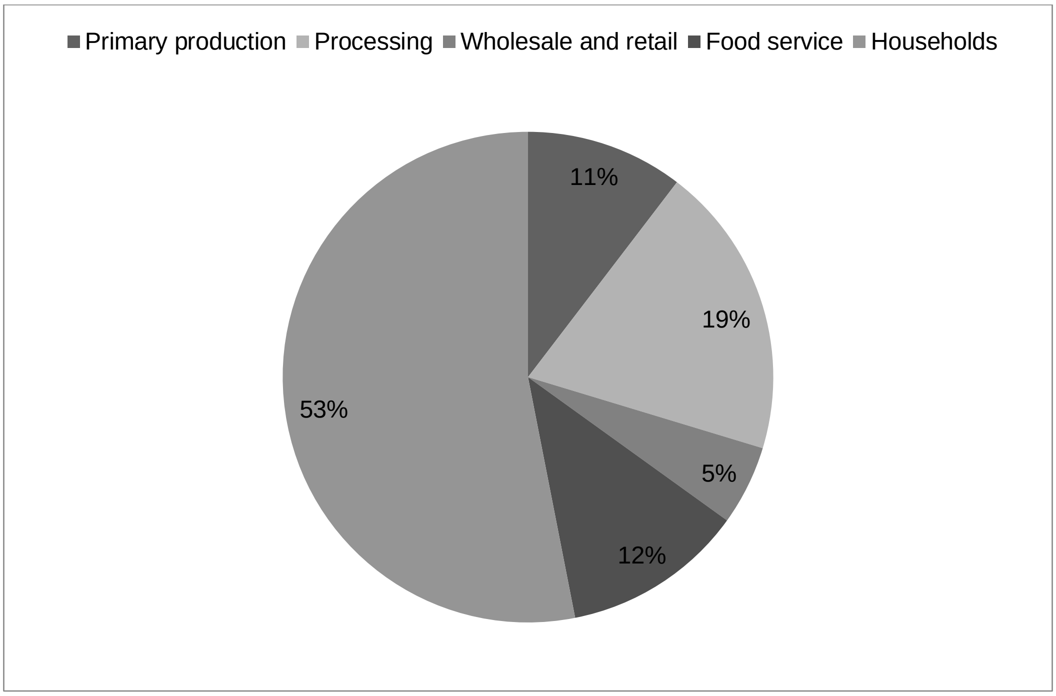

Figure 1. *Split of EU-28 food waste by sector in 2012; includes food and inedible parts associated with food. Source: based on Stenmarck et al. (2016) p.4.*

The results confirm the statements of Gustavsson et al. (FAO, 2011), the first global report on food waste by the FAO that households are wasting the most food in developed countries.

According to the country report for Hungary within the framework of the FUSIONS project, 1.8 million tons of food loss and waste is generated in the country. According to a recent survey, the amount of food waste did not decrease by 2016. Large amounts of food products are being unsold at the end of the food chain in retail stores and it is challenging to find reliable partners who can take responsibility for the distribution of these products. Thus, as a result of a lack of civil organizations and infrastructure food can hardly be transferred to those in need.

For our purposes we accept the definition of FAO regarding food loss and waste, as we apply the term food wastage to products that are directed to human consumption, excluding feed and parts of products which are not edible. We suggests that food loss occurs at the upstream phases of FSC (agricultural production (1) and postharvest handling and storage (2)), while food waste takes place at downstream phases.

As indicated earlier, there are marked differences across geographical regions regarding the amount and origin of food loss and food waste. For example, data of the National Planning Department of Colombia for 2016 estimated that about 9.76 million tons of agricultural and food products were lost or wasted in the country (Departamento Nacional de Planeación, 2016). This is equivalent to 34% of the total national food supply (i.e., 28.5 million tons) and is equivalent to the amount of food that can feed 8 million people in Bogotá. When examining the food loss and waste along the food supply chain, about 40.5% of food losses occur in the production phase, 20.6% during distribution, 19.8% during handling and storage, 15.6% during consumption, and the remaining 3.5% during processing and packaging. This shows that most of the food losses in Colombia occur in the upstream parts of the food chain, reflecting inadequate and inefficient production technologies, infrastructure and logistic systems. Particularly, the loss of fruits and vegetables is notable during the production, handling and storage, packaging, and distribution phases, while the roots and tubers comprises a significant food waste in the consumption phase.

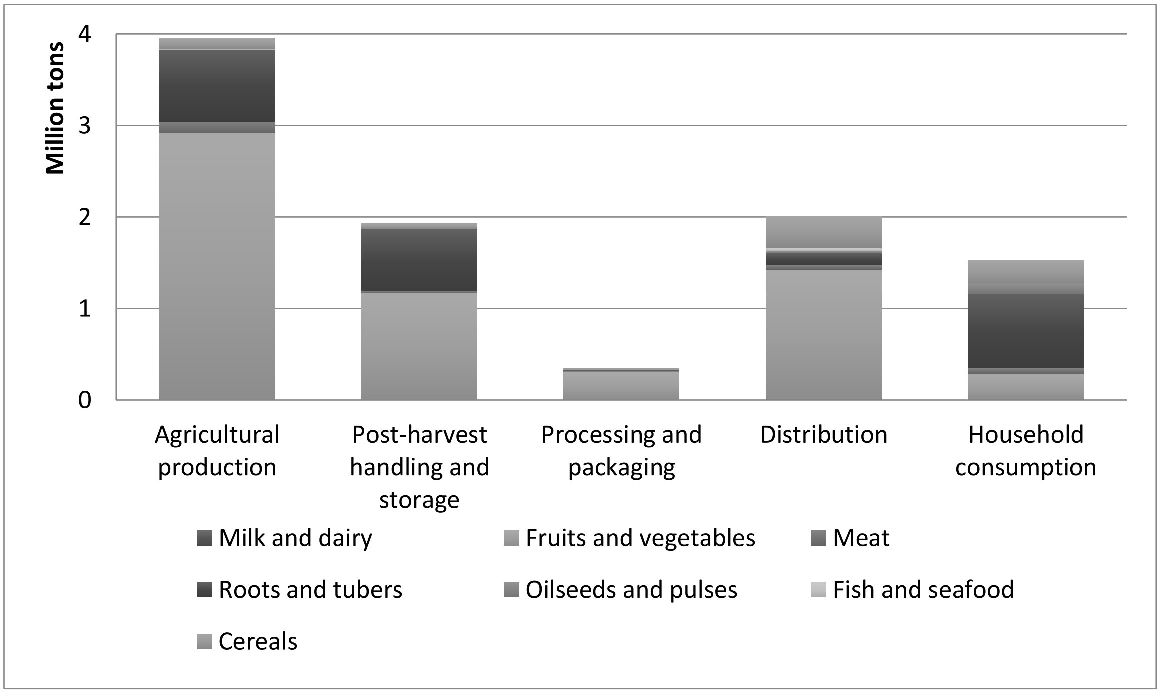

Figure 2. *Food loss and waste along the food chain in Colombia*
Source: Departamento Nacional de Planeación, 2016

2.4 National and international efforts to reduce food waste

Three years after its global survey, FAO published a report on mitigation possibilities of food wastage (FAO, 2014). The report titled ‘Mitigation of food wastage – societal costs and benefits’ provides information about how different countries/regions cope with food wastage at the different levels of the FSC. Case studies demonstrate good practices, for example upstream initiatives like the ‘Milk cooler in Kenya’, ‘Rice Super Bags in the Philippines’ and ‘Improved carrot sorting in Switzerland’, as well as downstream activities such as ‘Household food waste prevention in the UK’, ‘Food banks in Germany’ and ‘Canteen surplus to food banks in Italy’. Household food waste prevention in the UK in the framework of ‘The Waste and Resources Action Programme’ operates the ‘Love Food Hate Waste’ website where people can collect information about how to reduce food waste. The UK’s second biggest grocery chain, Sainsbury’s program produced a range of interventions for householders to test in its Waste Less, Save more pilot, which included food-sharing apps and smart fridges (Daily Planet, online). According to official statistics an average UK family discards £700 worth of food each year. For this reason the supermarket chain set a target of reducing household waste by 50%. But at the end of a ‘one-year £1m’ trial in the market town of Swadlincote, Derbyshire, the program has been abandoned as being unlikely to be met. Nevertheless, in the next phase of the programme, the chain will announce an urban trial in Peckham, London, to measure and analyse the challenges of reducing food waste for those living in dense residential – and typically multi-occupation – neighbourhoods.

Another European example is the ‘More food, less waste’ Strategy of Spain, which was introduced in 2013 in line with Directive 2008/98/EC of the European Parliament and of the Council. The strategy is implemented through recommendations, voluntary agreements and self-regulation. By focusing on five actions: a detailed study of food waste issues, focusing on why and how waste occurs (1), dissemination of good practice and public awareness (2), a review of policies (3), design and development of new technologies (4) and collaboration with other stakeholders (5) the strategy addresses challenges associated with food loss and waste along the whole FSC. As a result of the ‘What can I do?’ campaign all actors are informed regarding food waste mitigation and programs like the ‘The waste reduction week’ organized by the ministry, which provides access to knowledge for hospitality professionals, catering schools, primary schools and consumers (MAPAMA, online).

2.5 Social innovation and sustainable business models

Pol and Ville (2009) critically assess a number of recent definitions of social innovation. They come to the conclusion that while no one generally accepted definition exists, most attempts refer to new ideas, which are conducive to human welfare enhancement. They also provide their own interpretation of the notion: 'an innovation is termed a social innovation if the implied new idea has the potential to improve either the quality or the quantity of life' (Pol and Ville, 2009). Among possible examples they list innovations conducive to better education, better environmental quality and longer life expectancy.

Taking a processual perspective on social innovation Cajaiba-Santana defines social innovations as 'new social practices created from collective, intentional, and goal-oriented actions aimed at prompting social change through the reconfiguration of how social goals are accomplished' (Cajaiba-Santana, 2014, p.49).

Regarding the form and dissemination of social inventions, Howaldt and Schwarz (2010, p.31-32) argue that 'they can assume their form and be disseminated via the market (such as new services, business models, logistics and application concepts) as well as technological infrastructure ('web-based social networking'), social networking and social movements (gender mainstreaming), via governmental guidelines and support, via intermediary and self-organized institutions such as foundations, in inter and intra organizational processes, via the affect of charismatic individuals or social entrepreneurs, through 'living experiences' and a diverse array of forms of communication and cooperation as well as change-oriented 'capacity-building'.

The literature on social innovation distinguishes social innovation from technical innovations. Social innovations – unlike technical innovations – do not result in physical artefacts and are defined in terms of their positive outcomes (although social innovations do not necessarily have a positive impact for everyone). A topic often addressed regards the relationship between social and business innovation. Pol and Ville reflect on the types of innovations and come to the conclusion that there is a substantial overlap between social and business innovations: while not all business innovations can be considered as socially beneficial, many do provide consumers and other social groups with certain benefits. On the other hand, social innovations may happen outside of business and may or may not bring profit to their owners. The authors also define 'desirable social innovation' as the 'creation of new ideas displaying a positive impact on the quality and/or quantity of life' (Pol and Ville, 2009, p.884).

A parallel development of the discourse on social innovation in the management literature is the topic of innovative business models and more specifically the notion of sustainable business models. Such business models either offer environmental and/or social benefits in addition to serving business interest (e.g. product-service systems, industrial symbiosis and the sharing economy) or use market forces to further social interests as their primary aim (e.g. social entrepreneurs).

Boons and Lüdeke-Freund (2013) propose normative requirements that business models should meet in order to support sustainable innovation:

- the value proposition should provide measurable ecological and/or social value;
- suppliers should take responsibility for their own and their suppliers' stakeholders;
- customers should be motivated to take responsibility for their consumption and for the stakeholders of the companies involved in the supply chain;
- economic costs and benefits should be distributed appropriately among actors and should account for the company's ecological and social impacts.

3. Methodology

In the following section we shortly introduce a number of innovative solutions along the food supply chain, which aim at the mitigation of food loss and waste. We classify them according to the phase of the FSC where the wastage they aim at occurs using the phases identified by FAO (2011). Looking at the examples it is evident that the initiators of the innovative solutions may or may not be operating at the phase where they intend to reduce food waste.

First, we provide a short description of a broader set of innovative initiatives describing their major characteristics in a table format. Then, we concentrate on three short cases, which we introduce in more detail based on primary and secondary research including structured interviews with the initiators of the solutions.

We argue that the requirements defined by Boons and Lüdeke-Freund for sustainable business models can be adapted to evaluate examples of innovative solutions along the food supply chain. We will use this framework for the analysis of the more detailed cases and will also include a number of additional aspects reflecting on the motivation behind each initiative, the business rationale (if there exists one), the barriers to implementation and their long term perspectives.

4. Discussion: social innovation along the food supply chain

In this section we focus our attention on innovative social and business solutions, which have recently appeared along the food supply chain and which address the problem of food loss and waste. First, we provide a short overview of social innovations in general. Next, we describe a number of innovative initiatives, which aim at tackling the problem of food waste at the different phases of the FSC.

4.1 Examples of innovative solutions along the FSC

The following solutions aim at reducing food loss created at the upstream phases of the supply chain, namely agricultural production and post-harvest handling and storage.

Table 3. *Phases 1 and 2: Agricultural production and post-harvest handling and storage*

Name of initiative	Description	Phase of main operations
British supermarket: Asda[2]	'Beautiful on the Inside' range: 'wonky veg boxes' of imperfect produce at low prices	Retail
The Culinary Misfits cafe in Berlin[3]	The Culinary Misfits cafe in Berlin is the idea of Lea Brumsack and Tanja Krakowski who buy goods directly from farmers that many big supermarkets would reject because of aesthetic imperfections.	Food service
'Perfectly Imperfect' by Tesco[4]	In 2017, Tesco's 'Perfectly Imperfect' line has been introduced to Central Europe. Tesco has announced that, on a test basis, 50 Central European stores, including 12 in Hungary, will introduce the product line called 'Perfectly Imperfect' after its great success in Great Britain.	Retail
WastED[5]	WastED (debuted at Barber's New York City restaurant in 2015), is Don Barber's pop-up in London. The aim of the business is to create delicious dishes comprised entirely of the kind of off-cuts and trimmings that usually end up in the trash.	Food service
American Hungry Harvest[6]	The aim is to deliver farm-fresh and delicious items to doorstep across Maryland, D.C., Virginia, Pennsylvania, and New Jersey. The business fights against food wastage derived from aesthetic imperfections and logistical inefficiencies.	Distribution (retail) - Door-to-door delivery service

The following solutions aim at reducing waste created at the downstream phases of the supply chain: during processing and packaging and distribution (wholesale, retail).

Table 4. *Phases 3 and 4: Processing and packaging; distribution (wholesale, retail)*

Name of initiative	Description	Phase of main operations
Mobile processing units of cassava by a social enterprise Dutch Agricultural Development and Trading Company (DADTCO)	Introduced by a study of Food & Business Knowledge Platform the DADTCO developed mobile processing units that process the tubers into cassava cake, which can then be transported to a processing plant to produce high quality cassava flour. The company declares the solution educes loss and makes growing cassava a more viable option for many smallholders which is favourable since the demand for cassava is increasing.	Processing and packaging
Foodbanks, for e.g. Food Bank Association of Colombia (La Asociación Bancos de Alimentos de Colombia, ABACO)	Food banks acquire donated food from various sources along the food chain and make it available to those in need through a network of community agencies such as school feeding programs, food pantries, soup kitchens, and rehabilitation centres. ABACO has established partnerships with 15 companies, mostly retail chains and food manufacturers, and 10 service providers in education, logistics/transportation, and event organization.	Distribution
Profitline, a Colombian technical service provider	Profitline provides one of the approaches to manage the quality of food waste generated during the distribution stage. Founded in 2004, it provides technical service to support the management of product portfolio and reverse logistics (Colombia INN 2017). Its software tracks the expiration of products, such as pharmaceutical medicines, to ensure proper destruction and management of the expired products. Profitline also applies its platform to food products so that inventories of products near expiry dates are published in real time. A part of these products are marketed at discounted prices or donated to food banks.	Service provider

[2] http://your.asda.com/news-and-blogs/wonky-fruit-veg-boxes
[3] https://www.finedininglovers.com/blog/culinary-stops/culinary-misfits-berlin/
[4] http://www.freshplaza.com/article/169911/Tescos-Perfectly-Imperfect-line-introduced-to-Central-Europe, http://tesco.hu/perfectly-imperfect/
[5] https://www.finedininglovers.com/blog/news-trends/dan-barger-pop-up-london/
[6] http://www.hungryharvest.net/#how-it-works

The following table introduces initiatives aiming at the reduction of food waste at the household and end-of-life phases of the food chain.

Table 5. *Phases 5 and 6: Household consumption and end-of-life*

Name of initiative	Description	Phase of main operations
Food sharing refrigerators at Berlin[7]	Food sharing refrigerators at Berlin, stocked with leftovers. By 2012, the food-sharing website was up and running across Germany, and individuals, as well as supermarkets, restaurants, bakeries, and food stalls were going online to trade leftovers. Nevertheless, in February, 2016 Berlin's Public Refrigerators were declared a health hazard.	Distribution
'Solidarity fridges[8]' in Galdakao Basque town	In April, 2015 Galdakao Basque town (applying Berlin's initiative in a smaller town) established Spain's first communal refrigerator initiated by Mayor Ibon Uribe, where anyone can deposit food inside or help themselves. The city approved a small budget of 5,000 euros to pay for the fridge and an initial health safety study, as well as electricity and upkeep. Learning from the example of Berlins' case, the fridge was granted a special independent legal status, so that the city can't be sued if someone gets sick. For safety reasons, there are rules: no raw meat, fish or eggs, furthermore homemade food must be labeled with a date and thrown out after four days. Restaurants, local people deposit food in the fridge and people in need often take away goods in the night. As one of the volunteers who cleans out the fridge says there are grannies in the city who cook especially for this fridge.	Distribution
Donation programme by TESCO Hungary	Nearly 50% of TESCO stores in Hungary donate food items (vegetables, fruits and bakery products) to civil organisations, which share them with people in need on a daily basis. Foodstuff saved amounts to 500 kg/day in one of the stores of the chain alone. This provides a logistical challenge to those distributing food items and legislative hurdles (e.g. the consequences of regulations relating to the expiry of products) should also be overcome. Apart from the obvious benefits to those in need, the company also benefits from a reduction in waste management costs.	Distribution
Milk bar in Kőszeg, Hungary operated by Győrvár Tej Ltd.	In Hungary we witness the renaissance of Milk Bars (a form of hospitality in the Soviet era). Next to the Austro-Hungarian border, with approximately 12,000 inhabitants the Győrvár Tej Ltd. firm operates a milk bar in Kőszeg, a popular meeting place of the town and for the visitors too. With a product portfolio composed with milk and dairy products the management of the firm continuously try to cope with the food expiration. A part of the products unsold could be send back to the dairy and the processed goods and bakeries, yoghourts on expiry date are sold with 50% price reduction, consequently small amounts remain.	Distribution (retail/ food service phase)
Leftover Swap[9] – Passing on Leftover Food	Smartphone app both for Android and iPhone platforms that acts as a go-between, between people who have leftover or surplus food to donate, and people who are willing to accept this food. As the creators of the app claim that the benefit of using such an app prevent food going to waste, enables people to interact with each other in their community, and reduces the resources needed into making food in the first place.	Household/End-of-life
Mi Utcánk.hu (Our street.hu) an internet based Hungarian start-up	The 'Mi Utcánk.hu' is a community website, where after registration the users could make contact whit their neighbours. The main difference of the website from other community portals that it links users according to their addresses. Operating as a Local Exchange Trading System people can share their goods, advertise different programs, and ask for help. Food sharing is a common practice; consequently it contributes to food waste mitigation.	Household/ End-of-life

[7] Foodsharing.de
[8] http://www.npr.org/sections/thesalt/2015/08/13/431960054/to-cut-food-waste-spains-solidarity-fridge-supplies-endless-leftovers
[9] http://helpfromhome.org/leftover-swap-passing-on-leftover-food

The following sections provide three case studies at different phases of the FSC in more detail.

Case 1: Grocery chain

The multinational retail chain, TESCO introduced its 'Perfectly Imperfect' programme in Hungary in 2017[10]. The company, operating a retail network of more than two hundred outlets (including hypermarkets, supermarkets and TESCO express in the country, introduced its programme aiming at reducing food waste at the farm level in early 2017. The programme in Hungary follows a success story in the UK and aims at selling odd-looking vegetables with full nutritional value at discount prices. At the moment locally grown apple, potato and carrot are included in the programme.

TESCO, the first global retailer to quantify and publicly report on the levels of food waste arising along its operations, has joined the Champions 12.3 coalition comprising of the representatives of governments, businesses, international organizations, research institutions, farmer groups and civil society dedicated to inspire ambition, mobilize action, and accelerate progress toward achieving Target 12.3 – 'By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses'– of the UN Sustainable Development Goals by 2030 (Goal 12: Ensure sustainable consumption and production patterns).

The programme does provide a clear ecological and social value by increasing the amount of vegetables purchased from local farmers by 20-40% (e.g. by 30% in the case of apple). Previously, these vegetables were refused based on strict regulations regarding their quality and were either fed to animals or left on the farm to waste. The programme is thus beneficial to TESCO's suppliers, who can increase their sales and reduce wastage and related costs.

Customers also form an important part of the programme, since they should accept products with unusual appearance. Their motivation may be environmental, but the discounted price definitely plays a part. The economic benefits of the programme are distributed between the farmers, the retail chain and the consumers.

The company is motivated to implement the programme by its overarching objectives relating to food waste and an improvement of corporate image through the environmental campaign related to the programme. While customers can access lower priced products instead of traditional vegetables, sales of vegetables and other products may increase.

Although rather new, the program in Hungary seems to be successful and more stores are planned to join over the initial 12 hypermarkets. One evident constraint is the selection of potential additional products to be included in the programme. Products should originate from local farms and should be sold in large quantities over longer periods of time to be feasibly included in the programme (i.e. seasonal produce cannot be included). Products with proportionately lower waste levels and imported products cannot be included in the programme either.

Case 2: Milk bar in Kőszeg

Waste issues are also considered as important by a milk bar in Kőszeg, Hungary operated by Győrvár Tej Ltd., a regional dairy products distributor[11]. The enterprise, which also operates six other milk bars in Western Hungary, puts an emphasis on reducing food waste. Actions are driven by economic considerations, but they also answer important social challenges. Milk bars have a long tradition in Hungary selling milk and other dairy products, coffee and bakery products for consumption on the spot or for take away. The Kőszeg shop sells around 300 liter milk, 200-250 kilogram sour cream, 150 kilogram cottage cheese, 10-12 kilogram cheese and 15 kilogram liptauer arrives on weekly basis. Food waste is strictly controlled within the

[10] Based on an interview with the company's Public Affairs, Communications and CSR Manager and data provided by Tesco Hungary (date: April, 2017).
[11] Based on an interview with the deputy of Milk bar in Kőszeg (date: April, 2017).

company: no more than 2% of fresh milk and dairy products and 10% other foodstuff should be wasted. To reduce waste further, products with a short expiry date are sold with a 50% discount, resulting in very small amounts wasted. A group of regular customers look especially for these discounted products, especially on Monday, when more leftover products remain from the higher sales of the weekend. Furthermore, dairy products sold originate from the company's own plant within a short distance from the milk bars. Short transportation routes reduce harmful carbon and other emissions and help keep products fresh and healthy. Consequently we can claim that the value proposition provides measurable ecological and/or social value.

Established company objectives regarding food waste motivates shop managers to reduce waste, while customers, understanding the efforts of the company, take responsibility for their own consumption. The company's business model has benefits to all three domains of sustainable development and thus helps the long term operation of the company. There are some evident limitations, however. The company management is not aware of food waste arising at other phases of the food chain, thus cannot consider more systematic solutions. Food losses at the farm are not considered by shopkeepers and actions do not aim at food waste arising in the households. Another aspect to be considered is the small scale of operations and the transferability of the ideas to other businesses in the hospitality sector.

Case 3: Neighbourhood internet platform

Experimenting how community networks could cope with societal challenges, MiUtcánk.hu (meaning 'our street'), an internet based Hungarian start-up decided to create a platform where users could make contact with their neighbours after volunteer work in flood protection. Started in August 2014, the website soon reached 5,000 users, which increased to 30,000 in 2015 and is still growing. Operating as a Local Exchange Trading System people can share their goods, advertise different programs, and ask for help.

Sharing various goods with each other, participating at different events, travelling to work together (peer-to-peer ridesharing) all strengthen the links among neighbours and increases the level of trust, while fighting against wastes and other hazardous emissions thus generating clear ecological and social value.

The use of the website is free, but it requires registration allowing for the identification of the users. Trust us generated by an evaluation system, therefore 'suppliers' take responsibility for their own and their suppliers' stakeholders.

Budapest, the capital of the country is the hotspot of the Miutcánk.hu community website, thus forms of mutual help, which work well in smaller towns and villages are re-invented in an urban context (a kind of 'cosmopolitan localism'). By sharing various goods customers are motivated to take responsibility for their consumption. The increased interest in sharing goods and services, once they reach a critical mass, can potentially affect production systems. Consequently, companies involved in the supply chain of often shared products will be motivated to take responsibility in order to retain their market position.

The application started out as an award-winning start-up. The search for a business model, which can be sustained for an extended period is still under way, but if the idea turns successful in the market, it will guarantee sizable value for all its users.

5. Conclusions

Reducing food loss and waste is an important challenge all around the world: developing countries generate most of the wasted food at the production phase, while households are much more important in developed countries.

Our analysis demonstrated that food supply chains and their phases as identified by the literature can prove useful in analysing innovative solutions aiming at the mitigation of food loss and waste.

We identified several initiatives from around the world and classified them according to the phase of FSC at which the mitigated waste has been created. Further, we looked at three interesting case studies of food waste initiatives in more detail.

Successful initiatives already reaching thousands of people demonstrate that social innovation has a potentially significant role to play in mitigating food waste in the future. Although most of the initiatives are only in their infancy, they have large growth potentials, which can be utilised at low cost.

Regulatory authorities, however, are lagging behind and are not able to follow these new developments. There is a need to re-assess regulations relating to the reuse and recycling of food waste, such as regulations relating to expiry dates and the packaging, transportation and sale of food products.

Also, few members of FSC's have an overall understanding of their supply chains. They most often concentrate on one or two single phases and are not paying attention to other sources of waste thus preventing a more integrated approach.

New, innovative solutions also play an important part in raising the awareness of the consumers about the environmental and social aspects of food consumption. Participating in such schemes may have a positive influence on consumption patterns thus further reducing food wastage.

With all these new developments, it is still hard to foresee the future of these innovative solutions (see e.g. the banning of food sharing refrigerators in Berlin). This warrants more research as well as government support – since even a small amount of food diverted from waste can have an important effect on the life of many.

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Cultural values and the role of trust in agents and technology in consideration of the dynamic prices electric grid and efficiency at home

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Abstract

Perceptions of societal risks and cultural ideals are expected to partake in attitudes towards the digitalized grid with dynamic prices, whence reliance on automated systems is feasible. Moreover such potential changes in the consumers' lives confront them with environmental, economic, and technological norms and orientations. The aim is to probe Cultural Theory constructs' usefulness in understanding consumers' trust influence in intention to rely upon dynamic prices to consume off peaks, when presented with several possible auxiliary technologies which could be used at home. CT theory predicates different groups' risk perceptions and polarized attitude to solutions to environmental problems. Trust literature highlights the perception of similarity in values and intentions with other agents. Trust in IT technology literature focuses upon cognition and affect towards specific technologies, acknowledging several orders of factors, such as individual propensities, and perception of societal supporting forces impending upon a particular context. The ensuing picture is that of multiple determination, openness to meanings and viewpoints. Respondents were 571 consumers enrolled in a market firm, were given descriptions of dynamic prices grid and several auxiliary technologies, and answered a questionnaire comprising trust in several targets and intention. The study analyses myths about nature and risks perception, employs these measures to segment the sample, assess differences among clusters in trust in agents, trust technology and intentions of adhering to dynamic tariffs, and estimates predictive models of the latter variable. Willingness to adhere was predicted by different trust phenomena, spanning from expectations about the specific devices, to generalized trust in technology and beliefs about situational societal assurance but trust in technology emerged as the most important. Trust in agents was not represented. Would this outcome change for groups with different cultural orientations? In the sample, perceptions of environmental, economic and social conflicts concerns correlated with myths about nature significantly in an interpretable direction. Segmentation yielded 8 clusters, a few only matched Cultural orientations constructs. Willingness to adhere was lower in one cluster. It had uniform low concerns, and slight endorsement of nature as fragile. Although beliefs about the specific technology featured as the most predictive, the clusters differed in the kind of specific device where trust mattered, from the use of a monitor, to an automated method. Societal support represented by the belief that progress in law and society made it normal this kind of application was significant predictor for some groups. Trust in agents was significant for two groups, but for one it was trust in consumer support organizations and for the other, it was trust in energy provider. Myths and concerns with risks showed significance in a few clusters, but in differing directions. The significance of the meanings assigned to nature in regard to adhering to dynamic tariffs does not appear to be shared, and different orders of concerns predict willingness to adhere. Thus, groups with different orientations were found to be willing to adhere to dynamic tariffs and consume off peaks.

Keywords: Cultural values; Myths of nature, Agent trust, IT_trust, Dynamic Prices Grid

1. Introduction

The study addresses responses towards and acceptation of the digitalized grid with dynamic prices and of a variety of technologies for managing electricity consumption at home in terms of trust cognitions towards agents and technology. Assuming that smart grid with dynamic prices and warnings of off peak times and low prices represents a technological change of some magnitude for the consumers, calling for new behavioural and technological solutions in the use of electricity at home, this was conceived as potentially arising uncertainty, feelings of risk, and consideration of both beneficial outcomes and potential threats. Such change plausibly confronts consumers with environmental, economic, and technological norms and orientations that help resolve the issue of how to cope with uncertainty and position oneself to the proposed solutions. The aim is to probe Cultural Theory framework's usefulness, specifically differences in views of nature and perception of risks, in combination with trust in relevant agents, namely, the energy provider, the regulation agency, consumer support organizations, and research centres, and trust in technology, in relying upon dynamic prices to consume off peaks, when presented with several possible auxiliary technologies which could be used at home**.**

1.1. Cultural views on environmental and technological risks and solutions to environmental problems

Cultural Theory of Risk (CT) (Douglas, 1966, Douglas and Wildavsky, 1982) is a conceptual framework for addressing societal and cultural views on several risks, particularly environmental and technological ones, and perspectives on solutions to environmental problems. It argues for a social-cultural embeddedness of the perception of risks and solutions endorsed. Cultural views ground intuitive perceptions about what is dangerous, and why, premised on moral notions and convictions on social institutions. According to CT, divergent views on the ideal functioning of society, rooted in the process of social identification, organize perceptions of menaces and choices (Douglas and Wildavsky, 1982), as a form of social dialogue and protest (Douglas, 1997, cit. in Jackson, 2005). The basic constructs are social and structural in nature, namely the two-dimensional matrix of group (*collectivism* versus *individualism, i.e.,* the relative degree of group control and of individual self-sufficiency, a distinction regarding the border of the inner and outer sphere) and grid (*egalitarian* versus *hierarchical, i.e.,* a distinction of the degree and fixity of role stratification and durable symbolic authority relations or constraints on approved behaviours) of the range of possible social organizations, and ensuing four types of 'ideal' social order worldviews or types of cultural orientations: *egalitarian*, *hierarchical*, *individualistic* and *fatalistic* (Thompson et al 1990, cit. in Jackson, 2005). Initially applied between cultures, those constructs were generalized to resonate also with individual level ideals, and psychological types, rooted upon family and group socialization within the same culture. An egalitarian orientation is expressed in rejection of authoritarian institutions and formality; an hierarchic one, in adherence to institutions, regulations, or traditions; an individualist or entrepreneurial one in adherence to individual choice and personal freedom, and finally, a fatalist or isolated orientation in the stance of doing with the own resources (Jackson, 2005). Views on nature are deemed to be embedded in the same societal worldviews, regarded as mythical in quality, and also organized in a systemic contrast. 'Nature fragile' matching the egalitarian orientation, is the notion that '*small changes introduced by humans in global ecosystem can lead to a collapse*', 'Nature tolerant" attributed to hierarchic orientation, consist of view that '*nature compensates events up to a certain point, and experts are required to understand the limits of our intervention in nature*'; 'Nature benign' linked to the individualistic orientation is the view that '*nature generally 'forgives' the changes being able to recuperate its equilibrium*'; and, finally, 'nature chaotic', linked to a fatalistic orientation is the view that "nature is so capricious that not even experts can understand its tolerating limits" (Schwartz and Thompson, 1990, cit in Jackson, 2005; Lima and Castro, 2005). Whereas each view was theoretically tied to a cultural orientation, empirical correlations found between the two measures fit the assumption only imperfectly. Rippl (2002) reports correlations of .34 between Hierarchy and

Nature Tolerant Myth, .43 between Egalitarianism and Nature Fragile, -.26 between Individualism and Nature Capricious / Chaotic, and .70 between Fatalism and Nature Chaotic. Moreover, the study missed to find a specific myth of nature in relation to an individualistic orientation. In a Portuguese study, Lima and Castro (2005) reported factor loadings and cross loadings among items measuring views and factors interpreted along cultural orientations, which as a whole were supportive of the theoretical cultural views. Correlations among the factors of views of nature were also found to conform to cultural theory, displaying positive correlation coefficients of .19 among egalitarian and hierarchical orientations, which share a high group location, of .16 between individualistic and fatalistic, which share a low group location, and a negative coefficient of -.39 among egalitarian and individualistic orientations, opposed in the two dimensions.

Different propensity to perceive risk, emphasis on different types of risks, and preferences for their management are also expected within the framework (Thompson et al 1990, cit. in Jackson, 2005). Environmental and technological risks, or risks affecting many people and future generations would follow from an egalitarian worldview, together with a preference for political participation and behavioural solutions to these problems. Risks affecting social order would be perceived higher by individuals with a hierarchical worldview, who would support regulatory solutions and value expert advice. Management of environmental risks by embracing market principles and entrepreneurship is deemed characteristic of an individualistic worldview. Finally, avoidance of the issue altogether is associated to a fatalistic worldview. Regarding technological solutions, these can be regarded with suspicion in an egalitarian worldview.

Rippl (2002) analysed causal relations among each orientation and the perception of each of four types of risks _ ecological, social order, becoming infected with HIV and becoming unemployed_ in two models where different pairs of risks were employed as the criteria. She reports gamma coefficients for the following paths: from egalitarianism, .29 and .23 with ecological and unemployment risks, respectively; from hierarchy, .27 with social order and -.29 with ecological risks; from individualism, -.26 with social order and -.14 with unemployment; and from fatalism, .22 with unemployment risk.

Cultural theory encompasses among its constructs a normative-moral construal of conservation issues, policies, and accepted solutions. Poortinga, Steg and Vlek (2002) performed a test of CT and New Ecological Paradigm (NEP of Dunlap et al., 2000) and found support for their hypotheses that level of concern with environment differs in a consistent way the myth of nature endorsed, with higher ratings in NEP for ‘Nature Fragile’, intermediate for ‘Nature Tolerant’ and lower for ‘Nature Benign’.

1.2. Trust in agents and technology in coping with uncertainty and risk

The term ‘trust’ has been used in relation to behaviours, dispositions, decisions, institutions and social networks (Rousseau et al., 1998). The ‘core’ critical ingredients of a definition are synthesized across social science disciplines, and are resumed to “a willingness to be vulnerable” on another part, “based on confident positive expectations about his/her intentions and/or behaviour”. It is premised upon ‘perception’ or ‘preconscious expectation’ or also ‘perceived probabilities’. A reciprocal relation with risk is implied, because it arises the need to process trust information, form expectations of the other, and is part of the process reinforcing interdependence, when expectations are met. Trust propels risk taking and exposure to the other part (p. 395). The concept of trust opens towards a diversity of forms, depending on the trustor-trustee relation in aspects of specificity, generality, familiarity, and the degree of interdependence. However, it not possible to address trust without considering the role of institutions. Zucker (1986) offered the notion that there were three avenues for the actors to establish a world known in common and the rules of their interaction: the process and history of their interchange, social similarity among them, and formal social structures such as occupations, associations, and legal mechanisms. The institutionalization perspective of trust regards role expectations, norms, and even modelling as ‘forms of organizing the life world’, through a sense of what is appropriate to do, the identity that is enacted, and the roles engaged upon (DiMaggio and Powell, 1983; Scott 2001, cit. in Mollering, 2006, 64-65).

Earle and Siegrist (2006) and Earle (2010) elaborated on the notions of trust and confidence as forms of coping with uncertainty and risk. While cross-disciplinary, their formulation of ‘the consensual view on trust’ is particularly focused on environmental risk management issues. Social-relational *trust* applies to moral, intentional agents, and is concerned with trustee intentions and integrity, issues that pertain to the relation among the actors in a 'broad basis', whereas *confidence* can apply to people and/or non-intentional targets, such as technology, with a concern for ability aspects (capabilities, reliability), through consideration of more specific behaviours displayed in the past, or future behaviours under constraint. The subjective significance of two forms is expressed in contrasts of "warmth vs competence"; "morality vs competence" and "community vs agency" (Earle, 2010, p. 541). Furthermore, the two forms have distinct cognitive – social processes, contrasting in the continuum of implicit-explicit, hence leading to different outcomes. Heuristics most common in trust are those of similarity and affect. Similarity between self and other, based upon perception of shared group identities, works as a cue to positive expectations, and similarity of intentions is inferred thereby. Congruity of intentions with currently relevant values between self and other should be the most predictive of trust on a target. Conflicting values should have an opposite effect, yielding suspicion of bias, and conflict (Earle, op. cit p. 543).

For McKnight (2005) some meanings of trust _ i.e., *confidence*, given that artefacts lack volitional attributes _ can be extended from people, agents or groups, to technology, namely IT, because "people and technology can be expected to be more or less predictable, reliable, and not commit errors, or have crashes, and functional capacities of the technology are analogous to people's competences or abilities" (p.330). The model (McKnight, 2005; McKnight et al., 2011) comprises 5 main constructs: *disposition to trust technology in general*, or 'general tendency to be willing to commit or depend upon technology across a broad range of technologies or situations' (p.331), *institutional _based trust in technology*, the 'belief that success is likely because of technical or supportive situations and structures tied to a specific context or a class of trustees', referring to beliefs about technology in a specific context, itself comprising *Situation normalcy in technology*, i.e., the 'belief that using a specific class of technologies in a new way is normal and comfortable within a specific setting', *trusting beliefs_IT in specific technology*, which is a "secure conviction that the technology possesses the appropriate attributes" (e.g., functionality, reliability) to perform a task in a situation" and *Trusting intention*:, the "willingness to be vulnerable on that technology" (McKnight et al., 2011, p. 12:8). These factors can be measured and can be independent or can covary extensively. Beliefs are among the most central factors of trust, together with institutions, they have a causal effect upon intentions. When beliefs are high enough, they lead to intentions to trust, and these, above a certain threshold, motivate behaviours. Disposition to trust has an impact upon other sources of trust, namely institutional trust, and trust beliefs in specific technology. Institutional-based trust also influences beliefs. The societal roles and institutions provide an environment that is to a lesser or higher degree perceived as favourable to relying on the trustee in a transaction. In this model, these expectations can both influence intentions, and subsequently behaviours, or they can help build psychological factors that lead to formations of trusting beliefs and affect, which then ultimately inform decisions, intentions, and related behaviour.

In sum, trust concepts call attention to differences in perceptions of diverse agents as representatives of institutions (e.g. agents active in business transaction, in regulating commercialization of energy, in providing consumers with support, and research institutions), by their relation to consumers, as a function of cultural values and/or social concerns. It leads to the expectation that trust in agents that stems from identification with values and intentions that are active at the moment of appraising a policy will be part of the salient considerations about the solution and the technology. Different cultural values orientations can ground differential perceptions of similarity with the aforementioned agents, and possibly differential institutional trust, because science /technology and law /regulations may be differently entrusted by different groups. The importance of trust in agents and institutions, besides trust in the technology proper, could bear upon attitudes towards relying in a digitalized grid with dynamic prices and relying on auxiliary technological devices to manage electricity consumption at home. Given the environmental and economic import of the target proposal and the multiple facets of the situation, it is probably open to different meanings.

2. Method

The sample is composed of 571 participants enrolled in a market study firm. Minimum level of education was 12^{th} grade. Age ranged from 18 to 72 (m=31.3; sd=8.7), 58.7% were females.

A questionnaire was constructed for a larger study, designed to present as stimuli descriptions of smart meters, digitalized grid with dynamic prices and warnings of peak times and consumptions and several auxiliary technological devices which can provide aid in adapting to the scenario of a future grid. Descriptions of smart meters functionalities consisted of a summary of the features reported in Portuguese legislation of Ministry of the Economy and Employment's Secretary of Energy, of July the 22^{nd} of 2013. Description of smart grids was inspired in Darby (2011) definitions. Description of devices, such as monitors with historical registers of consumption, and programmable machines, plugs, and thermostats, and more advanced proposals like automated decision making aids, for prioritizing and programming tasks at home according to signs of lower cost electricity (off peak time). Prior to the stimuli, a first section of questionnaire included demographics, questions about the home, energy saving practices and beliefs, energy literacy, and experience and trust in several agents, namely involved in electricity distribution, energy commercialization regulation agency, consumer association organizations, and scientific institutions. Subsequent to the stimuli, respondents were asked to report thoughts they had upon reading the descriptions, feelings toward the digitalized grid, and to answer to the study's measures of trust in technology general, institutional, and specific to the three types of devices, willingness to adhere to the grid with dynamic prices and intentions to adopt at home the different devices in a future grid scenario, agreement with statements reflecting four myths about nature, and to rate several societal risks, comprising environmental, social-financial, societal order, and technological risks. Table 1 summarizes conceptual and internal consistency information on the measures.

Willingness to adhere to dynamic tariffs was measured with a single item: *I am willing to adhere to dynamic tariffs in order to use electricity in periods of /low demand*. Myths about nature (Thompson et al., 1990, cit in Rippl, 2002) were also assessed with single items. Sets of items were employed to measure concern with environmental, technological, social order, social–economic risks (Rippl, 2002) and /or were adapted from previous studies to measure trust beliefs in diverse agents, trust in technology (McKnight, 2005; McKnight et al., 2011) in general, institutional-based situation normalcy, and trust beliefs about monitors with a historic record, about programmable plugs and thermostats, and about automated decision aids. These measures were submitted to multiple principal components analyses, displaying dimensional structures compatible with the conceptual frameworks, with the exception of the two technological risks items which did not form a separate factor neither did they load highly in the ensuing three components. For each measure, mean scores were employed. Internal consistency by Cronbach's alpha ranged from good to high.

Descriptive statistics and bivariate correlations among the measures, hierarchical cluster followed by k-cluster analysis, multiple t-tests corrected for pairwise comparison, and multiple regression analysis for the whole sample and separately for each cluster of the criterion variable of willingness to adhere to the digitalized grid were performed with IBM spss statistics 24, and Addinsoft xlstat version 20. Level of significance adopted throughout the analyses was .05.

Table 1: Examples of items and internal consistency of each measure, by Cronbach's alpha.

Myths about nature (ratings in a 7-point scale)	Concerns with risks (ratings in a 10-point scale)	Trust in agents (ratings in a 7-point scale)
Nature fragile: *In nature, small changes introduced by humans can lead to a collapse;* Nature tolerant: *Nature compensates for disturbing events up to a degree, experts are needed for us to know the limits*; Nature Benign: *Nature always finds a way to get back to its equilibrium;* Nature chaotic: *Nature is chaotic so that humans, even experts, can hardly control anything*	Environmental: scarcity of natural resources; ozone depletion; global warming of the planet (α=0.910) Social order: civil disobedience; crime; civil apprise; social group conflicts (α=0.850) Social_financial: to become unemployed; to be in debt (α= 0.767); Two Technological hazards: nuclear power plants; Genetic engineering technology	For each trustee: a.*Takes into account consumers' interests* b.*Is fair, or promotes fairness* c.*Pays quality services* d.*Has a positive reputation* e.*Has transparent motives* f.*Protects the environment* Energy Provider (α=0.906) Energy Regulating Agency (α=0.958) Consumer support Organization (α=0.955) Research Centers (α=0.940)

Trust beliefs in general technology (ratings in a 7-point scale)	Institutional-based trust in technology_ situation normalcy (ratings in a 7-point scale)	Trust beliefs in specific technologies_ functionality and reliability (ratings in a 10-point scale)	Trust beliefs in technology_ comfort appraisals (ratings in a 10-point scale)
Regarding most technologies, I believe that: a.*They are efficacious doing what they were meant for*; b.*Most have the attributes or functionalities necessary in their domain of utilization*; c.*Most will allow me to do what I need done in my utilizations* α=0.900 d.*My typical approach to a new technology is to trust it until proof in contrary* f.*Generally I give the benefit of doubt to a new technology when using it for the first time*. α=0.875	a.*Progress of science and technology makes it normal the use of auxiliary technologies such as the described ones at home, in managing the use of electricity* b.*Progress of law and society in regulating commercial exchange make it normal the use of auxiliary technologies*. α=0.811	For three technological devices_: a.*Have the required functionalities to make me aware of consumptions* *b. to adapt to dynamic tariffs by adjusting consumption to price*; b.*Have what it takes to afford saving electricity by using only what is necessary for goals*; Monitors (α=0.927) Programmable plugs and thermostats (α=0.918) and automated decision making aids (α=0.957)	a.*I will feel completely comfortable when using these devices at home*. b.*All will work well when using the devices at home* Monitors (α=0.935) Programmable plugs and thermostats (α=0.941) and automated decision making aids (α=0.927)

3. Results and Discussion

3.1. Myths about nature and concerns for kinds of risks in the global sample

Descriptive statistics and correlations among ratings of myths about nature and mean concern for types of hazards for the whole sample are displayed in Table2. Views about nature are rated in decreasing levels _ significantly different at .05 level_ from nature fragile, tolerant and both benevolent and chaotic; the latter two views are not rated differently. Concern with risks is rated higher for economic kind, followed by environmental, and both social order, and nuclear risks, the latter two not differing significantly from one another, and rated the lowest for genetic engineering risks.

Table 2: Mean, standard deviation and correlations between the four views of nature and concerns for types of risks.

	M	SD	Nat Fragile	Nat Tolerant	Nat Benevolent	Nat Chaotic
Nat Fragile	5.75	1.29	1			
Nat Tolerant	5.24	1.46	.334**	1		
Nat Benevolent	4.65	1.77	.150**	.257**	1	
Nat Chaotic	4.58	1.74	.188**	.125**	..301**	1
Environment. Risks	7.85	1.96	.445**	,198**	.045	.089*
Social-Econ. Risks	8.32	1.98	.314**	.170**	.131**	.175**
Social Order Risks	7.15	2.01	.268**	.177**	.176**	.077
Genetic Engineer. Risks	6.23	2.66	.207**	.097*	.138**	.164**
Nuclear Power Plants Risks	7.03	2.56	.337**	.087*	.079	.102*

**Correlation is significant at .05 level; ** Correlation is significant at the .01 level (2-tailed).*

The highest correlations are found between 'Nature fragile' and 'Nature tolerant' items, on the one hand, and between 'Nature benevolent' and 'Nature chaotic' ones, on the other hand, in consonance with the commonalities of the worldviews found in the Lima and Castro study, and with the hypothesized locations along the group dimension (but not the grid dimension) of the CT matrix, respectively, in high group (Egalitarians and Hierarchists) and in low group (Individualists and Fatalists) quadrants. However, a moderate correlation is also found between the myths of 'Tolerant nature' and 'Benevolent Nature', attributed each to ideological positions that lie across the diagonal of the matrix. Single items measures may not tap all facets of the constructs and may contain substantial measurement error, thus the items content may emphasize the issue of the level of crisis perceived in nature, with Tolerant Nature expressing intermediate concern between that of Nature Fragile and of Nature

Benevolent views, and thus some overlap among pairs of orientations is likely. This outcome is similar to that of Poortinga, Steg and Vlek (2002), in a joint test of NEP and myths of nature.

Nature Fragile view correlated in high to moderate degree with increased perceptions of multiple risks, prominently environmental ones, followed by risks of nuclear power plants and social-economic ones; Nature Tolerant view displays modest correlations with several risks, balanced for environmental, economic and social-order concerns, and negligible for technological concerns; *Nature Benevolent* view displays low correlations with risk perceptions about social order, genetic engineering and economic risks, and no significant correlation with environmental concerns. Finally, *Nature Chaotic* perception correlates modestly with economic concerns and concerns with risks involved in genetic engineering. The patterns of correlations are compatible with CT's predictions that egalitarians, adherents to myth of nature fragile, are concerned with risks (nature imbalance, technology) that impend on many people and future generations, that hierarchists weigh comparatively more the social order ones, and favour solutions involving scientific and technological expertise, and that fatalists, prone to regard nature as chaotic, tend to be distanced from issues that could affect society and focus more on problems individually encountered. Regarding Nature Benevolent as a potential correlate of individualistic orientation, it is not incompatible with a joint regard for social and economic obstacles to individual initiative**.**

Interpretable patterns of relations were obtained, notwithstanding the fact that correlations among ratings of myths and concerns with risks were not clear enough to bring up common factors in principal components analysis, the ensuing solution displaying separate components for myths and for concerns about risks.

3.2. Modelling willingness to adhere to the dynamic prices grid with views of nature, concerns with risks, and trust in agents and in technology variables

Multiple linear regression analysis by stepwise method of willingness to adhere to dynamic prices grid to consume off peaks was performed on a set of scores of myths about nature, concerns with different risks, trust in several agents, trust in general technology, perceived societal support for trust in technology by progress in science /technology, and by progress in law /regulation, and specific beliefs about the proposed devices, namely monitors, programmable plugs /thermostats and automated decision making aids. The model retaining 6 from the 18 predictors, was significant $F(6, 522) = 56.09$; $p< .001$ and explained a substantial amount of variance R=.626, AdjR^2= .385. Individual standardized regression coefficients, and test of significance are presented in Table 3.

For the overall sample, willingness to adhere to dynamic prices grid was predicted by variables spanning across the different levels of trust phenomena, from positive expectations about the specific devices regarding comfort, to generalized trust in technology, to beliefs about contextual societal support. Trust in agents however was not represented.

Table 3. Predictors retained in the most explanatory regression model of willingness to adhere to dynamic grid: Standardized coefficients, t-test and significance levels.

	Beta	*t*	sig
Trust_AutomatDecMakAids_Comfortable/AllWillWorkWell	.250	5.067	.000
Trust_PlugsThermosts_Comfortable/AllWillWorkWell	.137	2.593	.010
GeneralPropensitytoTrustTechn_stance	.116	2.547	.011
Trust_Monitors_Comfortable/AllWillWorkWell	.135	2.421	.016
ProgressLawSociety MakesUseNormal	.107	2.409	.016
Myth_NatFragile	.085	2.426	.016

A proposed explanation for this outcome is that putative effects of divergent cultural orientations in regard to differential trust in agents with a potential role in driving expectations towards the digitalized grid and intentions of adhering may cancel each other out within the sample. Would this outcome change for groups with different cultural worldviews?

3.3. Clusters of respondents on myth of nature and concern for risks

Segmentation of data was performed on the measures of myths about nature and ratings of concern with societal risks, by HCA with squared Euclidian distance measure and complete linked aggregation method. The results suggested retaining 8 clusters, subsequently analysed with k-means clustering. Scores of the clusters *in the segmenting variables* and trust and adherence variables are displayed in table 4 and their profiles in Fig 1.

Table 4: Clusters' sizes, means and standard deviations in the segmenting variables, in trust in agents and in technology and in willingness to adhere to the digitalized grid.

Cluster	Cl 1	Cl 2	Cl 3	Cl 4	Cl 5	Cl 6	Cl 7	Cl 8	Total
n	90	90	49	46	128	49	43	72	567
Myths									
Nat._Fragile	5.4 (1.0)	6.1 (1.1)	5.5 (1.5)	5.9 (1.5)	6.3 (.86)	5.67 (1.3)	6.1 (1.3)	4.7 (1.4)	5.75 (1.3)
Nat_Tolerant	5.0 (1.1)	5.8 (1.2)	5.0 (1.4)	4.5 (1.9)	5.5 (1.4)	5.76 (1.2)	5.5 (1.8)	4.6 (1.4)	5.24 (1.5)
Nat_Benevol.	4.5 (1.4)	5.8 (1.1)	5.0 (1.7)	3.7 (2.1)	4.9 (1.9)	4.41 (1.7)	4.1 (2.2)	4.0 (1.5)	4.65 (1.8)
Nat_Chaotic	4.2 (1.3)	5.7 (1.2)	4.9 (1.6)	4.4 (2.0)	4.9 (1.8)	4.35 (1.7)	3.3 (2.2)	4.0(1.5)	4.59 (1.7)
Concern with Risks									
Environmental	7.15 (.9)	8.51 (.9)	5.22 (1.6)	8.95 (1.1)	9.59 (.5)	8.19 (1.0)	9.29 (.9)	4.84 (1.4)	7.86 (2.0)
SocioEconomic	7.08 (1.3)	9.22 (.8)	9.13 (1.0)	8.28 (2.0)	9.63 (.8)	8.90 (1.2)	9.17 (1.4)	4.99 (1.9)	8.32 (2.0)
SocialOrder	7.12 (.9)	8.09 (.8)	6.39 (1.4)	5.12 (1.1)	9.28 (.7)	5.60 (1.4)	8.63 (.9)	4.25 (1.5)	7.15 (2.0)
GenEngineer	6.57 (1.4)	7.24 (1.5)	4.04 (1.8)	7.02 (2.3)	8.95 (1.3)	4.12 (2.1)	2.91 (2.0)	4.04 (2.0)	6.22 (2.7)
Nuclear	7.00 (1.5)	8.04 (1.3)	4.84 (2.1)	8.02 (1.9)	9.51 (.8)	4.59 (2.3)	7.23 (2.1)	3.78 (1.7)	7.03 (2.6)
Trust in Agents									
EnergProvider	5.51 (1.9)	5.73 (1.9)	5.45 (2.1)	5.53 (2.2)	5.84 (2.4)	5.41 (2.4)	5.20 (2.1)	5.39 (2.1)	5.57 (2.2)
RegulatAgency	5.21 (2.0)	5.62 (1.9)	5.22 (2.2)	5.36 (2.4)	5.72 (2.3)	4.31 (2.4)	5.94 (1.9)	5.06 (1.8)	5.36 (2.1)
ConsumSupporOrg	6.58 (2.0)	7.28 (1.9)	7.22 (1.7)	7.14 (1.8)	7.41 (2.2)	7.02 (2.1)	7.12 (2.2)	6.70 (1.9)	7.07 (2.0)
ResearchCenters	6.22 (1.3)	6.46 (1.7)	6.25 (1.4)	6.47 (1.6)	6.81 (2.0)	6.16 (1.9)	6.33 (1.7)	6.12 (1.6)	6.40 (1.7)
Trust Technology									
GeneralPropensity_TrustTechn	6.59 (1.5)	7.00 (2.1)	6.75 (2.3)	6.99 (2.0)	7.26 (2.1)	7.14 (2.1)	6.91 (2.1)	6.35 (1.8)	6.89 (2.0)
GeneralBeliefTechn_functionality	6.99 (1.4)	7.45 (1.8)	7.23 (2.1)	7.59 (1.9)	7.78 (1.8)	7.47 (1.7)	7.74 (1.7)	6.68 (1.8)	7.37 (1.8)
ProgressScienceTechMakesUseNormal	7.68 (1.7)	8.06 (2.0)	7.96 (2.3)	8.04 (2.1)	8.54 (1.9)	8.40 (1.8)	8.97 (2.0)	7.04 (2.3)	8.07 (2.0)
ProgressLawRegulMakesUseNormal	6.80 (1.5)	7.35 (2.0)	7.11 (2.1)	7.72 (2.2)	7.90 (2.0)	7.04 (2.2)	7.58 (2.3)	6.57 (2.1)	7.29 (2.0)
Trust Specific Devices									
BeliefMonitors_Functionality	6.5 (1.8)	7.3 (2.0)	6.6 (2.4)	7.1 (2.3)	7.4 (2.3)	7.1 (2.4)	7.2 (2.4)	6.0 (2.3)	6.9 (2.2)
Monitors_Comfort/AllWillWorkWell	6.01 (2.0)	6.64 (2.5)	6.10 (2.8)	6.54 (2.5)	6.67 (2.7)	6.52 (2.7)	6.12 (2.9)	5.67 (2.5)	6.32 (2.6)
PlugsThermosts_Comfort/AllWillWorkWell	6.20 (2.0)	6.82 (2.4)	6.44 (2.5)	6.89 (2.4)	6.96 (2.6)	6.33 (2.8)	6.97 (2.3)	5.53 (2.2)	6.53 (2.4)
BeliefPlugsThermosts_Functionality	6.43 (1.8)	7.17 (2.1)	6.62 (2.2)	7.26 (2.3)	7.41 (2.4)	6.74 (2.4)	7.48 (2.0)	5.69 (2.3)	6.87 (2.3)
BeliefAutomDecMakAids_Functionality	6.08 (1.7)	6.83 (2.1)	6.20 (2.6)	6.26 (2.5)	7.12 (2.4)	5.95 (2.5)	6.89 (2.5)	5.15 (2.4)	6.39 (2.4)
AutoDecMakAid_Comfort/AlWillWorkWel	5.92 (1.8)	6.13 (2.6)	5.89 (2.7)	5.70 (2.6)	6.61 (2.6)	5.61 (2.8)	5.84 (3.2)	4.97 (2.4)	5.94 (2.6)
WillingAdhereDynamicTariffs	6.72 (2.1)	6.82 (2.5)	6.73 (2.6)	7.20 (2.6)	6.94 (2.6)	7.08 (2.5)	6.30 (3.2)	5.44 (2.5)	6.66 (2.6)

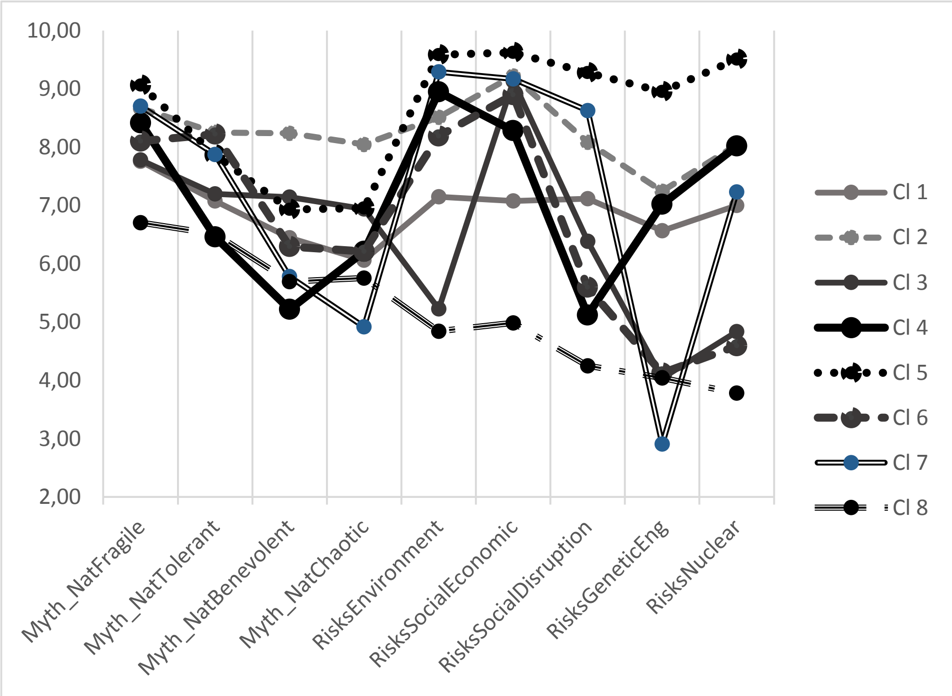

Fig 1. Clusters' profiles in the segmenting variables (rescaled to a common 1-10 scale).

Figure 1 suggests that some clusters differentiate more among perceptions of nature (clusters 4, 5 and 7) and others less (Cluster 3), and still others differentiate markedly among risk ratings (3, 4, 6, and 7), compared to others (1 and 5). The level of concern ratings differs markedly, with clusters 2 and 5 displaying the higher mean across risks, and cluster 8 the lowest. Given a common propensity to rate nature as fragile, clusters differ in whether they rate nature tolerant significantly lower as well as the remaining views. None of the clusters endorses the myths of nature chaotic or nature benevolent in an exclusive way, thus the corresponding cultural orientations cannot be said to be represented in the sample.

A characterization of the clusters is offered next, integrating the outcomes of intra-cluster comparison among variables by means of paired samples tests. Clusters 2 and 3 show only a slight preference for myth nature fragile, displaying rather flat profiles (in tests of differences of scores on myths, cluster 3 is the only one to not reject the null hypothesis). Whereas cluster 2 displays a similarly flat profile of responses to risks, all high (with a small elevation of concern with economic risks), cluster 3 holds very disparate concerns, elevated towards economic, intermediate to social order, and low to environmental and technological risks. The single most defining feature of Cluster 3 is the elevation of economic concerns. These two groups do not match with one of the ideological orientations stated in CT, but they are the ones that rate the myths of nature as benevolent and as chaotic as high as other myths. Clusters 1 and 5 endorse the nature fragile myth the most, and secondly, the nature tolerant one (in both there's a statistically significant difference between the two myths and with benevolent nature). Neither group shows notorious differentiation on the grounds of concerns for types of risks (although tests conducted for each cluster still lead to rejecting the null hypothesis), and the clusters differ in mean scores, the highest for cluster 5, possibly a difference in scale use. The two groups thus express concern for nature as fragile, but don't match this with any specific orientation of concerns with risks, except for the propensity to perceive risks of cluster 5. Cluster 8's myths ratings favour together nature as fragile and as tolerant (without significant difference among the two, as asserted by a related samples test), but not very highly. This cluster has rather low perceptions of any type of risks, the lowest compared to the remaining clusters, with slight elevation of environmental and economic risks. Cluster 4 rates high the nature fragile myth (Cl4) and significantly lower the nature tolerant one, thus can be interpreted as endorsing a single myth. It combines the perception of nature fragile with relatively high concern for economic, technological and environmental risks, and a devaluation of social order risks. This cluster (4) is thus a good match with CT egalitarian orientation. Clusters 6 and 7 endorse the two myths of nature fragile and nature tolerant, with no statistical significance between the scores, and comparatively disavow the nature benevolent and the nature chaotic views. The clusters differ partially in risk perception. Cluster 6 displays high concern with economic and environmental risks only. Cluster 7 displays a more mixed picture concerning technological risks, one item rated low and the other higher, but the highest concern is for environmental, economic and social order risks. The two can be interpreted in CT terms, as displaying attributes of the egalitarian and the hierarchic orientations, thus can be placed in a high group location.

Differences among clusters in trust in agents and trust in technology were established by multiple t-tests, two-sided, assuming equal variances adjusted for pairwise comparisons using the Bonferroni correction. Differences in trust in agents were found only in trust in the regulation agency _lower for Cluster 6, which views nature as tolerant and fragile and holds high concern for economic and environmental risks, relatively to Clusters 5, 2, and 7. Differences in trust in technology variables, namely Generalized Trust Beliefs regarding Functionality; Institutional Trust regarding the progress of Science/technology and Law/regulation; and Beliefs about the specific technologies under consideration, consistently show lower trust of Clusters 8 and 1 comparatively to Cluster 5, and of Cluster 8 comparatively to Clusters 2 and 7 in most variables. The same differences hold for Willingness to Adhere to Dynamic Tariffs, lower in Cluster 8. These differences display apparent correspondence with mean levels of concerns with risks of the different clusters, with higher concern clusters displaying higher trust. The differences also favor Cluster 4, a cluster associated with an egalitarian orientation relatively to Cluster 8, in regard to trust beliefs about plugs and thermostats, and Willingness to Adhere to Dynamic Tariffs Grid. Higher means in Willingness is observed for clusters 4, 6, and 5, and lower for cluster 8.

3.4. Predictors of willingness to adhere to the dynamic prices grid across the clusters of respondents

Variance on the dependent variable explained on the basis of the studied predictors, in the most explanatory regression model, as indicated by adjusted R^2, ranges from .166 to .632. In accordance with the outcome of the regression model for the whole sample, all the clusters have significant predictors represented by one or more of the following: trust beliefs about one of the specific devices' functionalities or comfort and positive expectations that all will work well, generalized trust beliefs /stance regarding technology and/or institutional trust in technology. Institutional trust represented by the belief that progress in law and regulation makes the use of technology in this context normal, is a significant predictor for clusters 2, 3, and 4, whereas generalized trust in technology is a predictor for clusters 1, 6, 7, and 8. In a similar vein, notwithstanding the fact that trust ratings for specific devices are highly correlated for all the clusters, predictors consisting of expectations about a monitor, the least automated device, is found for clusters 1,2,3 and 4; conversely trust in the more automated device occurs for clusters 5, 6, 7 and 8.

The outcomes lend themselves to the interpretation of different sources of motivation to adhere. On the one hand, a general stance or trust belief in technology and specific beliefs about automated solutions (clusters 6, 7 and 8) co-occurring with low technological risks perceptions, or a trend towards perceiving nature as tolerant (clusters 6; 7), or low risk perception generally (cluster 8). Interest in technology could be a driving force. Accordingly, clusters 7 and 8 display as predictors with negative coefficients, the concern with environment or perception of nature as fragile, in a counterintuitive way, and for cluster 7 nature tolerant views favor adherence. On the other hand, a sense of progress in law and regulation making it normal to adopt technology in the given context, and perception of monitors' comfort and/or functionalities for the proposed end, also support adherence. For clusters 2, 3 and 4, technology does not appear to be a primary source of adoption, but moreover institutional assurances, on the background of a medium or high level of concern across kinds of risks (clusters 2, 3) very high perception of environmental risks (cluster 4), or economic risks concern (cluster 3).

Aside from trust in technology, trust in agents is a predictor for two clusters. Trust in consumer support organizations is significant for Cluster 4. Trust in energy provider is significant for cluster 3.

Table 5.Results of multiple regression analyses of willingness to adhere to dynamic grid separately obtained for each cluster. ANOVAs, predictors retained in the most explanatory regression model, standardized coefficients, t-tests, significance levels and Adjusted R square are displayed

Cluster	Anova F	sig	Significant predictors	Beta	*t*	Sig.	Adjusted R^2
	9.354	.000					.166
Cl 1			BeliefsMonitors_FunctionaliesCapabiliities	.318	3.040	.003	
			GeneralPropensityTrustTechn_stance	.211	2.024	.046	
	34.969	.000					.459
Cl 2			BeliefsMonitors_FunctionaliesCapabilities	.328	3.015	.003	
			ProgressLawSocietyMakesUseNormal	.426	3.910	.000	
	8.399	.000					.346
Cl 3			ProgressLawSocietyMakesUseNormal	.277	2.120	.040	
			BeliefsMonitors_ComfortableAllWillWorkWell	.324	2.339	.025	
			Trust_EnergProvider	.299	2.258	.030	
	16.475	.000					.525
Cl 4			ProgressLawSocietyMakesUseNormal	.399	3.202	.003	
			BeliefsMonitors_ComfortableandAllWillWorkWell	.314	2.767	.009	
			Trust_ConsumSupporOrg	.279	2.333	.025	
	28.969	.000					.430
Cl 5			BeliefsPlugsThermosts_ComfortableAllWillWorkWell	.407	4.225	.000	
			BeliefsAutmatDecMakAids_FunctionalitiesCapabilities	.254	2.599	.011	
			Myth_NatBenevolent	.152	2.014	.046	
	13.226	.000					.337
Cl 6			GeneralPropensityTrustTechn_stance	.325	2.285	.027	
			BeliefsAutmatDecMakAids_ComfortAllWillWorkWell	.358	2.521	.015	
	17.742	.000					.632
Cl 7			BeliefsAutmatDecMakAids_ComfortAllWillWorkWell	.490	4.192	.000	
			GeneralizTRustBeliefTechn_functionality	.330	3.071	.004	
			ConcernsEnvironmentRisks	-.244	-2.446	.020	
			Myth_NatTolerant	.229	2.049	.048	
	17.213	.000					.499
Cl 8			BeliefsAutmatDecMakAids_FunctionalitiesCapabilities	.499	5.155	.000	
			GeneralizTRustBeliefTechn_functionality	.295	3.010	.004	
			Myth_NatFRagile	-.253	-2.842	.006	
			ConcernsSocialEconomicRisks	-.191	-2.162	.035	

For the cluster 4, highly willing to adhere to dynamic tariffs to consume off peaks, willingness is modeled by the combination of variables of trust in law and regulation affording a sense of normality of the change, an expectation of comfort and positive outcomes with the use of monitors, but also the support from consumer organizations. An egalitarian orientation is compatible with the outcomes under an interpretation along the lines of pro-environmental moral action. Motivation to adhere to dynamic tariffs probably arises from perception of threats to environment and to many people, and high concern for the environment, a sense of confidence in employing monitors in adjusting behaviors, and trust in the supportive roles of law and regulation towards making technology use normal, and of agencies supporting consumers. The agents are trusted to have a combination of attributes which would support the action, namely taking into consideration consumers' interests, having transparent intentions, good reputation, paying quality services, and acting to protect the environment. Adherence is represented as a behavioral intent to act in a pro-environmental way by monitoring electricity use, and having laws, regulations and agencies support consumers' action. For cluster 3, for whom environmental concern is low and frailty of nature hardly singularized, the combination of predictors is suggestive of a different motivation to adhere. The driving force is probably a motivation to pursue or conserve economic resources, consistently with the clusters high concern with socioeconomic risks. The intend to monitor behaviors in adjusting to prices can then be buttressed by laws and regulations which help entrust technology in this context, and trust in energy provider fills the gap in terms of trust in the economic exchange.

4. Conclusions

4.1. The view that nature is fragile is the most endorsed in the sample, followed by or combined with the view that nature is tolerant and experts are required to tell the limits. There may not be always a clear demarcation among these views, rather they may lie in a continuum of perception of ecocrisis. Among the clusters most willing to adhere to dynamic tariffs, are clusters with especially high environmental concern, e.g., cluster 4, but other clusters exist with above the mean ratings of willingness who rate economic problems as high or higher, e.g. cluster 3. This outcome leads to envisaging distinct motivations for adherence (environmental concerns or economic factors) that may be leveraged when promoting dynamic tariffs in tailored enrolment campaigns.

4.2. A noteworthy outcome is that one cluster (cluster 8), which had uniform low concerns, and only a relative slight endorsement of nature as fragile, displayed significantly lower willingness to adhere do dynamic tariffs. A possible implication of this is that, despite manifold initiatives and campaigns raising awareness of global environmental problems, namely climate change, it is possible that changes in energy use and production are not represented by all segments of consumers as part of the societal efforts, namely international under the UN-coordinated agreements efforts, to reduce green gas emissions. An eventuality that cannot not be discarded is that some consumers may not envision the main stakeholders as compromised with mitigating these problems. This concept is only partially overlapped with that of trust in agents, given that among the dimensions tackled was the environmental engagement believed of the agents. Future analyses could be undertaken at the level of more elementary aspects of trust in agents concerned with environmental protection, as contrasted with aggregated measures. The design of enrolment campaigns targeting end-users with such characteristics need to consider their main motivations do adhere to dynamic prices, which, is in this case, are not environmental concerns.

4.3. Some clusters who rate relatively higher the view of nature as tolerant and recognize the need for experts, namely clusters 5, 6 and 7, have their willingness to adhere dependent upon general trust in technology or trust in more automated devices. In contrast other consumers have the sense that progress in law and society is the basis that makes it normal to employ technology in this context, thus supporting adherence. The outcome leads to considering trust in technology at the different levels, both specific, and institutional or societal. This is consistent with the role of trust in agents for some groups. Two clusters who rely upon society in order to trust technology, clusters 3 and 4, displayed as factors for adoption the higher trust in agents (the Energy Provider for cluster 3, and the Consumers' Support Organization for cluster 4). Supportive agents of specific kinds (e.g., energy regulator, energy agencies, consumer associations) thus may become important for instrumental use of technology in the smart grid initiative, given that laws, regulation and societal representatives of the stakeholders, albeit diverse in accordance with different concerns of the consumers, may be complementary conditions functioning together.

4.4. Concerning specific trust in technology as predictor of willingness to adhere, different specific devices upon which trust mattered also differed among clusters, from the use of a monitor, to an automated method. Implications are manifold. Ensuring minimum or developing further the level of trust in technology in the specific devices in this kind of situation, namely, by building support services by the relevant stakeholders, should be important in order to dissipate doubts about reliability and functionalities of smart meters and other enabling technologies. The choice of diverse levels of automation by end-users appears to be an appropriate response to the diversity of interests and trust, which the industry should follow and design technologies accordingly. Some consumers do not look for highly automated devices at home, and prefer behavioral solutions supported by the use of monitors with the capacity to emit warnings, or may accept plugs with some programmable parameters. Hence, a vast portfolio of enabling technologies may the answer to respond to different end-users' preferences and profiles and comply with smart grid challenges.

This study presented some limitations, namely that some views about nature, such as exclusively benevolent, or chaotic, were not singled out in the composition of the clusters. This could be due to employment of single items, emphasis on ecocrisis content, or it could be a restriction in the sample. Furthermore, cluster analysis is inherently an exploratory tool sensitive to variations in the procedures and options taken. Notwithstanding, among the 8 clusters studied, some matched CT constructs, namely the egalitarian, and a composite high group orientation. The combined information on eco-crisis

perception and the profile of concerns with hazards afforded a consistent basis for addressing motivations and issues relevant for willingness to adhere to a digitalized grid and the use of technology to consume electricity off peaks. The further application of trust theoretical frameworks addressing both trust in agents and in technology and the different bases of trust provided an avenue to probing the challenges and the responses to this change. Jointly the information affords interpretations of motivations and trust heuristics about the envisioned move, under the assumption that the attitude expressed in willingness ratings does indeed hold implications for future adherence and /or adaptation to the dynamic prices grid and demand response management. A characterization of the clusters in sociodemographic, energy behaviours, and energy literacy variables is a complementary step to be carried out in the future.
To conclude, if confirmed across samples and methods, it can imply that, if options of devices are given, and the involvement of different agents with roles in society is underlined, the change represented by dynamic tariffs can be given positive meaning by individuals with different orientations. An implication of this is that the successful communication to consumers should highlight a combination of values, both intrinsic and instrumental, environmental and economic, that the grid and associated technologies can contemplate. An inclusive communication for adherence may thus stress different motives and supporting forces for different pathways into adoption.

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Convergence of HDI (Human Development Index), Sustainability and Corruption: sign for a change of gear in capitalism

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Abstract

The paper aims to analyse the relationship between human development, corruption and environmental performance. The study was carried out with secondary data from 178 countries, obtained by indicators: Human Development Index (HDI), created by the United Nations (UN); Corruption Perceptions Index (CPI), created by Transparency International and Environmental Performance Index (EPI), created by Yale University. The research used a quantitative approach, and can be described as exploratory-descriptive, from longitudinal perspective with cross-sections, considering the period from 2002 to 2014. Data analysis was performed by statistical method of correlation of variables, through the Pearson's correlation coefficient (r), which measures the tendency of two variables to change simultaneously, and tests were performed to verify the existence of correlations between the indices analysed. Thus, there is a positive correlation between HDI and EPI ($r >= 0.88$ for all years of analysis) and between CPI and EPI ($r >= 0.75$ for all years of analysis), being this correlation statistically superior for countries with high human development and low corruption levels. It is concluded that countries with high development tend to have a better environmental performance and that countries with low corruption levels also tend to have a better environmental performance.

Keywords: Human Development, Environment, Corruption, Correlation

1. Introduction

Companies have traditionally been conceived as self-centered and geared towards profit maximization. However, at no other time in history has the maximization axiom of pure profit ever been called into question (Jamali et al, 2008). Society's and scientists' efforts have sought to reinforce the need for organizations to take economic, social and environmental dimensions into account in their systemic decision-making (Elkington, 2012).

This quest to make its operations sustainable can come from pressure from lenders, customers, and other stakeholders. As a form of accountability, organizations are facing the challenge of evidencing information that goes beyond accounting, and information such as human capital, social capital, intellectual capital and corporate governance also become part of the reports disclosed.

Moneva, Rivera-Lírio, & Munoz-Torres (2007) assert that corporate cultures that embody social and ethical commitment values in their actions can attract and retain best employees, increase productivity and avoid legal infractions, thus reducing their costs and generating best results in financial terms. In addition, they can mitigate occurrence of corruption practices and positively affect economic development.

Degradations and environmental accidents affect not only the environment but also society around the world, and therefore minimizing and solving problems requires the effort of all. Within the society are the companies that, due to pressure or interest, begin to direct their efforts, to seek solutions not only for their clients, but for society in a broad way (Capra, 2005).

In this context, the paradigm of development supported by production of goods and services, which were idealized by capitalist prism, needs to be revised. The environment and its natural resources cannot be seen merely as input to productive process. This is because the concerns of all organization stakeholders must be taken into consideration, under penalty of legitimacy loss (Johnson & Greening, 1999, Knox & Maklan, 2004).

In many areas of society, sustainability has become the focus of debate. There seems to be a collective understanding that human organizations need to undergo fundamental change to become environmentally sustainable insofar as they constitute the primary force of planetary environment destruction (Goodland, 1995).

The current economic model was based on inexhaustibility of ecological resources vision, especially energy resources, and the change of this paradigm requires a time for understanding and reaction (Dreher, Casagrande, & Gomes, 2012). Nevertheless, we face a systemic challenge that no longer supports the archaic forms of management, and a new way of environmental resources management is vital (Sachs, Lopes, & Dowbor, 2010).

It was the United Nations Conference on the Human Environment in 1972 (Stockholm), which put the environment dimension on the international agenda, addressing for the first time the dependencies between development and environment. From this meeting, an alternative emerged that economic growth was still necessary, but it should be socially receptive and implemented by environmentally friendly methods, rather than favoring the predatory incorporation of nature's capital into GDP.

After this Conference, the discussions about sustainability have matured, and they have gained space. The concept foresees the existence of three systemic dimensions: environmental; social; and economic dimension (Elkington, 2012). The environmental pillar deals with the conservation and management of natural resources; the economic pillar alludes to financial consequences of the company's actions for the stakeholders; and the social pillar encompasses the need for equality, in the participation of social groups, in maintaining and improving the balance of the system, regarding rights and responsibilities (Sachs, 2009).

The sustainable development framework took place in 1987, with World Commission on Environment and Development (WCED) report, known as the Brundtland Commission report. From this perspective, organizational decisions must continually reassess space and resources limits that are used by mankind and their regeneration capacity so that future generations have access to these resources and a satisfactory life (Holdren & Ehrlich, 1971).

Since the second half of the 1990s, the understanding of sustainability and corporate social responsibility has gained even more importance in building long-term relationships with stakeholders, be they clients, suppliers, employees, shareholders and the community in general, and recognize the impact of productive activities in environmental resources degradation has become critical (Polonski & Rosenberger, 2001).

Another reflection of actions taken towards sustainable development is related to legitimacy. Gildia (1995) and Ciliberti, Pontrandolfo, & Scozzi (2008) declare that companies that adopt environmental preservation actions and good citizenship behaviors are strengthened by the confidence that derive from society, thus increasing their competitiveness. Research shows that people and/or buyers prefer to buy products, and/or invest in companies' shares with this performance policy.

Therefore, the purpose of a sustainable development process is to achieve sustainability in its different dimensions, and that the quality of the process is increasingly charged by society. Some symptoms of this demand can be identified through sustainability reports, which have been used for organizations accountability, as well as the creation of the Corporate Sustainability Index (ISE), by the São Paulo Stock Exchange, to reward companies that seek to combine development with eco-efficiency and social responsibility (Nunes, Teixeira, Nossa, & Galdi, 2010).

However, in the organizational field, not all sustainability dimensions are always considered, and, traditionally, the emphasis is on the economic dimension, to detriment of others. Many socio-environmental problems were caused because simple and fragmented decisions aimed at meeting only the economic dimension, according to concept of economic man, defended by the classic thinkers of the Administration, or by concept of limited rationality studied by Simon (1979).

Corporate scandals such as ENROM, AGF, the Subprime Mortgage Crisis in the first decade of the twenty-first century have reinforced the importance of corporate governance. It is understandable that investor protection has become a major issue for financial markets after the tremendous failures and scandals that have appeared.

For this credibility to occur, companies need to implement governance principles, keeping them in line with their practices. Literature generally points four principles to be observed: transparency, accountability, responsibility and fairness (Aras & Crowther, 2008). The main intention is to create a transparent environment in which each party - shareholders, managers, employees, suppliers and general society - can assume its responsibilities and contribute to the company's growth and value creation (Jamali et al. Al., 2008).

Thus, it can be said that corporate governance advocates transparency and respect for minority shareholder’s rights and can be an instrument to induce a virtuous cycle, in that it values economic actors that present good economic, social and environmental performance indexes (Grun, 2003). The importance of corporate governance is also reinforced by its quest to improve the laws, regulations, and contracts that govern corporate operations, as well as to ensure the rights of shareholders and stakeholders in general are safeguarded (Kolk, 2008).

Two notable aspects of corporate governance are: reduction of information asymmetry, which is well in line with a concern raised by agency theory (Jensen & Meckling, 1976); and generation of legitimacy (Aras, Crowther, 2008). With the dissemination of information, the organization can mitigate the advantages and disadvantages of privileged access to information (Lambert, Leuz, Verrechia, 2007) and provide gains in terms of organizational legitimacy using symbolic actions, that are part of the public image of the organization, and which is based on values shared by the general population (Neu et al., 1998, Searcy & Elkhawas, 2012).

One value that has been gaining prominence in stakeholder expectations is the attention given to sustainability in corporate governance (Elkington, 2012). Leo & Robles (2006) consider that society started to demand information about sustainability from companies, inducing the incorporation of economic, social and environmental aspects in their business reports. This perspective can demonstrate that corporate governance is concerned with creating a balance between a company's economic and social objectives, including aspects such as efficient resources usage, accountability in the use of its power, and company behavior related to environment (Sethi, 2002).

Therefore, corporate governance and sustainability practices have been jointly approached, and have as their main origin in Bowen (1957) study, who spoke about a vision of social responsibility aligned with company policies, as opposed to early philanthropic approach. In this sense, there are evidences that suggest that organizations are more inclined to broaden the basis of their performance evaluation from a short-term financial focus to include long-term, social, environmental and economic impacts (Hardjono & Van Marrewijk, 2001). This movement may affect even human development indicators.

The most widespread measure of quality of life up to the beginning of the 1990s was the Gross Domestic Product (GDP), but it is not enough to evaluate population’s living conditions. Thus, the progress of a country cannot be measured solely by citizens' wealth, but also by their health, quality of medical services and education (Sagar & Najam, 1998; Torres, Ferreira & Dini, 2003).

The idea of creating a scalar indicator that synthesizes all relevant poverty dimensions is old, but has had its greatest impulse with creation of the Human Development Index (HDI) (Barros, Carvalho & Franco, 2003).

The HDI is an indicator developed by the United Nations and it is used to measure the people’s quality of life in several countries around the world, considering GDP per capita, health and education. The result of this calculation is ordered and this scale considers 0 as the worst human development situation and 1 to the best human development situation (Barros, Carvalho & Franco, 2003, Silva & Panhoca, 2007).

Since HDI measures only the human development of countries, several other indicators were created to measure different dimensions, among which we can mention the Corruption Perceptions Index (CPI) and the Environmental Performance Index (EPI).

In 1995 Transparency International, a global movement that aims for a world free from corruption, created the Corruption Perception Index (CPI) with the main objective of bringing corruption matter to the global agenda (Transparency International, 2017a, Transparency International, 2017b). The CPI is a composite index obtained by several researches combination and that classifies countries based on corruption perception of public sector (Transparency International, 2016). Until the year of 2011, the CPI scale ranged from 0 (highly corrupt) to 10 (highly clean), and from 2012 its scale considers 0 (highly corrupt) to 100 (highly clean) (Transparency International, 2011, Transparency International, 2012).

The Environmental Performance Index (EPI) is an initiative led by Yale University started in 2006 which ranks countries' according their performance on high-priority environmental issues in two areas, protection of human health and protection of ecosystems, and whose scale considers 0 for the worst environmental performance and 100 for the best environmental performance (Hsu et al., 2016).

In this scenario, this research seeks to analyze whether there is a relation between human development, corruption and environmental performance. Therefore, this research has a quantitative approach and compares HDI, CPI and EPI through a statistical analysis using Pearson's correlation coefficient (r).

2. Methods

This research is characterized by being exploratory-descriptive, with a quantitative approach and was performed by analysis of secondary data. The descriptive characteristic results from the fact of establishing relations among the HDI, CPI and EPI indexes. Data referring to the HDI, CPI and EPI were obtained through internet downloads, from websites of the respective institutions, being considered to this research the years from 2002 to 2012 and 2014. The year 2013 was not considered due to the absence EPI's data.

The year of 2014 was the last year considered due to the absence of HDI data for the following years until the date used to collect data in this survey, which was on February 2nd, 2017.

Initially HDI, CPI and/or EPI data were collected from 195 different countries, which were organized in a spreadsheet. Subsequently, the data were filtered and the countries that did not present EPI data from any of analysed years were removed from the sample. The data of the EPI were withdrawn because this research seeks to perform an analysis of the EPI variation (dependent variable) according to the HDI and the CPI (independent variables), that is, it would not make sense to carry out the analysis for countries that did not present EPI data. Thus, the sample went to 178 countries.

Data analysis was carried out in four steps.

The first two steps sought to analyse correlations between HDI and EPI and between CPI and EPI. For each analysed year, a correlation analysis was done. The statistical analysis of the correlation between the indexes uses Pearson's correlation coefficient (r). According to Sweeney, Williams & Anderson (2013), Pearson's correlation coefficient is a measure of a linear relationship between two variables, which is not affected by the unit, and varies from -1 to +1, indicating the values of -1 and +1 perfectly linear relationships, and values close to 0 (zero) indicate a weak linear relationship. Hair et al. (2009) defines that the correlation coefficient indicates the strength of the association between the two any metric variables. The correlation coefficient is obtained by the following formula:

rxy = Sxy/SxSy

Where: rxy represents the sample correlation coefficient; Sxy represents the sample covariance; Sx is the sample standard deviation of x; and Sy represents the sample standard deviation of y (Sweeney et al., 2013).

Table 1 presents how will be the interpretation of the correlation coefficient values in this research. The table shows positive values (positive correlation), but the same interpretation will be adopted for the same range of negative values (negative correlation).

Table 1. *Interpretation of Correlation.*

Range	Interpretation
$r = 0$	No correlation
$0 < r \leq 0.2$	Very weak correlation
$0.2 < r \leq 0.4$	Weak correlation
$0.4 < r \leq 0.6$	Moderate correlation
$0.6 < r \leq 0.8$	Strong Correlation
$0.8 < r < 1$	Very strong correlation
$r = 1$	Perfect correlation

The alpha level used for this research was 0.05. The alpha level measures the maximum acceptable level of risk to reject a hypothesis, in other words, for the analysis performed, the chance to find an error that doesn't really exist is 5% (MiniTab, 2016).

The last two steps sought to analyze correlations between HDI and EPI, grouping countries according HDI quartiles, and between CPI and EPI, grouping countries according to CPI quartiles. Considering the HDI, it was decided to group the countries into quarters because of the constant changes in countries classification that happened over the years.

The second step performed an EPI analysis considering a grouping of countries according to HDI quartiles. It was done to verify if countries with high human development levels have superior environmental performance when compare to the other countries Therefore, a boxplot graphical analysis were done for each analysed year.

For this research will be considered outliers occurrences whose values are at least 1.5 times the interquartile range (Q3 - Q1) and the software used for statistical analysis of data was the Minitab version 17.

3. Results and Discussion

The first step sought to verify if there is a correlation between HDI and EPI indexes, in other words, to analyse if countries with high human development have superior environmental performance when compared to countries with low human development.

Table 2 presents the correlation and regression data that were obtained through correlation analysis between HDI and EPI indexes.

Table 2. *Correlation between HDI and EPI.*

Year	Number of Countries	p-Value	r	R^2	Regression equation
2002	160	$p < 0.001$	0.89	78.94%	Y = - 6.192 + 86.48 X
2003	162	$p < 0.001$	0.89	79.31%	Y = - 6.222 + 86.27 X

2004	164	p < 0.001	0.89	79.77%	Y = - 7.335 + 87.83 X
2005	173	p < 0.001	0.89	79.02%	Y = - 7.070 + 86.72 X
2006	173	p < 0.001	0.89	78.93%	Y = - 7.538 + 86.97 X
2007	173	p < 0.001	0.89	79.09%	Y = - 8.610 + 87.99 X
2008	173	p < 0.001	0.89	79.12%	Y = - 9.560 + 89.38 X
2009	173	p < 0.001	0.89	79.36%	Y = - 10.89 + 91.05 X
2010	176	p < 0.001	0.89	78.88%	Y = - 11.53 + 91.62 X
2011	176	p < 0.001	0.89	79.15%	Y = - 12.27 + 92.14 X
2012	176	p < 0.001	0.88	78.22%	Y = - 12.52 + 92.05 X
2014	176	p < 0.001	0.88	77.84%	- 13.17 + 92.00 X

All correlations analysed, which are evidenced by table 2, presented p-value lower than 0.001, in other words, lower than the alpha level of 0.05 that had been established. This means that the margin of error of the presented data is within the predetermined margin of error.

When analyse the correlation information contained in table 2, is perceivable a very strong correlation between HDI and EPI, because the correlation coefficient (r) found is 0.88 or higher. The coefficient of determination (R^2) ranged from 77.84% to 79.77%. In this way, it is noticed that the correlation between HDI and EPI is not a phenomenon that happened in an isolated year, but occurred in all analysed years.

Figure 1 represents EPI regression analysis in function of HDI for the year of 2014. In this figure, is perceivable the very strong correlation between the two indexes (r = 0.88). The coefficient of determination (R^2) indicates that 77.84% of the EPI variation can be explained by the proposed equation, which considers the HDI index as the only variable. The graphics of the other years were suppressed for being like the year of 2014.

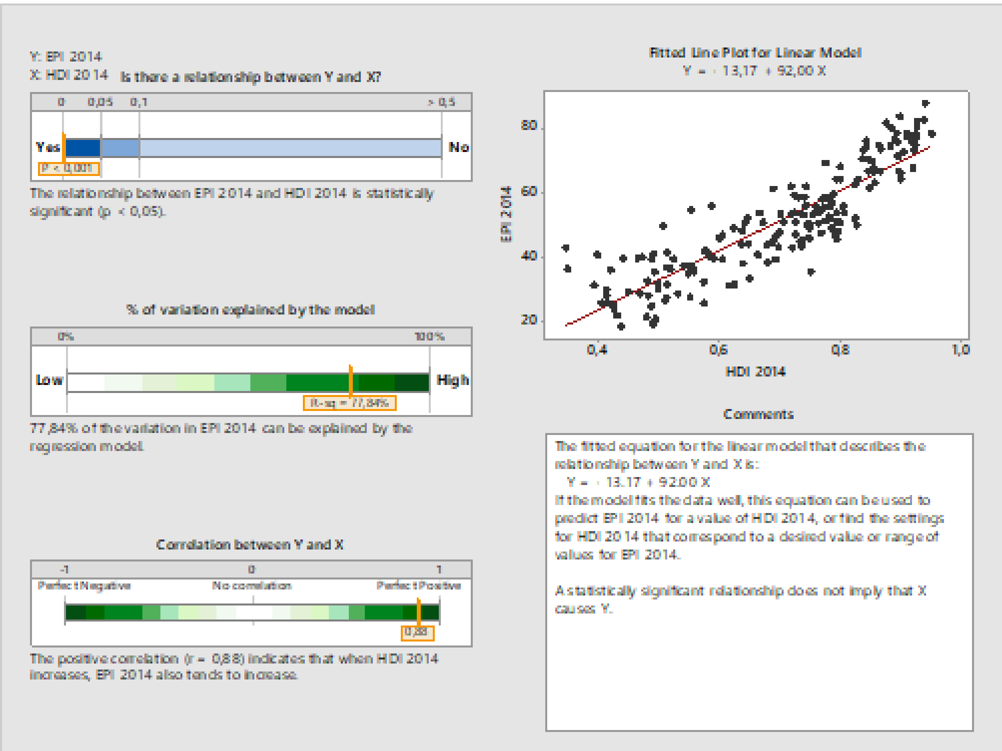

Figure 1. *Summary report of regression for EPI 2014 vs HDI 2014.*

The second step sought to verify if there is a correlation between CPI and EPI indexes, in other words, to analyse if countries with high corruption levels have lower environmental performance when compared to countries with low corruption levels.

Table 3 presents the correlation and regression data that were obtained through correlation analysis between CPI and EPI indexes.

Table 3. *Correlation between CPI and EPI.*

Year	Number of Countries	p-Value	r	R^2	Regression equation
2002	101	$p < 0.001$	0.81	65.08%	Y = 30.24 + 5.339 X
2003	130	$p < 0.001$	0.80	64.20%	Y = 28.39 + 5.632 X
2004	143	$p < 0.001$	0.78	61.14%	Y = 27.75 + 5.712 X
2005	156	$p < 0.001$	0.79	61.66%	Y = 25.19 + 6.089 X
2006	161	$p < 0.001$	0.79	61.95%	Y = 25.60 + 6.064 X
2007	173	$p < 0.001$	0.78	61.30%	Y = 24.63 + 6.285 X
2008	172	$p < 0.001$	0.78	60.53%	Y = 25.31 + 6.228 X
2009	172	$p < 0.001$	0.78	60.54%	Y = 25.29 + 6.273 X
2010	171	$p < 0.001$	0.77	59.01%	Y = 25.75 + 6.220 X
2011	173	$p < 0.001$	0.75	55.69%	Y = 26.73 + 5.966 X
2012	163	$p < 0.001$	0.77	59.83%	Y = 22.13 + 0.6766 X
2014	163	$p < 0.001$	0.79	61.87%	Y = 21.80 + 0.6825 X

All correlations analysed, which are evidenced by table 3, presented p-value lower than 0.001, in other words, lower than the alpha level of 0.05 that had been established. This means that the margin of error of the presented data is within the predetermined margin of error.

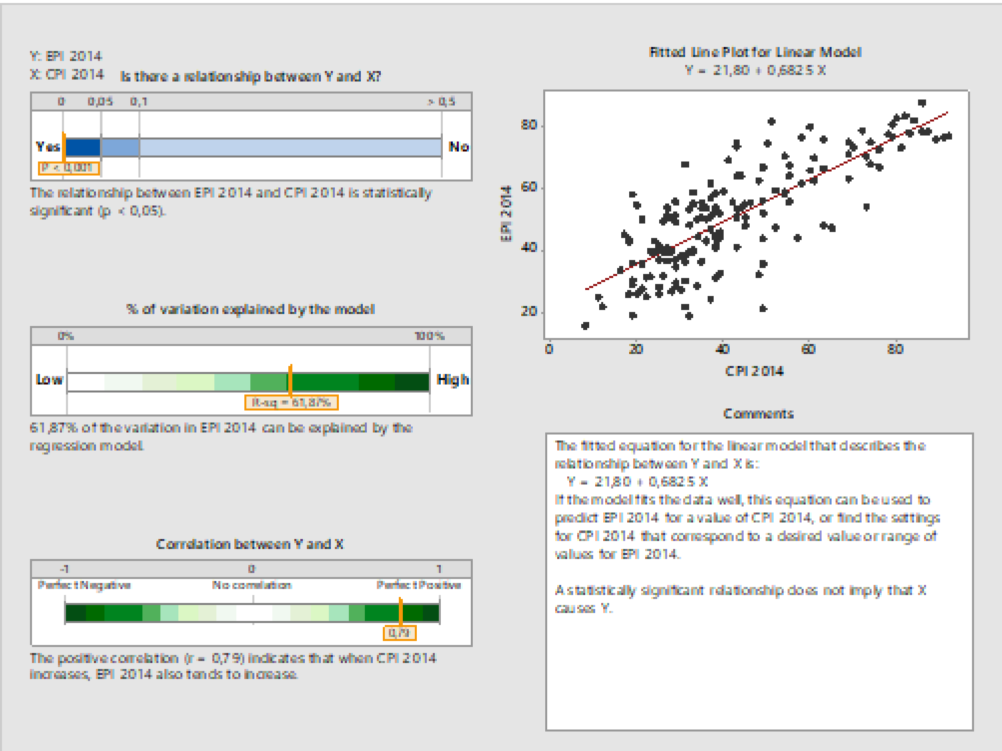

Figure 2. *Summary report of regression for EPI 2014 vs CPI 2014.*

When analyse the correlation information contained in table 3, is perceivable a strong or very strong correlation between CPI and EPI, according to analysed year, because the value of the correlation coefficient (r) found is 0.75 or higher. The coefficient of determination (R^2) ranged from 55.69% to 65.08%. Thus, it is noticed that the correlation between CPI and EPI is not a phenomenon that happened in an isolated year, but occurred in all analysed years.

Figure 2 represents a regression analysis of EPI index in function of CPI index in the year 2014. In this figure, is perceivable the strong correlation between the two indexes (r = 0.79). The coefficient of determination (R^2) indicates that 61.87% of the EDI variation can be explained by the proposed equation, which considers the CPI index as the only variable. The graphics of the other years were suppressed for being like the year of 2014.

Table 4 shows HDI descriptive statistic data. These data were used to elaborate HDI groups according to quartiles, being considered for the quartiles grouping following criteria: Quartile 1 from Minimum value to Q1 value; Quartile 2 from Q1 value to Median value; Quartile 3 from Median value to Q3 value; and Quartile 4 from Q3 value to Maximum value.

Table 4. *Descriptive Statistics of the HDI.*

Year	N	Mean	StDev	Min.	Q1	Median	Q3	Max.
2002	160	0.6370	0.1721	0.2660	0.4788	0.6710	0.7787	0.9180
2003	162	0.6419	0.1721	0.2700	0.4815	0.6780	0.7817	0.9240
2004	164	0.6472	0.1700	0.2780	0.4882	0.6825	0.7883	0.9290
2005	173	0.6496	0.1694	0.2860	0.4920	0.6890	0.7850	0.9310
2006	173	0.6564	0.1681	0.2930	0.5000	0.6960	0.7890	0.9340
2007	173	0.6633	0.1666	0.2980	0.5120	0.7000	0.7915	0.9360
2008	173	0.6691	0.1648	0.3070	0.5185	0.7050	0.7945	0.9360
2009	173	0.6728	0.1619	0.3120	0.5230	0.7080	0.7995	0.9360
2010	176	0.6781	0.1597	0.3230	0.5353	0.7115	0.8025	0.9390
2011	176	0.6831	0.1583	0.3310	0.5435	0.7170	0.8083	0.9410
2012	176	0.6881	0.1568	0.3410	0.5503	0.7205	0.8102	0.9420
2014	176	0.6955	0.1565	0.3470	0.5557	0.7310	0.8185	0.9480

Data in table 4 show that there was an improvement in countries' HDI performance, since there was an increase in the HDI level in all quartiles (Q1 and Q3), in the minimum and maximum values, and in mean and median, when comparing data from 2002 with 2014. It is also noticed that there was a decrease in the value of the standard deviation (StDev), which means a smaller data dispersion.

Table 5 presents descriptive statistics of EPI grouped by HDI quartiles. By analysing data in table 5, one realize that EPI values for quartiles 2 and 3 are overlapped for the years 2002 to 2004, from 2007 to 2012 and 2014. Thus, countries classified in quartile 1 have lower environmental performance, for these years, when compared to countries of other quartiles. There is also an overlap of EPI values for quartiles 1, 2 and 3 in the years 2005, 2006 and 2007. Thus, countries classified in quartile 4 have higher environmental performance when compared to countries of other quartiles for all analysed years.

The following countries were classified as outliers because they presented statistical lower environmental performance when compared to the countries of the respective quartiles:

- Bahamas in quartile 4 in the years of 2002, 2003, 2005, 2006;
- Argentina in quartile 4 in the years of 2007 2009, 2010, 2011, 2012 and 2014;
- Romania in quartile 4 in the year of 2008;
- Bangladesh in quartile 2 in the years of 2010 and 2011;
- Grenada in the quartile 3 in the years of 2010, 2011, 2012 and 2014.

And The following countries were classified as outliers because they presented statistical higher environmental performance when compared to the countries of the respective quartiles:

- Serbia in quartile 3 in the years of 2010 and 2014;
- Belarus in quartile 3 in the year of 2014.

Figure 3 illustrates the data contained in Table 6 for the year 2014. In this figure are showed the countries classified as outliers, that are: Grenada, Serbia, Belarus in quartile 3; and Argentina in quartile 4.

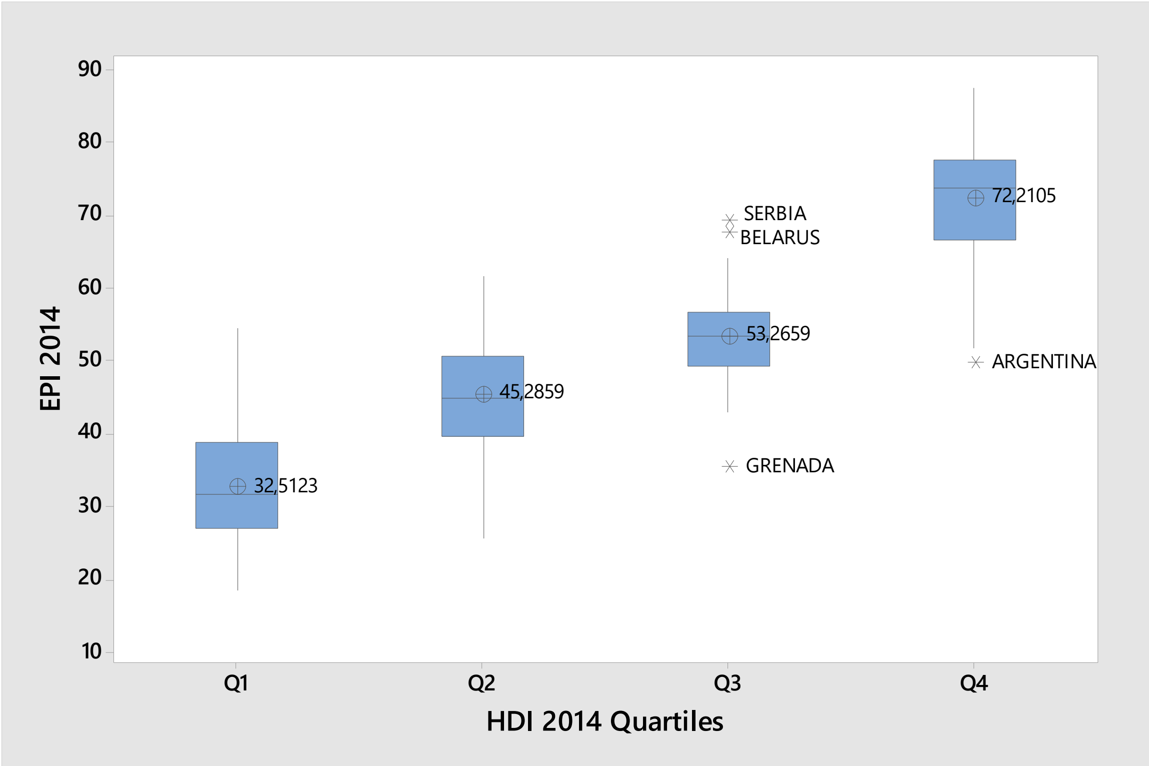

Figure 3. *Boxplot of EPI 2014*.

Table 5. *Descriptive Statistics of EPI grouped by HDI quartiles.*

Year	Quartile 1						Quartile 2						Quartile 4						Quartile 4					
	N	Min	Q1	Median	Q3	Max	N	Min	Q1	Median	Q3	Max	N	Min	Q1	Median	Q3	Max	N	Min	Q1	Median	Q3	Max
2002	40	16.96	24.61	29.89	35.98	47.61	40	24.63	36.60	42.49	49.96	57.09	40	40.38	46.50	51.18	57.68	72.52	40	45.41	65.40	71.06	75.78	86.97
2003	40	17.30	24.63	29.65	36.32	47.68	41	24.24	37.20	42.78	49.42	57.30	41	40.76	46.88	52.45	58.05	72.22	40	45.63	65.77	71.43	76.01	86.71
2004	41	16.16	25.06	30.26	36.69	47.77	41	25.33	37.41	43.28	50.56	57.66	41	40.91	47.17	52.51	57.31	72.47	41	52.43	66.11	71.96	76.10	86.64
2005	43	16.80	24.30	30.31	36.97	47.90	43	25.44	36.90	43.91	49.90	57.30	44	41.320	47.685	51.680	57.315	66.990	43	45.90	66.13	72.61	75.89	86.43
2006	43	17.66	24.73	30.40	37.02	48.05	42	25.43	36.71	43.38	50.20	57.75	45	41.700	48.055	52.140	56.935	66.920	43	45.94	66.34	72.67	76.31	85.95
2007	43	17.79	25.75	30.50	36.47	48.23	43	25.37	37.29	43.26	50.24	60.93	44	42.000	48.462	51.950	56.928	67.010	43	48.18	66.51	72.88	76.48	86.69
2008	43	17.92	26.14	30.60	36.70	48.44	43	25.23	38.13	44.66	50.63	61.10	44	42.300	48.815	52.555	57.110	68.580	43	50.03	66.67	73.12	76.77	88.36
2009	42	18.05	26.19	30.42	36.37	48.66	44	25.17	39.01	44.12	50.72	62.00	44	42.650	49.625	52.780	57.332	68.110	43	48.82	66.55	73.47	76.88	88.79
2010	44	18.20	26.32	31.05	36.78	48.90	44	25.32	40.65	44.80	50.58	62.11	44	35.130	50.060	53.395	57.550	69.260	44	49.20	66.81	73.56	77.08	88.60
2011	44	18.35	26.50	31.13	37.11	49.13	43	25.53	40.58	44.44	50.53	61.75	45	35.190	50.095	53.900	58.090	68.610	44	49.49	66.46	73.69	77.16	88.17
2012	44	18.43	26.82	31.51	37.26	49.54	44	25.61	40.43	44.87	51.61	61.68	44	35.240	49.278	53.530	57.560	69.130	44	49.55	66.62	73.82	77.65	87.67
2014	44	18.43	26.82	31.51	38.72	54.50	44	25.61	39.67	44.72	50.70	61.68	44	35.240	49.278	53.265	56.575	69.130	44	49.55	66.62	73.82	77.65	87.67

Table 6 shows CPI descriptive statistic data. These data were used to elaborate CPI groups according to quartiles, being considered for the quartiles grouping following criteria: Quartile 1 from Minimum value to Q1 value; Quartile 2 from Q1 value to Median value; Quartile 3 from Median value to Q3 value; and Quartile 4 from Q3 value to Maximum value.

Table 6. *Descriptive Statistics of the CPI.*

Year	N	Mean	StDev	Min.	Q1	Median	Q3	Max.
2002	101	4.522	2.356	1.200	2.600	3.700	6.150	9.700
2003	130	4.218	2.277	1.300	2.400	3.400	5.500	9.700
2004	143	4.159	2.219	1.500	2.500	3.400	5.300	9.700
2005	156	4.069	2.167	1.700	2.500	3.200	5.000	9.700
2006	161	4.050	2.130	1.800	2.500	3.200	5.100	9.600
2007	173	3.939	2.081	1.400	2.450	3.300	5.000	9.400
2008	172	3.960	2.098	1.000	2.425	3.200	5.100	9.300
2009	172	3.972	2.088	1.100	2.500	3.300	5.075	9.400
2010	171	3.988	2.088	1.100	2.400	3.300	5.100	9.300
2011	173	4.003	2.093	1.000	2.500	3.200	5.050	9.500
2012	163	42.58	19.39	8.00	28.00	37.00	54.00	90.00
2014	163	42.69	19.55	8.00	28.00	38.00	54.00	92.00

Data in table 6 show that there was not a significate evolution in countries' CPI performance, since there was not any significate increasing in the CPI level in quartiles (Q1 and Q3) neither in the minimum and maximum values, and in mean and median, when comparing data from 2002 with 2014.

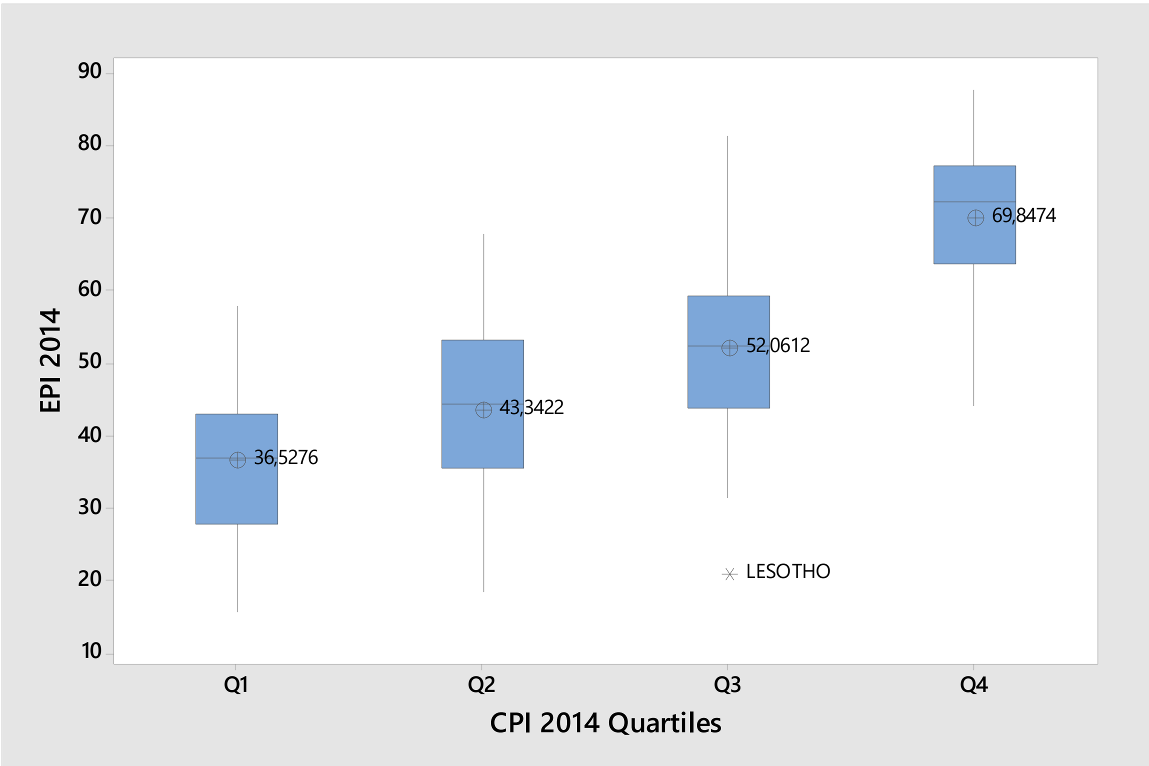

Figure 4. *Boxplot of EPI 2014 grouped by CPI quartiles.*

Table 7 presents descriptive statistics of EPI grouped by CPI quartiles. By analysing data in table 7, one realize that EPI values for quartiles 1 and 2 are overlapped for the years 2003 and 2004, and EPI values for quartiles 1, 2 and are overlapped for the year 2002 and from 205 to 2014. Thus, countries classified in quartile 4 have higher environmental performance when compared to countries of other quartiles for all analysed years.

The following countries were classified as outliers because they presented statistical lower environmental performance when compared to the countries of the respective quartiles:

- Botswana in quartile 4 in the years of 2002, 2003, 2004, 2005;
- Uruguay in quartile 4 in the years of 2003 and 2004;
- Oman in quartile 4 in the years of 2004 and 2005;
- Barbados in quartile 4 in the years of 2004 and 2005;
- Ghana in quartile 3 in the years of 2004 and 2005;
- Lesotho in quartile 3 in the years from 2005 to 2014;
- Cape Verde in the quartile 4 in the years of 2009 and 2012.

And The following countries were classified as outliers because they presented statistical higher environmental performance when compared to the countries of the respective quartiles:

- Czech Republic in quartile 3 in the years of 2004, 2005, 2009 and 2012;
- Slovakia in quartile 3 in the year of 2005;
- Belarus in quartile 1 in the years of 2006, 2009 and 2011.

Figure 4 illustrates the data contained in Table 7 for the year 2014. In this figure are showed the countries classified as outliers, that are: Grenada, Serbia, Belarus in quartile 3; and Argentina in quartile 4.

Table 7. *Descriptive Statistics of EPI grouped by CPI quartiles.*

Year	Quartile 1						Quartile 2						Quartile 4						Quartile 4					
	N	Min	Q1	Median	Q3	Max	N	Min	Q1	Median	Q3	Max	N	Min	Q1	Median	Q3	Max	N	Min	Q1	Median	Q3	Max
2002	22	17.92	34.03	43.28	49.17	57.16	24	29.63	37.52	44.10	50.83	55.72	30	29.81	50.11	57.44	65.33	78.74	25	44.41	69.74	74.32	77.72	86.97
2003	27	17.88	30.16	37.84	46.27	55.26	35	17.30	36.34	44.10	50.50	57.67	35	37.55	50.83	56.09	64.68	78.50	33	44.46	65.14	71.74	76.37	86.71
2004	35	18.07	29.67	37.99	46.64	57.81	36	16.16	36.61	43.76	50.75	65.64	36	31.24	50.91	55.05	61.16	79.20	36	44.97	65.43	72.83	76.31	86.64
2005	34	14.68	25.76	34.45	41.23	57.84	41	16.80	34.36	43.84	48.52	66.29	40	19.92	47.61	52.92	57.37	79.47	41	44.90	64.65	72.12	75.72	86.43
2006	34	18.27	27.16	35.32	42.14	65.74	46	17.66	35.56	43.99	49.62	66.86	40	19.98	43.89	52.43	59.14	79.66	41	45.03	62.33	71.52	76.17	85.95
2007	43	14.83	27.34	36.42	43.26	65.95	43	17.79	31.10	41.08	49.46	60.28	43	20.07	43.10	51.94	57.71	73.01	44	45.02	62.06	72.55	76.42	86.69
2008	43	14.90	27.73	37.77	45.01	67.14	40	17.92	32.40	40.02	48.72	60.85	43	20.18	44.00	52.12	58.09	74.29	46	41.49	59.84	70.70	76.74	88.36
2009	42	14.98	28.10	36.19	43.66	68.11	42	18.05	31.00	43.49	50.52	62.00	45	20.32	45.13	52.76	59.63	81.97	43	41.67	62.94	71.47	76.87	88.79
2010	35	15.35	27.91	35.57	41.07	57.82	50	18.20	34.97	44.44	51.50	67.58	43	20.47	45.76	54.77	60.88	81.93	43	43.50	63.27	72.03	77.03	88.60
2011	40	15.42	28.13	37.92	42.17	67.45	45	18.35	33.43	44.44	52.23	61.75	45	20.63	45.70	53.90	61.54	81.41	43	43.92	63.30	72.20	76.85	88.17
2012	36	15.47	27.59	36.33	42.31	57.80	44	18.43	33.36	44.52	51.08	73.28	42	20.81	44.73	53.24	59.07	81.47	41	44.07	64.78	72.91	77.55	87.67
2014	38	15.47	27.88	36.84	43.01	57.80	41	18.43	35.38	44.36	53.30	67.69	41	20.81	43.91	52.28	59.15	81.47	43	44.07	63.79	72.35	77.35	87.67

4. Conclusions

We are witnessing a new paradigm in terms of organizational behavior, in which corporations begin to consider, in a systemic way, the economic, social and environmental dimensions for their decision-making. More and more, the functionalist behavior defended by the so-called Chicago School, which had Milton Friedman as one of its exponents, spread the belief that the sole purpose of a company is profit. The universe of capitalism proved to be much more complex and challenging than that.

Thinking that a business exists only for profit is akin to thinking that a person lives only for food. Obviously, it is necessary to feed, otherwise the person does not survive, but life is much more than that. People eat to have energy to pursue and accomplish their life goals. A corporation also needs profit to live (pay employees, buy and maintain machines, R&D), but it must exist for much more noble meanings. The question is: profit ceases to be the cause of the existence of the organization and happens to be a consequence. Profit allows the organization to exist to add value to all its stakeholders.

Data obtained through analysis between HDI and EPI show a positive correlation between these indexes. The Pearson's correlation coefficient (r) was always equal or greater than 0.88 for all analyzed years (from 2002 to 2014), which indicates that the correlation was not an isolated phenomenon of a given year, but was repeated in all analyzed years. When considering the division of countries by HDI quartiles, it is also observed that countries with high levels of human development (quartile 4) have higher environmental performance where compared to countries of other quartiles, and this difference is statistically significant.

Thus, it is concluded that there is a positive correlation between human development (HDI) and environmental performance (EPI) of countries and that this relationship tends to be more accentuated for countries with high human development, that is, countries classified as very human development have an environmental performance statistically superior when compared to other countries.

Data obtained through analysis between CPI and EPI show a positive correlation between these indexes. The Pearson's correlation coefficient (r) was always equal or greater than 0.75 for all analyzed years (from 2002 to 2014), which indicates that the correlation was not an isolated phenomenon of a given year, but was repeated in all analyzed years. When considering the division of countries by CPI quartiles, it is also observed that countries with high levels of human development (quartile 4) have higher environmental performance where compared to countries of other quartiles, and this difference is statistically significant.

Thus, it is concluded that there is a positive correlation between corruption (CPI) and environmental performance (EPI) of countries and that this relationship tends to be more accentuated for countries with low corruption levels, that is, countries classified as less corrupt have an environmental performance statistically superior when compared to other countries.

As future researches, it is suggested the use of new indexes that can create a more complete model to explain the correlation between HDI and EPI as well the correlation between CPI and EPI with more accurate. It is also suggested a deeper understanding of the situations of countries identified as outlier.

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Analysis of Government effectiveness and its impact on the human being's development

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Abstract

One of the most important govern responsibility is to promote the well-being for its population. This can be achieved ensuring that law is fulfilled, order is assured and basic goods and public services are available to everyone. When legitimate laws are not the ones to guide Institutions, they tend to be less capable to deliver public services to population. It is known that many countries fail in their purpose to promote the welfare for their population. The lack of government effectiveness compromises the development of countries. The failure of national governance is pointed for World Bank as the main risk faced for Latin American and Sub-Saharan countries and is considered to be among the top three most likely risks in the Middle East and North Africa, East Asia and Pacific, and Central Asia countries. In this context, the research aims to investigate the government effectiveness and its impact on the human being's development. A quantitative approach was adopted for analysis. The use of HDI index, adopted by UN since 1990 to measure the human-being development in the countries, and World Governance Indicators (WGI), sustained by the World Bank since 1996, support the study. Results indicate the existence of correlation between the government effectiveness and the countries' human-being development. Results also indicate that countries with high levels of government effectiveness tend to have greater human-being development. The main contribution of this research lies on fomenting the debate, bringing actual perspectives on the subject and generating subsidies for the governmental efficiency improvement.

Keywords: Human Development, Government Effectiveness, Sustainable Development.

1. Introduction

One of the most important govern responsibility is to promote the well-being for its population. This can be achieved ensuring that law is fulfilled, order is assured and basic goods and public services are available to everyone. When legitimate laws are not the ones to guide Institutions, they tend to be less capable to deliver public services to population. Responsibility coverage is broad and affects countries in different perspectives and proportions. It is known that many countries fail in their purpose to promote the welfare for their population. According to the UN, corruption affect the Government's ability to provide basic services, feeds inequality and injustice. Thus, the lack of government effectiveness compromises the development of countries. Early 2017 the Transparency International published the ranking of corruption perception in which 2/3 of countries are below 50 on a scale of 0 (highly corrupt) to 100 (very clean). The failure of national governance is pointed for World Bank as the main risk faced for Latin American and Sub-Saharan countries and is among the top three most likely risk in the Middle East and North Africa, East Asia and Pacific, and Central Asia countries. Due to its relevance, in September/2015, the UN launched the Sustainable Development Goals (SDGs). Such initiatives, also known as Agenda 2030, foresee a series of targets to be implemented until 2030 by countries compromised with the sustainable development that signed Paris Agreement. In a total of 17 goals that cover areas of critical importance for humanity, such as planet, people, peace, prosperity, the highlight goes to SDG 16 entitled "Peace, Justice and Strong Institutions". In this context, the research aims to **investigate the government effectiveness and its impact on the human being's development.**

Government effectiveness is a complex definition. Cameron and Whetten (1983) argue that there is title consensus of what organizational effectiveness is. One of the reasons is that exists a confusion of concepts in relation to effectiveness and performance. They both are considered as "the overall ability of organizations to perform well or effectively pursue their missions" (Selden & Sowa, 2004, p. 396).

Lee & Whitford (2009), understanding that there are several ways to assess effectiveness, did an extended review in the literature to identify the different measure criteria for effectiveness used in empirical researches. The results are presented in table 1.

Table 1. *Effectiveness Measurement Criteria.*

Author(s)	Units of analysis	Measurement criteria of effectiveness (performance)
Putnam (1993)	Italian regional governments	Three performance dimensions: – Policy processes: indicators such as cabinet stability, budget promptness, and statistical and information services – Policy pronouncements: indicators such as reform legislation and legislative innovation – Policy implementation: indicators such as the number of day care centres or family clinics, industrial policy instruments, agricultural spending capacity, local health unit expenditures, housing and urban development, and bureaucratic responsiveness
Berman and Wang (2000)	U.S. county government	Performance measurement by survey – workload or output, effectiveness or outcome, and service quality
Brewer and Selden (2000)	Multiple federal agencies	Employees' perception of organizational performance – Internal efficiency, internal effectiveness, internal fairness, external efficiency, external effectiveness, and external fairness
Heinrich and Lynn (2000)	Program performance	– Earnings of participants in job training program under Job Training Partnership Act (JTPA)
Provan & Milward (2001)	Network	Evaluation at three levels of analysis: community, network, and organization/participant levels – Community level: cost to community, building social capital, aggregate indicators of client well-being, public perceptions that problem is being solved, and changes in the incidence of the problem – Network level: membership growth, range of services provided, absence of service duplication, relationship strength, creation and maintenance of network administrative organization, integration / coordination of services, cost of network maintenance, and member commitment to network goals – Organization/participant level: agency survival, enhanced legitimacy, resource acquisition, cost of services, service access, client outcomes, minimum conflict for multiprogram agencies across multiple networks
Boyne (2002)	English local governments	Dimensions of performance – Outputs: quantity and quality – Efficiency: cost per unit of output – Service outcomes: formal effectiveness, impact, equity, and cost per unit of service outcome – Responsiveness: consumer satisfaction, citizen satisfaction, staff satisfaction, and cost per unit of responsiveness – Democratic outcomes: probity, participation, accountability, and cost per unit of democratic outcome

Knack (2002)	States' entire governments	Government performance project ratings – Overall performance – Performance in financial management, capital management, human resources, managing for results, and information technology
Boyne (2003)	Literature review of performance of public service organization	Seven types of performance indicators – Quantity of output, quality of outputs, efficiency, equity, outcomes, value for money, and consumer satisfaction
O'Toole & Meier (2003)	Program	Program performance – Pass rate on Texas Assessment of Academic Skills (TAAS)
Selden & Sowa (2004)	Multiple public agencies in NY and VA	Assessed by both objective and perceptual measures – Management capacity, program capacity, management outcomes, and program outcomes
Brewer (2004)	25 Western countries' government	International Country Risk Group (ICRG) assessments – Quality of bureaucracy, corruption in government, and rule of law
Andrews et al. (2005)	Multiple English local governments	Two measures of organizational performance – Best Value Performance Indicator (BVPI): percentage of citizens satisfied with the overall service provided by their authority – Core Service Performance (CSP): quantity of outputs, quality of outputs, efficiency, outcomes, value for money, and consumer satisfaction with individual services
Chun & Rainey (2005)	Multiple federal agencies	Perceived organizational effectiveness – Managerial performance, customer service orientation, productivity, and work quality
Walker & Boyne (2006)	Welsh local governments	Subjective and objective measures of the following dimensions – Effectiveness, output quality, output quantity and equity
Light (2006)	Multiple federal agencies	Federal employees' perceptions of organizational performance – Helping people, spending money wisely, being fair in decisions, and running programs and services

Source: Lee & Whitford (2009)

Behn (2003) argues that "collections of performance measures should be selected with the characteristics necessary to help achieve eight managerial purposes: evaluation, control, budgeting, motivation, promotion, celebration, learning, and improvement" (Lee & Whitford, 2009). Due to the complexity to define and measure government effectiveness, any definition used is subject to imprecision, although, if you can measure it, you can improve it. In this regard, the World Bank Government Effectiveness index is effective in evaluating entire government effectiveness. The Government Effectiveness rate captures the perceptions of the public services quality, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. The data used are a combination of data from 6 representative sources - Economist Intelligence Unit Riskwire & Democracy Index, World Economic Forum Global Competitiveness Report, Gallup World Poll, Institutional Profiles Database, Political Economic Risk Consultancy Corruption in Asia Survey and Global Insight Business Conditions and Risk Indicators – and additional 10 non-representative sources.

Notwithstanding the approach used by the World Bank is based on perception and not on an objective approach, it has the support of Lee & Whitford (2009) for three main reasons. First, the concept is socially constructed with multiple stakeholders ensuring that complex and multiple dimensions of government performance are captured. Second, there is a positive correlation between perceived and objective measures of organizational performance. Third, "perception data for measuring effectiveness at this level or units of analysis are probably at least as good as objective data, were they available"

(Lee & Whitford, 2009, p. 255). Kaufmann et al. (1999) also agree that a non-objective approach can be important on circumstances where objective data can be difficult to be obtained.

According to Davis (2016, p. 3), "*good and effective governance is needed to address the problems of human development*", and that government effectiveness is one of the most influential to reduce poverty, improving human development. In a study developed in sub-Saharan Africa, the author empirically demonstrated that:

> "*Government effectiveness was the most consistent good governance factor influencing the greatest amount of change in the measures of the quality of life, followed by the rule of law. Similarly, government effectiveness, and political stability and absence of violence, appeared to individually have the greatest and most consistent influence on the measures of human development in sub-Saharan Africa*".

The author also indicates that government effectiveness was the most relevant good governance indicator to explain changes in six human development indicators examined in the study.

The research paper is structured as follows: Section 2 presents the methodological procedures used in this research, while section 3 provides the data results and analysis. In the sequence, the research conclusion is presented.

2. Methods

This research is characterized by being exploratory-descriptive, with a quantitative approach and was performed by analysis of secondary data. The descriptive characteristic results from the fact of establishing relations between the HDI and GE indexes. Data referring to the HDI and GE were obtained through internet downloads, from websites of the respective institutions, being considered for this research the years of 1996, 1998, 2000 and the years from 2002 to 2015. The years of 1997, 1999 and 2001 were not considered due to the absence of GE data. The year of 2015 was the last year considered due to the absence of HDI data for the following years until the date used to collect data in this survey, which was on February 2nd, 2017.

Initially, HDI and/or GE data were collected from 212 different countries, which were organized in a spreadsheet. Subsequently, data were filtered and countries that did not present HDI or GE data for any year of the analysis were removed from the sample. As a result, the sample for this research totalized 187 countries, what means that the countries selected present HDI and GE data for at least one year of analysis.

The data analysis was carried out in two steps. In the first step, for each analysed year, a correlation analysis was done. The correlation statistical analysis between the indexes used the Pearson correlation coefficient (r). According to Sweeney, Williams & Anderson (2013), Pearson's correlation coefficient is a measure of a linear relationship between two variables, which is not affected by the unit, and varies from -1 to +1, indicating the values of -1 and + 1 perfectly linear relationships, and values close to 0 (zero) indicate a weak linear relationship. Hair et al. (2009) defines that the correlation coefficient indicates the strength of the association between the two any metric variables. The correlation coefficient is obtained by the following formula:

$r_{xy} = S_{xy}/S_xS_y$

Where: r_{xy} represents the sample correlation coefficient; S_{xy} represents the sample covariance; S_x is the sample standard deviation of x; and S_y represents the sample standard deviation of y (Sweeney et al., 2013).

It should be noted that, due to the analysis carried out year by year, the number of countries considered for each year also varied due to the existence of HDI and GE data in the respective year. Thus, analyses result tables will indicate the number of countries considered for each one of the analyses.

Table 2 presents how will be the interpretation of the correlation coefficient values in this research. The table shows positive values (positive correlation), but the same interpretation will be adopted for the same range of negative values (negative correlation).

Table 2. *Interpretation of Correlation.*

Range	Interpretation
$r = 0$	No correlation
$0 < r \leq 0.2$	Very weak correlation
$0.2 < r \leq 0.4$	Weak correlation
$0.4 < r \leq 0.6$	Moderate correlation
$0.6 < r \leq 0.8$	Strong Correlation
$0.8 < r < 1$	Very strong correlation
$r = 1$	Perfect correlation

The second step performed an HDI analysis considering a grouping of countries according to GE quartiles. It was done to verify if countries with high GE levels have superior performance when compare to the other countries Therefore, ANOVA hypothesis tests and boxplot graphical analysis were done for each analysed year.

The alpha level used for this research was 0.05. The alpha level measures the maximum acceptable level of risk to reject a hypothesis, in other words, for the analysis performed, the chance to find an error that doesn't really exist is 5% (MiniTab, 2016).

For this research, it was considered outlier occurrences those values with at least 1.5 times the interquartile range (Q3 - Q1).

The HDI classification adopted by this paper is based on 2015 Human Development Report Technical Notes, which classify: low human development countries with HDI value bellow of 0.550; medium human development countries with HDI value between 0.550 and 0.699; high human development countries with HDI value between 0.700 and 0.799; and very high human development countries with HDI value 0.800 or above (Human Development Report, 2015).

The software used for statistical analyse of data was the Minitab version 17.

3. Results and Discussion

The first step sought to verify whether there was a correlation between HDI and GE indexes. It focused to analyse if countries with high GE levels had superior human development when compared to countries with low GE levels.

Table 3 presents the correlation and regression data obtained through correlation analysis between HDI and GE indexes.

Table 3. *Correlation Between HDI and GE.*

Year	Number of Countries	p-Value	r	R2	Regression equation
1996	146	$p < 0.001$	0.79	61,99%	Y = 0.6082 + 0.1351 X
1998	148	$p < 0.001$	0.78	61.18%	Y = 0.6184 + 0.1333 X
2000	166	$p < 0.001$	0.79	62.69%	Y = 0.6288 + 0.1347 X
2002	167	$p < 0.001$	0.80	63.60%	Y = 0.6385 + 0.1343 X
2003	168	$p < 0.001$	0.80	64.47%	Y = 0.6408 + 0.1369 X
2004	170	$p < 0.001$	0.80	64.78%	Y = 0.6479 + 0.1347 X

2005	180	p < 0.001	0.81	66.29%	Y = 0.6582 + 0.1390 X
2006	180	p < 0.001	0.81	66.07%	Y = 0.6634 + 0.1371 X
2007	180	p < 0.001	0.80	64.43%	Y = 0.6694 + 0.1344 X
2008	181	p < 0.001	0.80	64.35%	Y = 0.6753 + 0.1338 X
2009	181	p < 0.001	0.81	66.07%	Y = 0.6796 + 0.1328 X
2010	186	p < 0.001	0.81	65.58%	Y = 0.6844 + 0.1297 X
2011	187	p < 0.001	0.81	65.35%	Y = 0.6885 + 0.1294 X
2012	187	p < 0.001	0.82	66.87%	Y = 0.6935 + 0.1299 X
2013	187	p < 0.001	0.82	67.95%	Y = 0.6972 + 0.1309 X
2014	187	p < 0.001	0.85	71.93%	Y = 0.7012 + 0.1342 X
2015	187	p < 0.001	0.85	71.98%	Y = 0.7035 + 0.1339 X

All analysed correlations, which are evidenced in Table 3, presented p-value lower than 0.001, in other words, lower than the alpha level of 0.05 that had been established. This means that the margin of error of the presented data is within the predetermined margin of error.

When analysing the correlation information contained in table 3, is perceivable a strong correlation between HDI and GE, because the value of the correlation coefficient (r) showed was 0.78 or superior and the coefficient of determination (R^2) ranged from 61.18% to 71.98%. The existence of a high correlation coefficient for all analysed years suggests that relation between HDI and GE was not an isolated phenomenon but that has been occurring along all period.

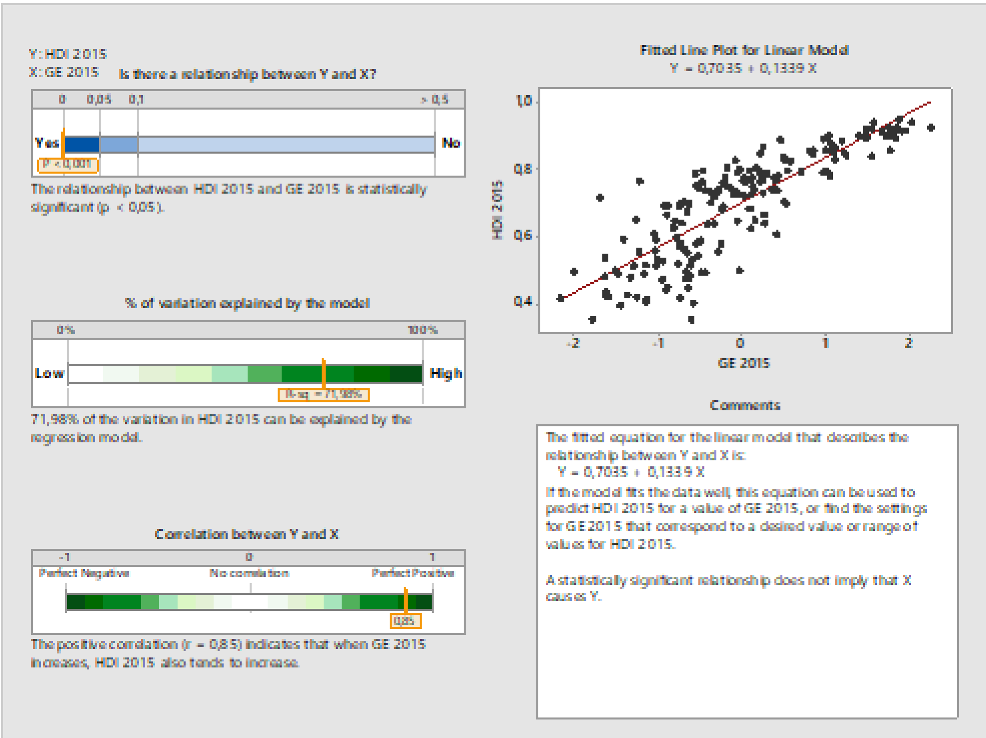

Figure 1. *Regression for HDI 2015 vs GE 2015*

Figure 1 represents a regression analysis of HDI index in relation to GE index for the 2015 year. In this figure, is perceivable the strong correlation between the two indexes (r = 0.85). The coefficient of determination (R^2) indicates that 71.94% of the HDI variation can be explained by the proposed equation, which considers the GE index as the only variable. Similar results were obtained in the analysis of previous years, so graphic from previous years were suppressed.

Table 4. *Descriptive Statistics of GE.*

Year	Mean	StDev	Min.	Q1	Median	Q3	Max.
1996	0.0641	0.9849	-1.947	-0.6720	-0.1450	0.7565	2.101
1998	0.0550	0.9980	-2.241	-0.6480	-0.1275	0.6608	2.123
2000	0.0015	1.0050	-2.325	-0.7162	-0.1785	0.6042	2.171
2002	-0.0002	1.0119	-2.038	-0.8020	-0.1720	0.6260	2.169
2003	0.0151	1.0016	-2.248	-0.7010	-0.2115	0.6838	2.264
2004	0.0021	1.0084	-1.677	-0.7025	-0.2165	0.6560	2.345
2005	-0.0506	0.9839	-1.658	-0.7983	-0.2660	0.6102	2.158
2006	-0.0396	0.9891	-1.770	-0.7870	-0.2200	0.6302	2.253
2007	-0.0346	0.9869	-1.787	-0.7737	-0.2230	0.5633	2.375
2008	-0.0306	0.9783	-1.807	-0.7625	-0.1870	0.5810	2.431
2009	-0.0360	0.9817	-1.773	-0.7805	-0.2490	0.6240	2.281
2010	-0.0250	0.9854	-1.743	-0.7865	-0.1835	0.6775	2.254
2011	-0.0293	0.9822	-1.878	-0.7600	-0.1530	0.6750	2.260
2012	-0.0294	0.9819	-1.660	-0.7920	-0.2000	0.6810	2.228
2013	-0.0275	0.9819	-1.694	-0.7900	-0.1580	0.7230	2.181
2014	-0.0316	0.9843	-2.087	-0.7130	-0.1180	0.5330	2.194
2015	-0.0341	0.9859	-2.171	-0.7280	-0.1830	0.5130	2.252

Table 4 shows GE descriptive statistic data. These data were used to elaborate GE groups according to quartiles. The following criteria were considered to group into quartiles: Quartile 1 from Minimum value to Q1 value; Quartile 2 from Q1 value to Median value; Quartile 3 from Median value to Q3 value; and Quartile 4 from Q3 value to Maximum value.

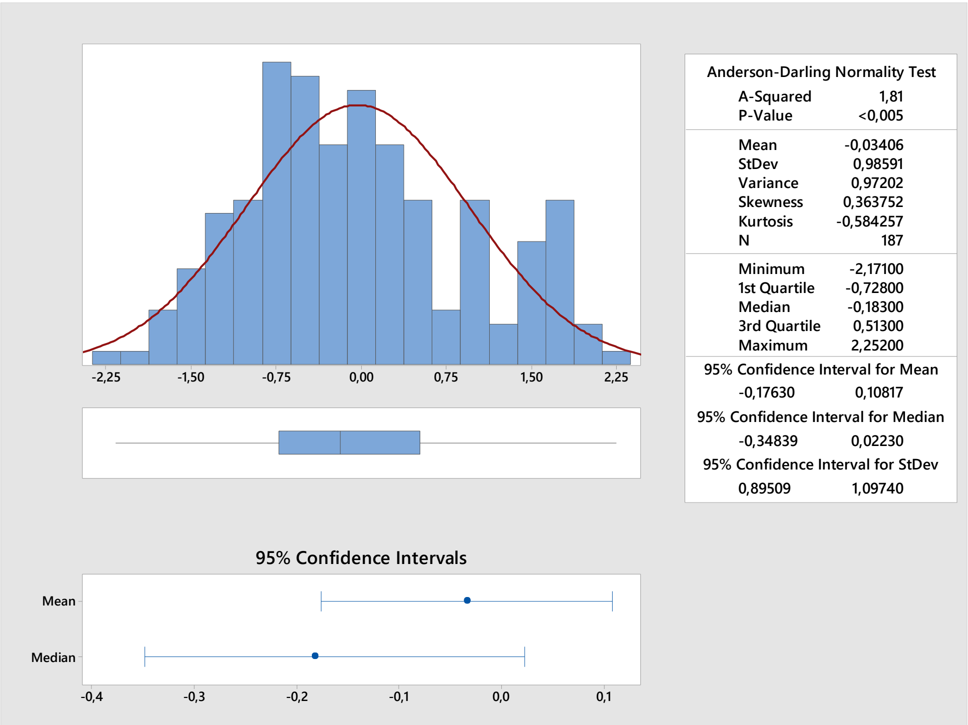

Figure 2. *Summary Report for GE 2015*

Figure 2 shows the data contained in Table 4 for the year 2015. The graphical analysis on Figure 2 and the data contained in Table 4 show a high standard deviation, meaning that the data are not concentrated around the mean but they are widely dispersed. All years analysed presented similar result.

Table 5 shows data for ANOVA from the perspective of GE quartiles groups. Table 5 data analysis results shows an overlap between HDI values of quartiles 1 and 2 for the years 1998, 2000, 2004 and 2007, that is, the difference of mean value for these quartiles are not statistically significant. For all other years, the difference between the quartiles averages is statistically significant. This scenario reinforces that countries with high GE levels tend to have greater human development as stated by Davis (2016).

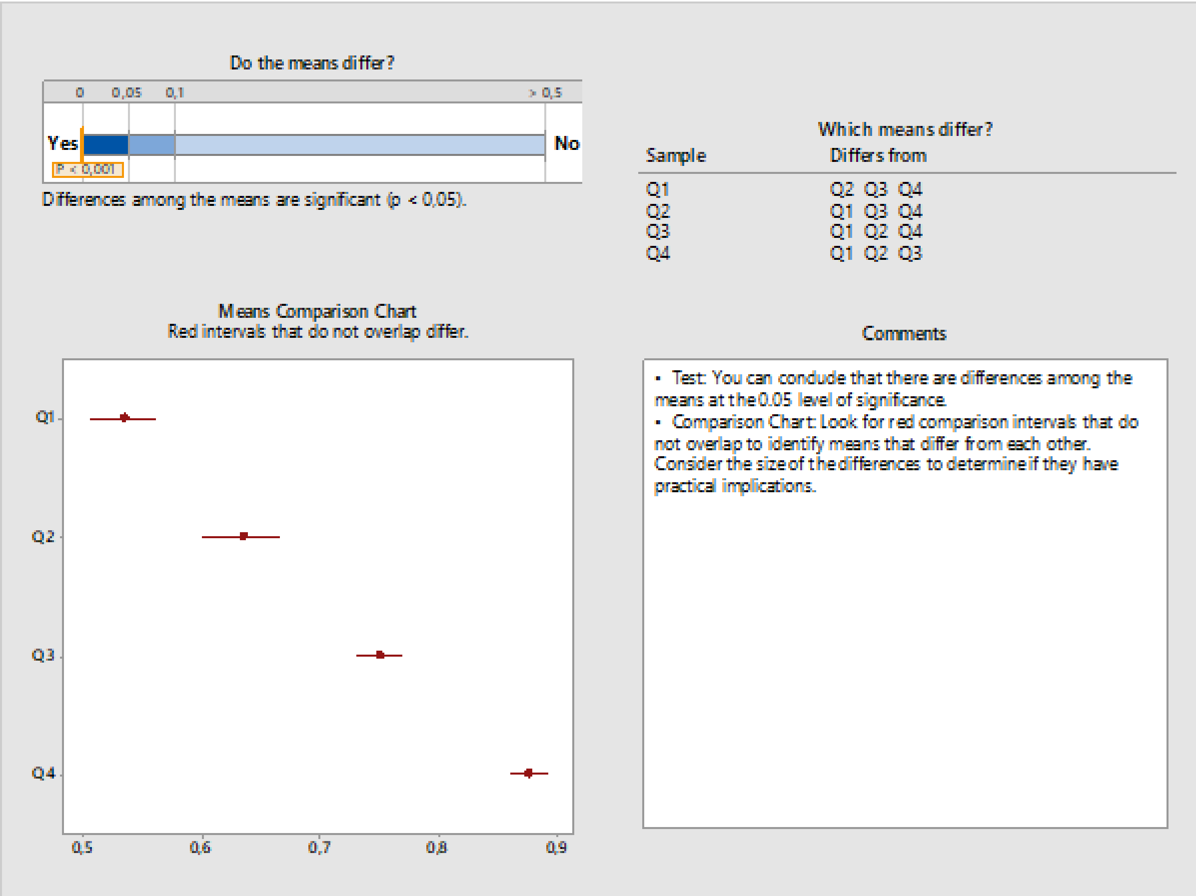

Figure 3. *One-Way ANOVA for HDI 2015 by GE Quartiles*

Table 6 presents descriptive statistic data for HDI grouped by GE quartiles. Data analysis indicates that exists an overlap among quartiles 1, 2 and 3 for all analysed year. In other words, only quartile 4 has its Q1 value above Q3 value of previous quartile. At least 75% of countries of quartile 1 have HDI performance higher than quartile 3 countries.

In figure 4 one can see a HDI boxplot graphic grouped by GE quartiles. Through an analysis of the graph and data presented in table 6, one can be seen that the countries classified in quartile 4 have significantly higher human development when compared to the countries of the other quartiles. It can also be verified that there is an overlap of values among quartiles 1, 2 and 3. Graphic shows three countries classified as outliers: Bhutan and Rwanda for quartile 3; and Botswana for quartile 4. These countries, despite of having high GE levels, have lower human development when compared to the countries of their respective quartiles yet.

Table 5. *ANOVA Hypothesis Test of HDI grouped by GE Quartiles.*

Year	Quartile 1 (GE)				Quartile 2 (GE)				Quartile 3 (GE)				Quartile 4 (GE)			
	N	Mean	StDev	95% CI	N	Mean	StDev	95% CI	N	Mean	StDev	95% CI	N	Mean	StDev	95% CI
1996	35	0.4665	0.1494	(0.4274; 0.5057)	37	0.5572	0.1044	(0.5191; 0.5952)	38	0.6362	0.1307	(0,5987; 0,6738)	36	0.8039	0.0684	(0.7653; 0.8425)
1998	37	0.4835	0.1479	(0.4466; 0.5204)	37	0.5428	0.1237	(0.5059; 0.5797)	37	0.6599	0.1021	(0,6230; 0,6967)	37	0.8168	0.0625	(0.7799; 0.8536)
2000	41	0.4784	0.1471	(0.4446; 0.5122)	42	0.5480	0.1181	(0.5146; 0.5814)	42	0.6627	0.0977	(0,6293; 0,6961)	41	0.2815	0.05362	(0.79437; 0.86192)
2002	41	0.4835	0.1411	(0.4494; 0.5177)	42	0.5671	0.1233	(0.5334; 0.6009)	42	0.6671	0.1025	(0,6333; 0,7008)	42	0.83262	0.06103	(0.79885; 0.86639)
2003	42	0.4755	0.1290	(0.4428; 0.5083)	42	0.5784	0.1264	(0.5456; 0.6111)	42	0.6819	0.0970	(0,6492; 0,7146)	42	0.83567	0.06397	(0.80295; 0.86838)
2004	42	0.4934	0.1257	(0.4611; 0.5256)	43	0.5673	0.1328	(0.5355; 0.5991)	43	0.6900	0.0890	(0,6582; 0,7219)	42	0.84300	0.05736	(0.81079; 0.87521)
2005	45	0.4799	0.1163	(0.4484; 0.5115)	45	0.5963	0.1310	(0.5648; 0.6278)	45	0.6954	0.0978	(0,6639; 0,7269)	45	0.8332	0.0752	(0.8016; 0.8647)
2006	44	0.4971	0.1172	(0.4667; 0.5274)	46	0.5792	0.1364	(0.5496; 0.6089)	45	0.7060	0.0768	(0,6760; 0,7360)	45	0.84784	0.05668	(0.81786; 0.87783)
2007	45	0.5151	0.1281	(0.4842; 0.5460)	45	0.5818	0.1274	(0.5509; 0.6127)	45	0.7136	0.0864	(0,6827; 0,7445)	45	0.84856	0.06381	(0.81764; 0.87948)
2008	45	0.5209	0.1231	(0.4901; 0.5517)	45	0.5977	0.1317	(0.5669; 0.6285)	46	0.7094	0.0912	(0,6790; 0,7398)	45	0.85580	0.05468	(0.82504; 0.88656)
2009	45	0.5164	0.1138	(0.4870; 0.5458)	45	0.6108	0.1325	(0.5814; 0.6402)	46	0.7158	0.0816	(0,6867; 0,7449)	45	0.85551	0.05397	(0.82609; 0.88493)
2010	46	0.5274	0.1162	(0.4982; 0.5565)	47	0.6184	0.1285	(0.5896; 0.6473)	47	0.7217	0.0829	(0,6929; 0,7506)	46	0.85746	0.05679	(0.82830; 0.88661)
2011	46	0.5288	0.1128	(0.5002; 0.5575)	47	0.6218	0.1285	(0.5935; 0.6501)	47	0.7247	0.0801	(0,6964; 0,7530)	47	0.86019	0.05637	(0.83187; 0.88852)
2012	46	0.5394	0.1130	(0.5107; 0.5681)	47	0.6232	0.1302	(0.5948; 0.6516)	47	0.7293	0.0785	(0,7009; 0,7577)	47	0.86349	0.05572	(0.83510; 0.89188)
2013	46	0.5409	0.1122	(0.5126; 0.5693)	47	0.6250	0.1262	(0.5970; 0.6530)	47	0.7397	0.0775	(0,7116; 0,7677)	47	0.86555	0.05938	(0.83751; 0.89360)
2014	46	0.5288	0.0986	(0.5031; 0.5545)	47	0.6380	0.1221	(0.6125; 0.6634)	47	0.7403	0.0686	(0,7149; 0,7658)	47	0.87723	0.04388	(0.85180; 0.90267)
2015	46	0.5334	0.1022	(0.5074; 0.5593)	47	0.6340	0.1164	(0.6083; 0.6597)	47	0.7493	0.0724	(0,7236; 0,7750)	47	0.87553	0.05162	(0.84985; 0.90121)

Table 6. *Descriptive Statistics of HDI grouped by GE Quartiles.*

Year	Quartile 1 (GE)						Quartile 2 (GE)						Quartile 3 (GE)						Quartile 4 (GE)					
	N	Min	Q1	Median	Q3	Max	N	Min	Q1	Median	Q3	Max	N	Min	Q1	Median	Q3	Max	N	Min	Q1	Median	Q3	Max
1996	35	0.2370	0.3360	0.4320	0.6100	0.7140	37	0.3570	0.4580	0.5770	0.6390	0.7270	38	0.2540	0.5795	0.6755	0.7210	0.7970	36	0.5330	0.7785	0.8180	0.8505	0.8880
1998	37	0.2490	0.3465	0.4380	0.6265	0.7230	37	0.2800	0.4415	0.5750	0.6520	0.7360	37	0.3760	0.5950	0.6710	0.7355	0.8040	37	0.5620	0.7885	0.8340	0.8575	0.9060
2000	41	0.2550	0.3515	0.4420	0.6330	0.7320	42	0.2980	0.4455	0.5820	0.6538	0.7420	42	0.3810	0.6070	0.6820	0.7228	0.8090	41	0.6290	0.7990	0.8370	0.8640	0.9170
2002	41	0.2660	0.3730	0.4470	0.6140	0.7400	42	0.3180	0.4570	0.6055	0.6673	0.7700	42	0.4010	0.6078	0.6915	0.7290	0.8150	42	0.6130	0.8055	0.8420	0.8748	0.9180
2003	42	0.2700	0.3785	0.4570	0.6048	0.7470	42	0.3320	0.4595	0.6205	0.6873	0.7540	42	0.4390	0.6208	0.6930	0.7410	0.8280	42	0.5800	0.7960	0.8505	0.8800	0.9240
2004	42	0.2860	0.4035	0.4680	0.6210	0.7480	43	0.2780	0.4460	0.6090	0.6920	0.7610	43	0.4150	0.6420	0.7030	0.7450	0.8340	42	0.609	0.81025	0.8565	0.886	0.9290
2005	45	0.2900	0.4045	0.4560	0.5400	0.7520	45	0.2860	0.4805	0.6360	0.6965	0.7670	45	0.4220	0.6460	0.7050	0.7535	0.8560	45	0.609	0.799	0.858	0.889	0.9310
2006	44	0.306	0.4143	0.4795	0.5867	0.7560	46	0.293	0.4532	0.6215	0.7000	0.7730	45	0.519	0.6525	0.714	0.76	0.8620	45	0.702	0.8105	0.867	0.8905	0.9340
2007	45	0.2980	0.4220	0.4810	0.6410	0.7570	45	0.3450	0.4685	0.5970	0.6985	0.7800	45	0.4380	0.6655	0.7350	0.7725	0.8660	45	0.646	0.813	0.873	0.8935	0.9360
2008	45	0.3360	0.4250	0.4870	0.6290	0.7710	45	0.3070	0.4890	0.6360	0.7055	0.7950	46	0.4440	0.6618	0.7275	0.7760	0.8680	45	0.709	0.8225	0.876	0.8965	0.9360
2009	45	0.3520	0.4360	0.4920	0.5940	0.7800	45	0.3120	0.4865	0.6530	0.7110	0.8020	46	0.4540	0.6673	0.7230	0.7732	0.8690	45	0.711	0.8205	0.872	0.8965	0.9360
2010	46	0.3610	0.4485	0.4985	0.6072	0.7870	47	0.3230	0.4980	0.6620	0.7120	0.8160	47	0.4640	0.6780	0.7370	0.7800	0.8720	46	0.712	0.823	0.879	0.90225	0.9390
2011	46	0.3660	0.4378	0.5055	0.6142	0.7930	47	0.3310	0.5040	0.6550	0.7170	0.8180	47	0.4750	0.6870	0.7350	0.7780	0.8770	47	0.713	0.824	0.884	0.9040	0.9410
2012	46	0.3700	0.4443	0.5110	0.6313	0.7960	47	0.3410	0.5090	0.6470	0.7370	0.8230	47	0.4850	0.6930	0.7370	0.7810	0.8760	47	0.717	0.829	0.887	0.9070	0.9420
2013	46	0.3450	0.4517	0.5105	0.6255	0.7960	47	0.3450	0.5120	0.6390	0.7410	0.8250	47	0.4880	0.7010	0.7490	0.7870	0.8770	47	0.72	0.841	0.89	0.9120	0.9450
2014	46	0.3470	0.4363	0.5135	0.5933	0.7690	47	0.3510	0.5410	0.6710	0.7410	0.8260	47	0.4930	0.7020	0.7510	0.7840	0.8810	47	0.779	0.845	0.892	0.9160	0.9480
2015	46	0.3520	0.4403	0.5155	0.6108	0.7670	47	0.3530	0.5410	0.6740	0.7390	0.7960	47	0.4980	0.7250	0.7650	0.7940	0.8870	47	0.698	0.847	0.893	0.9170	0.9490

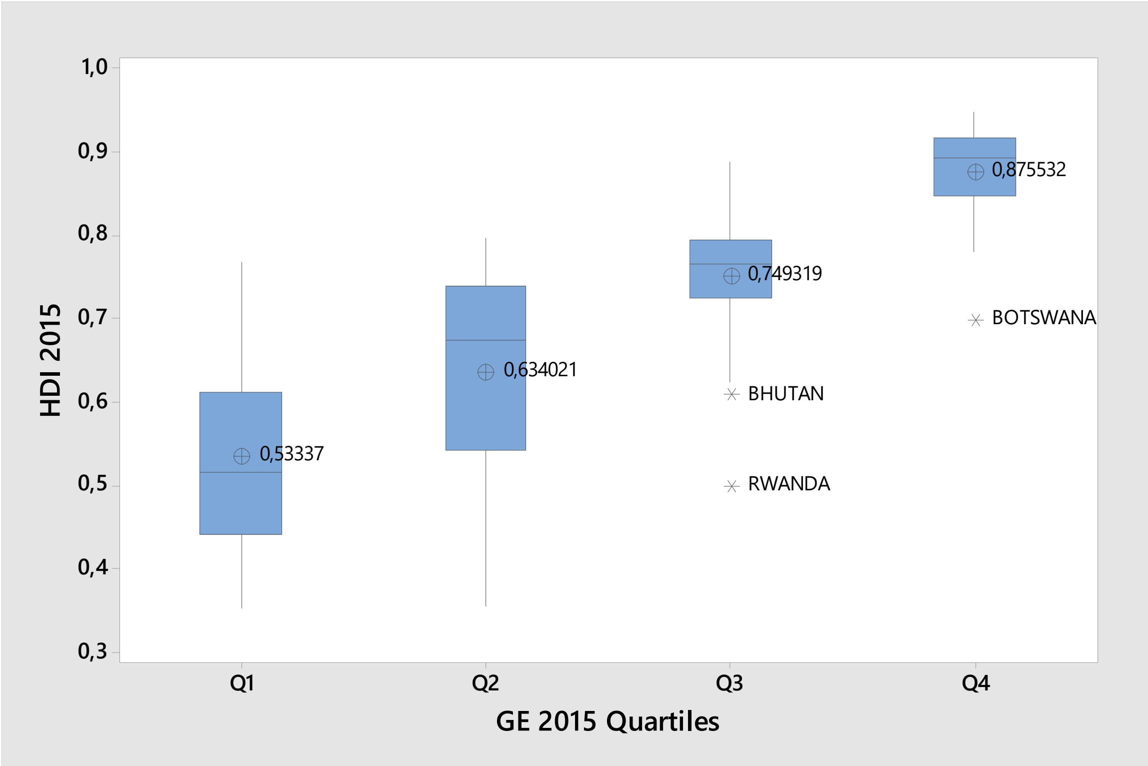

Figure 4. *Boxplot of HDI 2015*

The analysis indicates that, in countries with high HDI, the only outlier (with low GE) identified was Libya in 2005. On the other hand, countries with low HDI and high GE, like Senegal and South Africa, were the ones that appeared most in the period of 1998 to 2005 and Rwanda in the period of 2007 to 2015. Other countries appeared sporadically in the analysis.

When data are analyzed at continental level, as shown in table 7, it can be verified that the Africa, Oceania and South America continents have low levels of government effectiveness (quartiles Q1 e Q2). On the other hand, Europe and North America continents have high level of GE. And, when continents are grouped by HDI categories, as shown in table 8, it can be verified that the Africa is classified as low human development. Thus, this reinforces the correlation between GE and HDI.

Table 7. *Proportion of countries group by continents separated by 2015 GE quartiles.*

Continent	Q1	Q2	Q3	Q4
Africa	54,72%	28,30%	13,21%	3,77%
Asia	21,74%	23,91%	32,61%	21,74%
Central America and Antilles	15,00%	25,00%	50,00%	10,00%
Europe	0,00%	9,52%	26,19%	64,29%
North America	0,00%	0,00%	33,33%	66,67%
Oceania	18,18%	54,55%	9,09%	18,18%
South America	16,67%	50,00%	16,67%	16,67%

Table 8. *Proportion of countries group by 2015 HDI categories separated by 2015 GE quartiles.*

Continent	Low Human Development	Medium Human Development	High Human Development	Very High Human Development
Africa	66,04%	24,53%	9,43%	0,00%
Asia	6,52%	34,78%	34,78%	23,91%

Central America and Antilles	5,00%	20,00%	75,00%	0,00%
Europe	0,00%	2,38%	16,67%	80,95%
North America	0,00%	0,00%	33,33%	66,67%
Oceania	18,18%	27,27%	36,36%	18,18%
South America	0,00%	25,00%	58,33%	16,67%

4. Conclusions

The government of each country is responsible to effectiveness lead its population for a sustainable development. The research investigated the government effectiveness and its impact on the human being's development. The approach used was based on secondary data and expanded studies done in single countries. The analysis foundation is statistical based with the support of World Bank Government Effectiveness index and UN HDI index. The literature existed has been developing a discussion on how to measure effectiveness. Notwithstanding the government effectiveness index used measures perception, it is well accepted by the academy.

Statistical results demonstrate the existence of correlation between Government Effectiveness and Human Development (r value was 0.78 or high), indicating that the effectiveness of the government has directly impact on the human development. The correlation identified is considered strong and it appears consistently in all analysed years. Outliers appears in the analysis but can be considered irrelevant in number if compared to the total of countries included in the analysis. Thus, it concludes that there is a positive correlation between GE and HDI and that this correlation tends to be more accentuated for countries with high government effectiveness.

The main contribution of this research lies on fomenting the debate, bringing actual perspectives on the subject and generating subsidies for the governmental efficiency improvement. Data also suggest that one way to improve HDI, and consequently the well-being of the population, is through improvement of government effectiveness. The results can be used as a basis for future qualitative research, as well as for orientation of countries, state and municipalities, in the development of more effective tools for human development and efficiency of public power. Considering that the indexes used in the research are a combination of other indexes, future researches can also be done with the combination of these indexes to promote a deeper analysis.

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Local democracy initiatives in Sweden: Inclusive or exclusive participatory democracy?

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Abstract

Participatory democracy emphasizes the importance of the public political participation. Citizen engagement is crucial for advancing sustainable development at local level. Citizen participation initiatives at local level in Sweden include among others civic dialogues in the planning, e-petitions and citizen proposals (CP). While participatory democrats recognize the need for representative democracy they also see the possibility and benefits of more political involvement by the public than is currently practiced. The arguments in favour of enhancing citizen participation focus on its different benefits. In this paper the design and practice of citizen involvement through CP in Sweden is studied. The aspects for analysis are chosen considering the Michels & De Graaf (2010) framework (*inclusion, civic skills, limited deliberation*), as well as the high administrative burden of handling CP and the high level of proposals considering issues already in progress (*effectiveness*). The paper is based on a study of municipal webpages and a case study of CPs in the municipality of Eskilstuna. The amount submitted CP is growing. Still, this initiative for increased public participation in form of CP both in most municipalities having this instrument as well as in Eskilstuna have some shortcomings regarding inclusiveness, development civic skills, limited deliberation and effectiveness. The intentions with the instrument to involve citizens, children, youths and non-electors with foreign background have merely influenced spreading of this measure among Swedish municipalities. Furthermore, the *citizen* based terminology in local democracy initiatives is by nature excluding and should be changed to *resident* based terminology.

Keywords: Citizen proposal, Participatory democracy, Inclusion, Civic skills and virtues, Deliberation

1. Introduction

The role of local authorities is crucial to create healthy, equitable and economically sustainable communities. Furthermore, engaging citizens is a key point in the implementation of sustainable development (Lafferty, 2014; Rosenland, 2012). There are various definitions of citizen participation. Verba, Scholzman and Brady (1995) defined it as any voluntary action by citizens that is more or less directly aimed at influencing the management of collective affairs and public decision making. A ladder of participation, from elemental to more in-depth participation (e.g. information, communication, consultation, deliberation and decision making) based on levels of interaction and influence in the decision-making process was introduced by Arnstein (1996). A variety of new forms to involve citizens are developed as 'democratic innovations' (Smith, 2009; Newton & Geissel, 2011; Åström et al., 2016) and as 'new spaces for participation' (Cornwall, 2004; Gaventa, 2006).The spaces for participation are not neutral but as Cornwall (2004) stressed they are themselves shaped by power relations which both surround and enter them.

The concept of 'citizen participation' has received much attention from different disciplines and fields of study. For example public administration scholars seen citizen participation in decision making as a means of collaborating with citizens to promote democratic values such as responsiveness and accountability as well as means of more effective delivery of services. Political scientists pay considerable attention to what qualifies as a valid act of participation and how can acts on participation be qualified (se for overview (Gibson & Cantijoch, 2013). Theorists in democratic theory argue that a stronger role for citizens is vital for democracy. Especially, theories on participatory democracy, deliberative democracy and social capital argue that citizen participation contribute to a better democracy; citizens become more politically and socially educated. Individuals can go beyond their own self-interest and come to know what is best for the community or nation as a whole by communicating with and learning from one another. Still, contribution of participation to democracy differs according to type of democratic innovations and the benefits to individual democratic citizenship are more conclusive than the benefits to democracy as a whole (Michels, 2011). Critics of citizen participation warn that socioeconomic bias privileges higher-income residents and concerns about unequal participation is a central theme in the scholarship on citizens' involvement in civic and political life. For example Hansson et al. (2013) stressed the importance of recognition for equal representation in participatory processes in urban planning. Based on participatory democracy, deliberative democracy and social capital Michel (2011) highlights four contribution of participation to elements of democracy: influence on decision-making, inclusion, skills and virtues, deliberation, and legitimacy. Obstacles to effective citizen participation in policy decision making can be related to citizen, policy makers and to design (Kathlene & Martin, 1991).

While there is a growing interest in e-participation and e-government (Kim & Lee, 2012; Vincente & Novo, 2014; Karlsson & Åström, 2015) as well as citizens' engagement by using Internet and social media (Bonsón, Royo & Ratkai, 2015) not much research has been carried out on the process of citizen proposals. Empirical Swedish studies focus among others on e-petition system (Åström et al., 2016), participation in local journalism (Carlsson & Nilsson, 2016), participation i neighbourhood development and public health initiatives (Fröding et al., 2012) and citizen dialogues (Tahvilzadeh, 2015). In this paper the design and practice of citizen involvement through citizen proposals will be studied with the main focus on inclusion, but even on civic skills, limited deliberation and effectiveness.

Following this introduction section is a section on the political and institutional setting of the local government system in Sweden. The third section outlines development of and legislation on CP in Sweden, followed by the analytical framework, method and materials. The sixth section presents results and discussions. Finally, main conclusions are stated.

2. The Swedish system of government

The Swedish constitution states that public power in Sweden proceeds from the people. This is the foundation of parliamentary democracy in Sweden. As shown in Figure 1 Sweden has three levels of domestic government: national, regional and local.

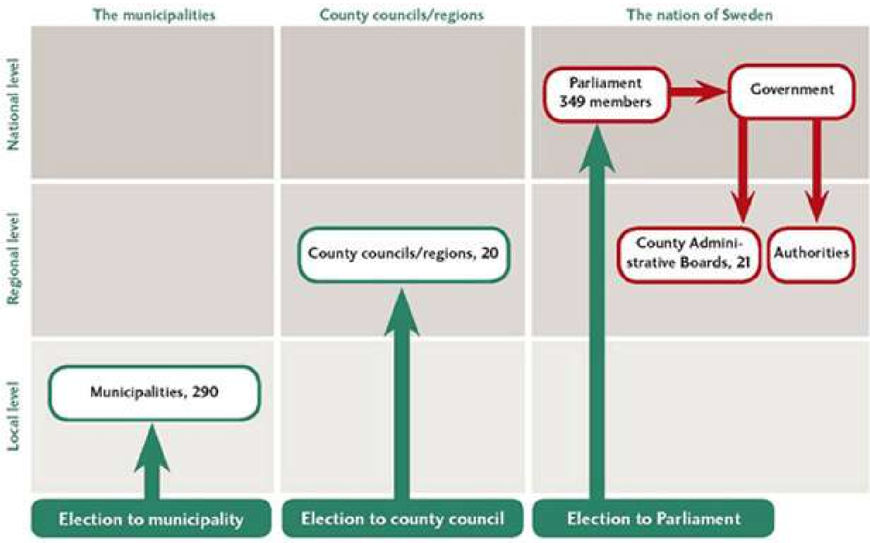

Figure 1. Three levels of domestic government i Sweden, 2015)

On entering the EU in 1995 Sweden also acquired the European level of government. Some issues previously decided by the Riksdag are nowadays decided at the EU level. The Swedish Constitution contains provisions defining the relationship between decision-making and executive power. The 1992 Swedish Local Government Act (LGA) regulates the division into municipalities and the organization and powers of the municipalities and county councils. It also contains rules for elected representatives, municipal councils, executive boards and committees. There is no hierarchical relation between local and regional level since municipalities at local level, counties and regions at regional level, all have their own self-governing local authorities with responsibility for different activities.

Electoral system: Parliamentary, municipal and county/ regional elections are held on the same day as the general election. In these elections, Swedes vote for political parties to represent them in the three political assemblies: the municipal assembly, the county council or regional assembly and the national parliament (the Riksdag). To be entitled to vote in the municipal and county council/regional elections, voters must be at least 18 years of age and a resident of the municipality and county concerned. Swedish citizenship is not required in order to vote in local and county/regional elections, but voters must either be citizens of another EU member state or Nordic country and registered in Sweden at the time of the election, or have been registered as a resident in Sweden for the last three years.

Central government: The 349-member Riksdag is Sweden's primary representative forum. The Riksdag makes the decisions and the Government implements them. The Government is assisted in this task by the Government Offices and some 360 government agencies. The Government also submits proposals for new laws or law amendments to the Riksdag.

Regional government: Sweden is divided into 20 counties. Political tasks at this level are undertaken by the county council. The county councils are entitled to levy income taxes to cover their costs. County administrative boards are the government bodies for the counties.

Local government: the entire territory of Sweden is divided into 290 municipalities. Each municipality has an elected assembly or council; the municipal council, which takes decisions on municipal matters. The municipal council appoints the municipal executive board, which leads and coordinates municipality work. The municipalities are entitled to levy income taxes and charge for various services.

3. Citizen proposals Sweden

Citizen proposals (CP) means that all who are registered in a municipality, including those without the legal right to vote, can raise issues to local government regarding the local areas of responsibility. This democratic innovation is regulated in by the LGA: since July 1, 2002, the Swedish municipalities and county council has the possibility of making decisions regarding so called citizen proposal. As a matter of fact, some municipalities (23) make it eligible for its residents to raise the issue to the council before this instrument got legislative status (SCB, 2012). The mechanism of CP spread further among Swedish municipalities after changing of LGA and 83 of Sweden's municipalities introduced CP during 2002 -2006, 17 more municipalities during 2006-2010 (SCB, 2012). According to SCB (2016)there were 195 municipalities and county councils that has introduced CP. The amount submitted proposals was in 2015 4500 and is increasing (SCB, 2016). According to a survey conducted by SALAR[1] (2015) on proposals submitted during 2014, only 14 % was approved, while 33 % rejected. A share of 9 % were cancelled and 44 % were explained 'answered'. A few municipalities have withdrawn CP because of the high administrative pressure and the very low share of proposals approved (Umeå). In the meantime the development of information and communication technologies has led to new forms of participation, such as e-petition and some of municipalities are switching from CP to e-petitions, although there are also few examples on municipalities with both CP and e-petition. Some other municipalities, "participation laggards" ? e.g. Västerås, increased participation for the residents introducing e-petition.

Box 1 presents the overview of development of this mechanism for participation in Sweden since 1996. In the first proposal, by the Democracy Development Committee (1996), only residents eligible to vote should get the right to raise issues. This proposal was sent for consultation to municipalities, authorities and organizations. The risk of increase in workload was one of arguments against introducing CP. Organizations such as Folkrörelserådet [Popular Movements Association], Folkbildningsförbundet [The Swedish Adult Education Association], Hem och skola [The Swedish Association of Parents and Next Friends], LO [The Swedish Trade Union Confederation], SIOS [The Cooperation Group for Ethnic Associations in Sweden] were positive, while the predecessors of SALAR delivered a negative opinion.

BOX 1: The development of citizen proposals in Sweden	
1996 Central Government Commission (Demokratiutvecklingskommitté 1995-1996: SOU1996:162) "On Citizen Conditions – a Democratic Infrastructure"	Commitment: investigate and propose measures that could increase citizen influence and involvement in society. Proposal: make it legally binding through the Local Government Act that *anyone who is eligible to vote* in local elections shall have the right send a CP to the municipal council
2001 Central Government Commission (Kommundemokratikommittén 2000-2001 SOU 2001:48) "To be Involved Seriously - Development of Democracy in Municipalities and County Councils"	Proposal: all persons registered as a *resident* of a municipality shall have a right to raise a proposal to the municipal council – this should be labelled citizen proposal [medborgarförslag] (p. 423)
2002 July 1 Formally introducing CP in Sweden	Reform of Local Government Act chapter 5 and chapter 6

[1] The Swedish Association of Local Authorities and Regions (SALAR) is both an employers' organisation and an organisation that represents and advocates for local government in Sweden. All of Sweden's municipalities, county councils and regions are members of SALAR. SALAR represents and acts on their initiative.

2007 July 1 Government Bill 2006/07:24 "Simplified Processing of Citizen Proposals"	Simplified processing of CP according to Local Government Act. The municipal council could send a CP directly to a municipal committee [nämnd], thus speeding up its preparation.
2016 Central Government Commission (Commission on Democracy 2014-2016 SOU 2016:5) "Let More People Create the Future!"	Proposal (still undecided): People´s proposal instead of CP (to be explained and discussed at the very end of this paper)

Launching CP meant inclusion of the reform into the Local Government Act. After six years the regulation of CP was modified in terms of "Simplified processing" [Förenklad hantering]. The current regulations are presented in Box 2. CP should be processed so as to enable the council to make a decision within a year of the date on which citizen proposal was tabled.

BOX 2: Regulation of citizen proposals in Local Government Act	
Chapter 5 Councils	
Raising of matters in the council; section 23: 5	Matters may be raised in the council by 5. *A person who is registered as a resident* in the municipality or in a municipality coming under the county council, if the council has so decided (CP)
Preparation of business; section 33	A motion (proposal raised by one or several elected representatives) or a CP shall be processed so as to enable the council to *make a decision within a year* of the date on which the motion or CP was tabled. If the processing of the matter cannot be concluded within this period, the fact that this is so shall be reported to the council within the same period, along with the results of the processing to date. The council may then cancel any further processing of the motion or CP.
Preparation of business section 26	Before a matter is decided by the council, it shall have been prepared either by a committee whose sphere of activity it concerns or by a council drafting committee.
Working procedure section 64	If the council has decided under Section 23 (5) to allow the tabling of CP, the standing orders shall include provisions on the handling of such proposals.
Chapter 6 The executive committee and other committees	
Right of outsiders to attend Section 19 a	The council may allow a committee to let the initiator(s) of a CP attend a meeting when the CP is discussed, but not when decision is to be taken.
Handläggning av ärenden som väckts genom medborgarförslag Section 27 a	If possible a matter initiated by a CP shall be decided upon within one year after received by the council. Once a year a due committee shall inform the council about its handling of CPs, even in cases of not having reached a decision.
Delegation Section 34	Decision-making powers may not be delegated in cases of the following kinds: 4. ärenden som väckts genom medborgarförslag och som överlåtits till nämnden,

4. Analytical framework

Considering participatory democracy, deliberative democracy and social capital Michels and De Graaf (2010) highlights four contributions of participation to elements of democracy: influence on decision-making, inclusion, skills and virtues, deliberation, and legitimacy. Inclusion and contribution to civic skills were also main motives for introducing CP in Sweden (SOU 2016:5). The Commission viewed CP as an including reform giving the voice to individuals without a legal right to vote, i.e. children, youth and foreign citizens. The Commission also expressed hope on a scenario that citizens would together discuss and formulate proposals. The aspects for analysis of CP in this study (se table1) are chosen considering the Michels & De Graaf (2010) motives for introducing CP, also taking into account the high administrative burden of handling CP and the high level of proposals considering issues already in progress. These aspects, presented in table 1, include: *inclusion*, *civic skills*, *limited deliberation* and *effectiveness*.

Compared to other forms of democratic innovations, CP by nature do not approximate a deliberative model of democracy; therefore the term *limited deliberation* is used.

Table 1. Framework of analysis: Aspects of citizen participation and civic proposals.

Aspect	Indicator
Inclusion	• Target groups • Languages access (Simple Swedish, English, Plain language/ bureaucratic language) • Design of submission (form, e –post, e-service) • Support
Civic skills and virtues	• Description of decisions • Record of proposals • Record of proposals with decision
Limited deliberation	• Access to submitted proposals • Interaction with politicians (presence, participation) • Interaction with other people or organizations
Effectiveness	• Information about differences between CP and other means of comments and suggestions • Encouragement to take part of submitted proposals or other information on the webpage or contacting the municipalities

5. Methods and materials

The paper is based on a study of municipal webpages and a case study. The qualitative content analysis of information about CPs available on webpages of all Swedish municipalities has been performed in February 2017with focus on indicators presented in table 1. The main method is qualitative although some rough quantifications are also applied. There are 290 municipalities in Sweden, 188 of them have used the instrument CP. ‘Very few’ implies when the amount is less than 20, ‘f*ew*’ when the amount is less than 50.

For the case study Eskilstuna has been chosen, one of 26 municipalities engaged with the development of local democracy in a project started by SALAR in 2007. The aim of the project was to introduce citizen panels among Swedish municipalities and county councils. The period between the elections 2006 and 2010 was characterized by a number of democracy-related SALAR initiatives such as the creation of a special “task force” for developing local democracy, and the arrangement of an “annual democracy week” with lectures, meeting places in neighborhoods, and democracy awards. During the next election[2] period democracy initiatives were pushed into the background in favor of actions motivated by reference to sustainable development. Still, CP was introduced on 1 January 2013. The empirical material in the case study consists of 117 CPs submitted between 2013 and 2015. The information on proposals and the process

[2] Popular elections to the parliament [riksdagen], local and regional councils are held every fourth year at the same date.

of handling them was supported by the municipality. Eskilstuna is situated in Stockholm-Mälar Region and in 2014 the number of residents passed 100,000.

6. Results and Discussion

Table 2 shows results on the analytical indicators. 188 (65%) of Sweden's 290 municipalities inform about CP on their websites. The information on CP provided by municipalities and the design of the instrument are to great extent similar, although there are also some modest variations. From a policy spreading perspective (Stone, 2012) CP can be seen as an instrument for increased participatory at local level which spread among municipalities where the local authorities imitate each other without deeper reflection. One can wonder how it can be possible that intentions with the instrument to involve citizens, children, youths and non-electors with foreign background have so merely influenced spreading of this instrument among Swedish municipalities. Both external and internal factors are central for a municipality to introduce or not an innovation or reform (Borgström, 2002). The municipalities have often shortage of resources and external drivers and support are important. It is therefore interesting to see the role SALAR have in this spreading process. It is remarkable that SALAR publish a great amount of materials and different publications on citizen dialogue while the material available about citizen proposals consist now onl of a short fact sheet (SALAR, 2007) and of one report with result on survey on CP in 2014 (SALAR,2015). In all these documents the issue of inclusion and ways to effective handling going beyond legislations are not treated. Municipalities provide a detailed description of handling process, which is bureaucratic and not merely adjusted for the target groups. It should be added that SALAR has had at works since the introduction of CP at least three circulars (SALAR 2002:128, SALAR 2005.93; SALAR2007:42). Way the SALAR has not endorsed in the process of spreading of CP is beyond the scope of this paper.

There is also the issue of terminology, *citizen based* initiatives to increase public participation at local level can have exclusive effect on residents without citizenship. The *citizenship* at state level should be translate to the *resident* at local level (se for example, Arboga, 2015). This issue is not only actually in the case of CP. For example the Umeå municipality continue instead of CP with Citizens gate [Medbrogarslussen] while there are many examples on municipalities switching from citizen/medborgare to resident/invånare in the case of resident dialogue [invånardialog]. Remarkably, SALAR is using the citizen based term, citizen dialogue [medborgardialog].

3.1 Information about citizen proposal on the webpages of Swedish municipalities

The vast majority of municipalities provide information about CP under an own heading, mostly Citizen Proposal which makes this participatory instrument more visible. Nevertheless, some of the municipalities place this information without an own heading while some others (e.g. Munkedal, Nora, Åmål) have decided to increase the visibility of the instrument by a heading both direct under main heading (e.g. Municipality and politics) and by a heading or information under subheading (e.g. Influence/Dialog).

Very few municipalities provide short information under subheading for influence and in addition more information under the heading for E-service (Hagfors) or even on the form for CP (Ydre).

All municipalities having adopted CP provide the information about the instrument on their website. The amount information provided varies, from 50-100 words (very few municipalities) to 500-700 words (majority of municipalities). This more detailed information is often structured under titles such as Who can submit a citizen proposal? What can a citizen proposal be about? How a citizen proposal is handle? How a citizen proposal can be submitted? Oskarshamn municipality is an exception, having heading Where is the information about CP available? also and informing that full information about CP is available in the reception of the City Hall, municipal library or at branch libraries to the municipal library. A few municipalities (about 10) have also a link to a document about CP. These documents have the character of an internal document (according to requirements on standing order i LGA (chapter 5, section 64). Another one municipality (Karlsborg) has link to the Standing order for the Assembly.

Table 2.Information about CP and design of CP in Swedish municipalities (2016). Share in percent for n=188, with one exception for n=290; Very few < 20; few < 50. Common used heading are presented. Main heading' means one of the main headings on the municipal website. 'Heading for CP' means heading where the specific information about CP is provided.

Indicators			Share
Information about CP (n=290)			65 %
Information	Main heading		Municipality and politics Municipality and democracy Politics and participation Municipality/About Municipality
	Subheading		How to influence/Influence yourself/ Take part and influence/ Influence / Influence your municipality/ Citizen influence Dialogue and comments
	Heading or title for CO		Citizen Proposal /Leave Citizen Proposal Proposal Citizen initiative
	Specific document		about 5 %
Inclusion	Targets group	Children, youth and non-electors with foreign background	about 50 %
		Only Children and youth	very few
	Language access	Simple Swedish [Lättsvenska]	very few
		English	very few
	Submission	Form	about 40%
		E-post	about 10 %
		E-service	about 20%
	Support		very few
Civil skills and virtues	Information on possible decisions/answers		5 (3%)
	Record of proposals		35 (19 %)
	Record of proposals with decision or answer		13 (7 %)
Limited deliberation	Access to submitted proposals		35 (19 %)
	Interaction with other people or organisations		few
	Interaction with politicians		about 50 %
Effectiveness	Information about differences between CP and other means of comments and suggestions		about 40 %
	Encouragement to take part of submitted proposals		very few
	Encouragement to take information on the webpage or contacting the municipalities		very few

3.2 Inclusion

One purpose with introducing CP was to involve those without a legal right to vote in the local politics. Surprisingly, not more than half of municipalities using CP target these groups explicitly in the information. Even more surprising is that few of these municipalities target groups direct only children/youth but not non-electors with foreign background (Surahammar, Luleå, Vaggeryd)

Regarding language access (both information in English and only Swedish) the municipalities with CP have made pure efforts. Some municipalities offer selected information in English (and other languages). But even those municipalities having information about how governing is organized lack information about how to influence, while the Right to Public Access [offentlighetsprincipen] is often mentioned. Still, there are few municipalities with information about influence and CP in English (e.g. Luleå). One of these municipalities has short information about CP in English and link to a Swedish site (Örnsköldsvik). In the case of Ronneby municipality the information provided in English is more detailed. Åre is a municipality in northern Sweden. The municipality has under the main heading *Municipality & Politics* 12 subheadings. One of them is *Influence* where CP are to find, another one subheading is *Lappish*. Under this subheading there are 12 further subheadings. But even this municipality providing information in one of minorities' language under heading about *Municipality & politics* do not provide information about CP in this language. Following answer came to the questions if the information about CP was available in Lappish: "Unfortunately not……it was very good idea, and when CP project will restart again submission of CP will also be translate to Lappish" (2017. 03.27).

Not only that very few municipalities offer information about CP in Simple Swedish, language is often complicated, more or less replicating official formulations from the Local Government Act. Not only children and youth may find it difficult to understand this one: "The citizen proposal is remitted to due committee and shall be prepared in a way that the council can take a decision within one year after it was raised. When decisions in the municipal council are to be taken the initiator should be informed and have a right to speak in the council". No example of information about CP in plain Swedish was found, and very few municipalities offer support; Dorotea municipality offers "language help" and Orust municipality offers "help with formulating CP".

With very few exceptions (e.g. Karlsborg) all municipalities have information about submission of CP. The submission can be done in several ways; in person to the reception or to the Council, by e-mail, or by using e-service. Submission in person and by ordinary mail are always implied, but municipalities with e-service is only about 30 %, and those offering e-mail even lower (10%). Municipalities offering submission both via e-mail and e-service are very few. Using e-service requires mobile identity which can be a threshold for some persons. The low share of the much more convenient way of submitting via e-mail, both for children and adults, is unexpected. In a highly digitalized country like Sweden3 it is amazing that some municipalities argue that e-mail cannot be used for submission because the CP has to be signed (e.g. Svedala, Skurup, Uppvidinge). Taking digital pictures of documents and attaching to e-mails is otherwise

[3] Sweden ranks 3rd of 28 European countries in Digital Economy and Society Index (DESI) 2017 (EC, 2017).

quite common in use in Sweden. A lot of municipalities, but not all, offer a form. The share of municipalities with form is bigger than the share with e-service.

3.2. Civic skills and virtues

The CP instrument can contribute to development of civic skills in different ways. Understanding the process of handling CP and the decisions on CP are some examples. As mentioned above, the municipalities devote much attention to describing the process and the title *How a citizen proposal is handle?* is often used in information on CP. Nevertheless, very few municipalities (7 %) (Härryda, Mellerud, Gagnef, Nordmaling, Nyköping) explain the decisions the local authority can pass to a CP. Results also show that municipalities have different alternatives for decisions. For example Mellerud municipality: Will be implemented, Is answered, Proposal rejects; Nordmaling: Proposal will be either rejected or approved. Nyköping municipality explains under the heading *What will happens with your CP*? that the Assembly can: Raise your CP; convert your CP to a comment; Reject your CP, Refer to an answer to earlier CP, Not further prepare your CP, but in the record of CP under caption Decision only rejection, approval or empty space are used. Record on submitted CP is provided by not more than 34 of 188 municipalities(19 %) , 4 other municipalities referrer to the protocols. The share of municipalities that record CP with decision is even lower, only 7 %. The possibilities of taking part of submitted CP and passed decision is also low. The Avesta municipality is a positive example. Under heading *If your proposal will be rejected?* follows explanation that rejection does not make a proposal meaningless. A CP can be a start point for a new debate, and the local media follow the work of Assembly and take notice of new issues.

3.3. Limited deliberation

As already mentioned, compared to other forms of democratic innovations, such as citizen dialog, CP by nature do not approximate a deliberative model of democracy. Still, there are possibilities to facilitate limited deliberation in the design of the instrument. Access to submitted proposal make it possible to take part of issues concerning other residents. According to legislation the CP have to been submitted by residents, not associations, clubs or other organizations. Still they can be discussed and developed with other residents or associations. This can be encouraged in the information. Interaction with politicians can take place both before and after submitting; here this indicator refers to legislation and possibilities for the initiator(s) of a CP to attend a meeting when the CP is discussed (Chapter 6 § 19 a).

How the municipality interpret this piece of legislation in their design of the instrument varies to a great extent, from requirement on participation or offering the possibility of presence or participation to not mentioning this issue at all. Svenjunga municipality is a positive expectation with greatest extant of deliberation/interacting. While many municipalities inform that CP will be a public handling this municipality facilitates Forum for CP where CP are published in 30 days for comments and complementing.

3.4 Effectiveness

As handling of CP means growing administrative burden one could expect that both SALAR[4] and municipalities have paid a lot of attention to the issue of effectiveness. Nevertheless, very few examples

[4] The Swedish Association of Local Authorities and Regions (SALAR) is both an employers' organisation and an organisation that represents and advocates for local government in Sweden. All of Sweden's municipalities, county councils and regions are members of SALAR. SALAR represents and acts on their initiative.

on direct attempting to avoid proposals concerning issues already in progress or issues already proposed in submitted CP can be identified. The Falun municipality encourage residents: "Find out so much fact as possible. Contact the politicians and officials to familiarize yourself with what is already in progress". Kinda municipality recommends checking out the website. Some municipalities encourage getting in touch for more information in case of any uncertainty (Karlskrona, Ljusnaberg, Kinda). One municipality (Karlskrona) point out two subjects (about national roads and about public transport) and inform who is to be addressed in this issues, instead of the municipality.

Nyköping municipality suggests to check record of proposals. Astonishingly, some few municipalities (Skövde, Säffle) inform that "if largely similar proposal has been processed during last two years the proposal will not be handled" without having any CP register. There are also examples on limiting the amount CP that could be submitted by the same initiator[5] per year (max 3 /Mellerud, max 5/Tranemo) which is actually according to a circular from SALAR (2005) not in accordance with legislation about freedom of speech. Another way to increase effectiveness is reducing amount CP through pointing out differences between raising a CP and providing comments. Some municipalities (e.g. Kramfors, Vadstena, Arvika) stress that fast response is given to the comments while handling CP takes time. Some municipalities highlights attempts with titles Before *you formulate a citizen proposal* (Falun), *A citizen proposal takes time!* (Arvika), *Tip* (Nyköping).

3.5 The citizen proposals in Eskilstuna municipality

Citizen proposals in Eskilstuna were introduced on 1 January 2013, with the decision on the evaluation after one year while the municipal board has been commissioned in 2013 to investigate and recommend different types of e-tools. The evaluation were conducted in February 2014 and recommendation was to continue citizen proposals and further developed this tool with e-service, which is implemented. The submitted proposals can get one of following answers: Approved: (adopted) implemented by the relevant committee, Rejected: is not implemented, Explained answered: work or investigation is underway in agreement with an earlier decision / mission, Cancelled: The proposal does not meet the formal requirements for a citizen proposal Local Government Act, the proposal is outside the municipal area (outside the municipal competence). The amount submitted proposals is growing (Table 1). During 2013 the inhabitants of Eskilstuna has submitted 33 proposals, during 2014 five more (38) and the amount submitted proposals 2015 was 46. The amount proposals approved varies between years.

Table 3. *Decision on proposals submitted 2013, 2014 and 2015.*

Year	Submitted	Approved	Rejected	Answered	Cancelled
2013	33	14 %	41 %	37 %	8 %
2014	38	21 %	21 %	42 %	14 %
2015	46	8 %	47 %	35 %	0 %
total	117	14 %	38 %	38 %	6 %

[5] It is explained that the proposals above the amount will be treated as normal piece of correspondence.

Figure 3 presents the share of submitted proposals during 2014 in each category. The proposals related to culture /leisure are most common (29 %), followed by availability/democracy (21%), environment/waste (18 %) and school related issues (15%).

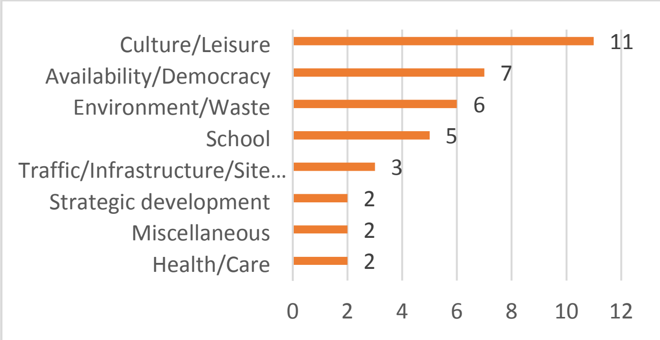

Figure 1. *Categories of proposals submitted 2014.*

As shown in table 4 the vast majority (92 %) of proposals was submitted by a single proposer. Two of proposers has submitted several proposals each year, one proposer during two of three studied years.

Table 4. *CP and their proposers.*

Year	Amount CP	One proposer	two or more proposer
2013	33	32	1
2014	38	34	4 (1CP/10 proposers)
2015	46	42	3 (1 CP/ plenty of people)
tot	117 (100%)	108 (92%)	8 (8%)

Introducing citizen proposals show that the municipality of Eskilstuna has a goal of increased public participation. Still, the design of CP in the municipality scores rather low regarding studied aspects (table 5). The municipal website of Eskilstuna has only Swedish and Finish versions while the share of inhabitants with foreign background is rather high (19 % in 2010). Furthermore, the work with citizens' proposals in the municipality does not provide opportunities to deliberation and to development of civic skills. There is no easy available list with submitted citizens' proposals and decision.

Table 5. *The design of CP in Eskilstuna municipality.*

	Cell of table	
Information	Main heading	Municipality and Politics
	Subheading	Insight, Dialogue, and Influence
	Heading for CO	Citizen Proposal
Inclusion	Targets group	Children, youth and non-electors with foreign background
	Language access	No
	Submission	From available; E-service, post , personally; nothing about t e-post
	Support	No
Civil skills and virtues	Information on possible decisions/answers	No
	Record of proposals	No
	Record of proposals with decision or answer	No
	Any feedback to the public about CP on the website	No
Limited deliberation	Access to submitted proposals	No
	Interaction with other people or organisations	A CP can be submitted by one or more persons
	Interaction with politicians	Nothing about it
Effectiveness		No

4. Conclusions

Citizen proposal is one of several measures introduced in the Swedish local government system, with the intent to make it possible for citizens and other local inhabitants to raise issues for consideration and, possibly, decision by a municipal council or committee. The analysis of municipal websites shows that most municipalities that have adopted CP also inform about it, although with different degrees of substance, clarity, and detail. Although positive examples are found and the amount submitted CP is growing a general conclusion is that there are serious concerns with regard to inclusiveness and even development civic skills, limited deliberation and effectiveness.

Most striking is that the intentions with the instrument to involve citizens, children, youths and non-electors with foreign background have merely influenced spreading of this measure among Swedish municipalities as well as the citizen based terminology of this measure is by nature excluding.

There are few other examples on democratic innovations that are legislated as CP. This has enabled the spreading of the instrument; on the other hand this formalization can contributed to the drawbacks. The requirements on standing order for example could made that local authorities, even those aware of target groups, has not managed to have the eyes of targets groups in information about the instrument. It is regrettable that such actor as SALAR[6] do not helped the municipalities to keep target groups and intentions with CP in mind.

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Immersed Engagement: A new approach to collaborative planning in Aotearoa - New Zealand

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Abstract

This paper aims to introduce the concept of immersed engagement in urban planning, a engagement technique used to support and enhance collaboration between different organisations and communities involved in processes of urban planning. The need for collaboration, cooperation, and co-creation in urban planning is becoming increasingly recognised in many countries including New Zealand. In recent decades, significant collaborative work has taken place between local government planning authorities and industry, research institutes and universities to engage local communities in broader decision-making processes. Collaboration can take many forms, from information exchange to consultation partnerships, and these often occurs in the urban planning process. However, current engagement and participation frameworks have limitations in integrating information, feedback, and advice from the public into the core of decision-making in urban planning. The concept of immersed engagement emerged in this context, and is aimed at promoting long-lasting, trustworthy and ongoing engagement between government and a range of stakeholders. This paper focuses on the concept of immersed engagement and the potential it offers to advance co-creation and shared decision-making, as an alternative to conventional participatory approaches used in urban planning. Additionally, this paper looks at how best to implement immersed engagement, and examines the benefits of this new engagement technique, through lessons drawn from two research projects in New Zealand. The paper concludes by discussing the implications of advancing this engagement technique in the international context of urban and collaborative planning.

Keywords: Immersed Engagement, Urban Planning, Collaboration, Collaborative Planning, Decision-making.

1. Introduction

The emergence of public and citizen participation principles in the 60s (see, for example, Arnstein, 1969; Reynolds, 1969) prompted public participation to gain traction in urban planning. Governmental and planning processes have progressively embraced participatory models, attempting to include the voices of citizens and communities in decision-making (Brownill & Carpenter, 2007). Conventional planning approaches, in which decision-making is mostly centred on planners expertise, have loosened to accommodate opportunities for public participation in single or multiple stages of planning (Campbell & Marshall, 1999; Carr & Dionisio, 2017). However, the extent to which expert-led frameworks accommodate participation in planning is often related to political desire (Albrechts, 2003; Arnstein, 1969; Forester, 1999). This raises the concern that in many cases, public participation and engagement may be just another ‘box to tick’ in the urban planning process, instead of being a genuine attempt to take on board public opinion.

To address some of the systemic complexities of public participation and engagement in urban planning, a number of theories and techniques have been developed and trialled, with a particular focus on developing consensus (Forester, 1999; Healey, 1997; J. Innes, 1995), and ensure better integration of participation outcomes in decision-making. These have included and range of approaches including intensive communication, collaboration, and deliberation processes (Anderson, Cissna, & Clune, 2003; Campbell & Marshall, 1999; Dennis, 2006; Forester, 1999). In New Zealand, there has been significant recent effort to establish meaningful collaborations between local governments, local industry, research institutes, universities, and other local institutions and NGOs to broaden decision-making processes across wider institutional landscapes (Higgins, 2010; Montgomery, 2008). The emerging emphasis on partnering and collaborating with local industry and local governments, for the distribution of government research funds is another clear example of this. These efforts for collaboration pose significant opportunities for better integration of public participation and engagement in urban planning (Dionisio, Kingham, Banwell, & Neville, 2016), allowing a diverse range of organisations, including community groups, and local NGOs representing specific communities, to collaborate in the processes of decision-making and monitoring of local plans.

Collaborative planning approaches present an alternative to established participation processes, which often put the public through exhausting consultation processes to generate feedback on planning processes that may or not be considered in planning and policy (Carr, 2012). 'Share an Idea' was a consultation campaign organised by the Christchurch City Council in May 2011, after the February 2011 earthquake, to collect ideas on how the public envisioned the rebuild of the city. The consultation was very successful, with approximately 106,000 ideas shared, showing the willingness of citizens and communities to engage in the debate about the future of Christchurch (Bennett, 2014; Christchurch City Council, 2012; Kingham, Dionisio, & Newman, 2016). Despite the achievements of collecting the visions of the community and generating real momentum for engagement, the outcomes of 'Share an Idea' as integrated into the Draft Central City Plan, have since been overlooked in further planning decisions made by the Canterbury Earthquake Recovery Authority (CERA)[1] (Bennett, 2014). The non-integration of the consultation outcomes in the Central City Recovery Plan (CCRP) developed by CERA, meant that the 'public participation' box was ticked in the procedures of urban planning, but the opportunity for sustained engagement about the future of the city has been lost. This is a strong case in point to which collaborative approaches could have supported the integration of consultation outcomes in further planning decisions.

Collaboration can take many forms, from remote information exchange to consultation partnerships, active cooperation, co-creation, or rooted operational relationships between different organisations and groups. It was in this context that the idea of immersed engagement was developed, with the aim to build long-lasting and ongoing collaboration to improve public participation and community engagement in urban planning. The concept of immersed engagement emerged in the course of another research project – Greening the Greyfields (GtG) – which aimed at incorporating new geospatial tools into urban planning decision-making in the Christchurch post-earthquake rebuild. Immersed engagement was, in fact, an unexpected outcome of the GtG research project. This article builds on empirical observations resulting from the GtG implementation, to tell the story of immersed engagement and provide recommendations for future applications of this novel engagement technique.

This paper focuses on the concept of immersed engagement to advance collaboration and shared decision-making in urban planning, as an alternative to conventional participatory approaches. It discusses implementation issues of immersed engagement and its practicalities, through the experiences of two research experiences in Christchurch, focused on urban regeneration; one in the Christchurch City Council and another in Regenerate Christchurch[2]. This paper also examines the broader benefits of this novel engagement technique to assist urban planning and concludes by discussing possible implications and contributions in the New Zealand and internationally.

[1] The Canterbury Earthquake Recovery Authority (CERA) was central government authority established in 2011 following the Christchurch earthquakes to coordinate and manage the rebuild of the city.

[2] Regenerate Christchurch was one of three entities established in April 2016 to replace CERA (which only ever had a 5 year lifespan); its role was specifically to lead the regeneration of Christchurch.

2. The basis for Immersed Engagement

Immersed engagement is designed to support and enhance meaningful collaborations, and trustworthy relationships between planning authorities, organisations, local communities and research teams. It is compatible with collaborative planning, because both are built on the notion that planning involves human interaction to develop interconnections between different people and organisations in the construct of a shared outcome to solve or tackle a problem that involves multiple actors, in other words, the construct of governance (Bogason, 2000; Healey, 2003, 2003). Similar to communicative planning, immersed engagement integrates the concept of communicative rationality as a core principle to build, moderate and evaluate interactions in the course of planning (Forester, 1999; Hoch, 2002; J. E. Innes, 1996).

The origins of collaborative planning are deep-rooted in social theory, with key research embedding Habermas' notion of interactive relationships to develop governance processes (1984), Giddens' conception of interaction between different actors in the mutual construction of 'structure and agency' (1979, 1984), and also Bourdieu's theory of symbolic power (1977) (Healey, 2003). Some of the theoretical ramifications of collaborative planning diverted towards the inclusion of cultural theories, such as Foucault's theory of disciplinary power (1979) (Healey, 2003). The foundations of collaborative planning focus on the design of processes to integrate governance in the transformation and management of places and landscapes; an alternative to conspiratorial politics, expert-led planning, top-down decision-making, and bureaucratically driven deliberation (Healey, 2003; J. Innes & Booher, 2000). In the 1990s, collaborative planning and consensus building became largely accepted in the U.S. and Europe, with the emergence of new forms of collaboration and partnership between local governments, planning authorities, institutions, and community groups (Healey, 1998). The designation 'collaborative planning', however, has been misapplied by planners, decision-makers and politicians attempting to define arising governance trends that are deeply entrenched in business management literature (see Huxhman, 1996) (Healey, 2003). Also, some of the new collaboration and partnering schemes, developed at that time, had critical shortcomings in the integration of features promoting equity, jeopardising the reputation of collaborative planning's original concept (Healey, 1997). In the late 1990s, a number of critiques from planning theorists to collaborative planning were supported by the empirics of collaboration and partnering schemes which extensively misdirected the principals of collaborative planning (Healey, 2003). Nevertheless, there is also a significant repertoire of collaborative planning initiatives in Europe and U.S. that advanced the integration of public participation and engagement in the practices and frameworks of urban planning (Innes & Booher, 2004). Co-design, shared decision-making, and the emergence of community-led initiatives in urban planning (Carr & Dionisio, 2017) are examples of advances made in collaborative planning. However, it remains critical to address some of the criticisms of the late 1990s for better integration of equity in planning decision-making, to improve the practicalities of collaborative planning. It is in this context, that improved engagement techniques are necessary to guarantee the appropriate representation and embeddedness of communities and citizens' perspectives in the processes of deliberation, design and implementation stages of urban planning.

The spectrum of public participation, as defined by the International Association of Public Participation (IAP2), integrates several levels in which varying participation rights ranging from information, consultation, and involvement, to engagement and empowerment, are conferred to the public (Fig.1) (International Association of Public Participation, 2017). The decision on the levels to which the public has the right to participate in urban planning, however, remains a discretionary power of politicians and decision-makers. Also, the integration of information, feedback, input, or advice provided by the public in urban planning decision-making rests merely as a 'promise' to the public, which can be discretionarily altered to fit into political agendas, processual frameworks led by experts, and bureaucratic procedures (Carr & Dionisio, 2017). Due to the shortcomings of current engagement frameworks, public participation and engagement are still vulnerable to become just another 'box to tick' in the processes of decision-making in urban planning. These limitations exacerbate and substantiate criticisms to collaborative planning, regarding the need to ensure better equity and transparency in the processes of decision-making.

	Inform	Consult	Involve	Collaborate	Empower
Public Participation **Goal**	**Provide the public with information** on issues underlying urban planning decision	**Obtain public feedback** on urban planning decisions	**Work with the public** to ensure that public concerns and aspirations are considered	**Partner with the public** in the different stages of decision-making	**Place final decision-making in the hands of the public**
Promise to the Public	**Keep the public informed** about urban planning decisions	**Inform and provide feedback to the public** on how the public input influenced decisions	**Integrate the perspectives of the public** in alternative decisions and provide feedback to the public how decisions integrate their perspectives	**Search for public advice and innovation** in the formulation of decisions and development of urban plans	**Implement what the public decides**
Level of engagement between authorities, organisations, and communities	**Superficial:** information exchange	**Moderate:** casual opportunities to get/provide feedback	**Participative:** opportunity to be part of decision-making	**Engaged:** opportunity to actively be involved in decision-making	**Leading:** opportunity to make decisions

Figure 1. *The spectrum of public participation, as defined by the International Association of Public Participation (IAP2, 2017).*

It was in this context that immersed engagement was conceptualised as a novel technique to promote long-lasting, meaningful and ongoing collaborations or partnerships for a shared and evolving construct of decision-making in urban planning. The implementation of another research project focused on urban regeneration in Christchurch, with the aim of assisting the post-earthquake rebuild – the GtG research project -, led to a series of observations in the attempt to apply current engagement frameworks. In this initial experience, the engagement objective was to implement two geospatial tools, developed within the GtG project, to assist urban planning decision-making amongst decision-makers, urban planners and designers; and support the city council in engaging with local communities. In engaging with the city council, with urban planning and community development teams as our research partners, it was observed that shared time (between researcher and council staff) was crucial. These interactions resulted in increased capacity to align our research outcomes more efficiently within the planners' workflows. It was also observed that our engagement at the council had multiple levels of depth (reflected in shared time), at different points in time or with different council teams, which then influenced the capacity to align our research with the partners' practices and activities (Fig.2).

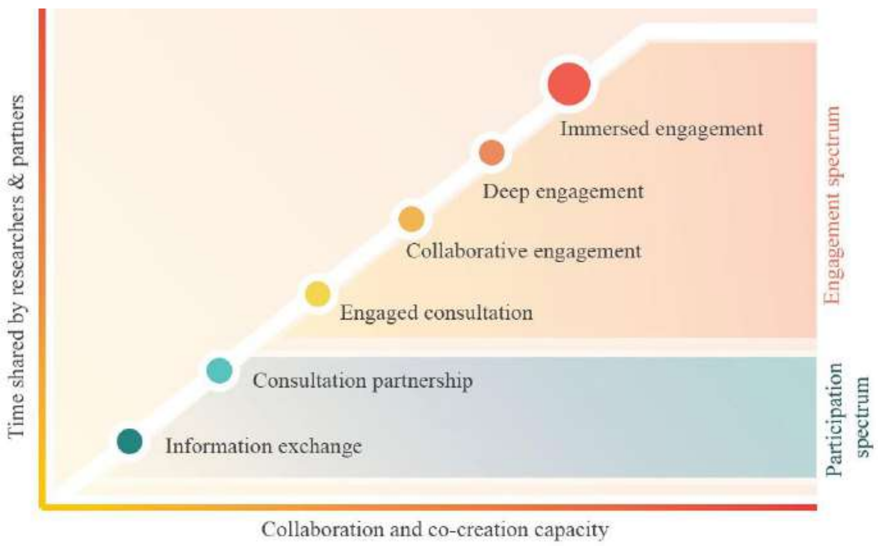

Figure 2. *Immersed Engagement and the multiple levels of participation and engagement.*

The more time researchers spent working side by side with planners, often in local council offices (immersed in the partners' environments), the more efficient was communication, and more meaningful were the produced outcomes. Immersed engagement aligns with the fundamentals of collaborative planning, regarding the construction of interactive relationships to develop governance processes (Giddens, 1984; Habermas, 1984; Healey, 1997) with application in urban planning. Additionally, it may also provide an advanced alternative to current participation frameworks to overcome some lingering shortcomings.

As our engagement in the Christchurch City Council progressed, it became clear that the implementation of new geospatial tools to assist decision-making in urban planning was far more complex than anticipated. At the time that the GtG research was initiated in Christchurch, only three years had passed since the 2011 earthquakes and there were, as there are currently, undergoing changes to political and organisational structures at the local and regional levels, which has been reflected in increased pressure on planning teams at the council. Additionally, the geospatial tools being implemented in Christchurch were created to assist urban regeneration in mid-suburban areas in Australian cities, which was not the same situation as that in Christchurch where the focus was post-disaster rebuild and recovery. In attempting to implement the geospatial tools and investigate the implications of their usability in planning teams in the specific context of Christchurch, it became apparent that it was required to advance current participation and engagement practices, such as IAP2' framework. The engagement techniques that were available to implement our research at the council were not producing the desired outcomes. This was the main rationale for reviewing the collaborative planning approach, and initiate a new engagement practice (unnamed at that time). This was based on our initial observations, that longer periods of shared time working with council teams was positively associated with productive interactions and better alignment between our research and planners' workflows. The name, immersed engagement, came later, once the implementation of GtG research and the new geospatial tools gained a more productive momentum amidst several planning teams across the council by virtue of our new engagement technique. The term 'immersed' was the most appropriate to encompass the nature of our new engagement practice, and to express the importance of sharing time, place, and perspectives with our partners at the council.

3. Implementing Immersed Engagement

To ensure meaningful, long-lasting and trustworthy relationships between the different actors, this research proposes four key implementation principles built from our experiences in trialling immersed engagement: (1) Immersing in time, place and perspectives, (2) developing trust, (3) fostering meaning, and (4) ensuring continuity. This section examines these four key principles through the analysis of our experiences in trialling immersed engagement, to provide recommendations for future applications.

3.1 *Immersing in time, place and perspectives*

Immersed engagement requires close proximity between partners, to create a favourable environment to develop trust, foster meaning and ensure continuity of the engagement relationships (Glackin & Dionisio, 2016). Partners may include practitioners, planners, designers, decision-makers, or community representatives, with distinct affiliations, interests and perspectives. In our experience, it was fundamental to share significant periods of time with key partners (immersing in time) – up to 5 hours per week – and working in their office (immersed in place), to overcome possible shortcomings resulting from different perspectives and positionalities. Spending significant periods of time with our partners in their office, allowed the partners to get to know our research team, informally inquire about the project during morning tea, and develop a relationship with the GtG research. Before initiating the immersed engagement, the GtG engagement methodology was trialled to implement new geospatial tools through training workshops with planning teams in the council, which proved to be an inefficient approach because either the council teams had only short periods of time available to book formal meetings such as workshops, or if the workshops progressed for longer periods, most participants would either arrive or leave in the middle of the workshops. This experience revealed that the implementation of the geospatial tools required informal gatherings and casual chatter about the project, as an alternative to formal, rigid, and time restricted meetings. Hot desking in partners' usual working places, in their comfort zone, once or twice a week usually on a regular basis, implied the willingness to understand their perspectives and incorporate them in the GtG research. This perceived willingness generated more openness, empathy, and better connectedness between the researchers and the council partners. This was a favourable environment to immerse the research in the partners' perspective and further develop a deepening trust between researchers and council teams. These created conditions also allowed a more positive perception on the accountability of the researchers in the council, fostering the beginning of what is now a trustworthy, long-lasting engaged collaboration.

3.2 *Developing trust*

Immersed engagement is based on relationships built on trust. In the organisational context, trust implies reliability, openness, confidence in the competency of partners, and perceived transparency and fairness (Farrar, 2005). In the context of engagement, however, the trust may be mutual between partners but it extensively relies on the performance of a trustee to earn a position of trust in the perspective of a trustor (Misztal, 1996). In the experience of the GtG research project, the research team was the trustee and the diverse partnering council teams were the trustors. Initiating and nurturing trust with our council partners was not a difficult task, it occurred spontaneously by sharing time together in diverse situations, such as hot desking, informal or some formal meetings, and catch-ups on progress reporting in the desks of partners. Spending time together in diverse situations, as an alternative to solely formal meetings and workshops, provided opportunities for researchers and partners to know each other better, exchange perspectives, and develop trust. This is a common feature of ethnographic studies, in which researchers need to gain proximity and trust from communities in order to understand their customs and perspectives (Geertz, 1973).

The quest for proximity – in sharing time, place, and perspective – to develop trust with partners, raises critical issues that need consideration in the application of immersed engagement. First, there are a number of ethical issues in conducting research on, or implementing, immersed engagement. These include human ethical considerations regarding individuals working, collaborating or volunteering in partnering organisations, aiming to guarantee the personal and professional integrity, safety, and wellbeing of participants. There are also organisational ethical considerations regarding the structures of information, confidentiality, reporting, supervising and cohort (McDaniel, 2004) that must be considered in implementing immersed engagement. In our experience, both at the Christchurch City Council and at Regenerate Christchurch, it was useful to have induction activities provided to the immersed researcher, informing about required or preferred conduct regarding organisational ethics. In case the induction information is not provided, it is fundamental that the immersed party seeks for this type of information prior to initiating the engagement, to ensure the compliance to organisational ethics and the preservation of trust.

Secondly, it is relevant to consider positionality when implementing immersed engagement. The exchange of perspectives between the immersed parties and partners must be monitored and managed frequently, through engagement reports or journals. This practice is relevant to ensure that each party involved in immersed engagement is capable of maintaining an autonomous position with ethical and professional integrity without exposing the position and integrity of other involved parties.

3.3 *Fostering meaningfulness*

The application of immersed engagement requires the promotion of meaningful interactions, activities and outcomes that are equally relevant to all partners involved. Meaningfulness nurtures the relationships and interactions between partners, by a shared focus and resource in the activities of engagement that are developed to create beneficial outcomes for the hosting organisations and immersed parties. The immersed time, hot desking at the council and at Regenerate Christchurch, is spent in activities and tasks directly related to the project we aim to implement while putting the geospatial tools to use according to the specific needs of different teams. During our immersed engagement with the council urban regeneration team, we had the chance to test the usability of both geospatial tools because two planners requested assistance in specific projects they were working on at the time. Similarly, in Regenerate Christchurch, our research and expertise are being put into practice in a specific project that is a priority for the urban design team. The alignment of the immersed research with the specific needs of different teams, or the same teams in different points in time, allows the establishment of common objectives, where perspectives and outcomes line up in a collaborative effort, maintaining all partners actively engaged.

To align an immersed project within an organisation, to put the immersed project to use addressing the specific needs of teams (fostering meaningfulness), it is fundamental to maintain active communication lines with key partners within teams. In our immersed engagement experiences, this occurred spontaneously because of the planners, specifically seeking for the support of our project, were those working in a specific task or workflow that related with the capabilities of the new geospatial tools and applied research. For each application of the GtG research with the council and Regenerate Christchurch partners, there was a specific key planner, which fundamental to the success of the immersed engagement and the research project.

Another relevant aspect to fostering meaningfulness is the creation of outcomes that are useful for all partners. Outcomes can be presented in diverse means, such as reports, assessments, maps, tables, or can also be provided in the form of advice and feedback, to meet the specific needs of partners within the immersed project. In our immersed engagement experiences, the outcomes were defined according to the specific needs of planning teams and determined jointly with key planners directing the collaboration. Maps were one appropriate outcome to assist a specific key planner in the identification of areas ripe for urban regeneration across the city, whereas others requested summary tables and brief reports to compare diverse urban development scenarios. Readiness and adaptability are fundamental to immersed engagement to ensure the capacity to execute tasks meeting the needs of partners and maintain reliability for the continuation of collaborations.

3.4 *Ensuring continuity*

Continuity should be promoted in immersed engagement to allow partners to have an ongoing role in the project to assist their workflows (trust) while generating common goals between partners (meaningfulness). Continuity implies consistency, dependability, and approachability. In our immersed engagement experience, it has been fundamental to hot desk at the partners' offices on a regular basis, to create a routine to which the planning teams can expect the immersed researcher at a given time of the day and day of the week. This regularity facilitates collaborative interactions, discarding the need to schedule meetings, and allowing partners to plan ahead for specific tasks or actions to put the immersed project to use for the support of their workflows. The consistency of time spent at partnering organisations also allows partners to consider time in the management and execution of tasks, increasing the capacity to incorporate the immersed project in current workflows. It is relevant to maintain consistency, even throughout periods where there are fewer interactions during the immersed time due to the increased workloads of partners. Our experience revealed that hot desking at our partners' offices generates a positive expectation from planners in relation to the immersed project.

Dependability is another key feature to ensure the continuity of immersed engagement. It is relevant to meet deadlines in delivering agreed outcomes, and show readiness, interest and openness to expanding the application of the immersed engagement. Dependability will generate trust from partners, which is crucial to forming new ideas to put the immersed project to use again within future workflows or tasks. Dependability and consistency are braided in the construct of trust and meaningfulness in the implementation of engagement. Our experiences showed that this is possible to develop stable dependability and consistency within planning teams, throughout time and with enduring performance. The immersed engagement of GtG at the Christchurch City Council lasted for about ten months and supported three distinct case studies developed in the urban regeneration team. For the past three months, the project is immersed at Regenerate Christchurch to help with scenario development for the regeneration of the central city. In moving the engagement from the council to another local planning authority, it is relevant to note that most of the staff members of both organisations work closely together and there was a general understanding amongst our council partners that GtG would timely to assist Regenerate Christchurch. After this shift of partners, the GtG research project continues to communicate with council partners on a regular basis in a collaborative engagement level (Fig.2). This shows that the quality of the relationships and interactions established through immersed engagement, may allow for the potential to give continuity to collaboration beyond the time or objectives of a specific project.

To implement immersed engagement it is also relevant to consider the approachability of the immersed researchers, and the openness of the immersed project. Approachability allows partners to be curious about the project, its current and potential applications, which may generate a positive debate about its opportunities and challenges. Implementing the GtG's geospatial tools to assess their usability at the council required immersed researchers to develop an approachable attitude to maximise feedback from multiple teams across the council. Advancing current methods or tools, or whatever project outcomes are being implemented or tested through immersed engagement, will require an 'open door' to consider new possibilities for future collaboration. With efficient approachability, immersed engagement can go beyond the time and focus constraints of current projects and ensure the continuity of collaborations.

4. The benefits and potential of Immersed Engagement

The many benefits observed in trialling immersed engagement in the Christchurch City Council and at Regenerate Christchurch, shows that it has the potential for other applications across the public sector, with involvement of multiple partners, organisations, authorities, and community representatives. Our experiences and empirical observations were engrained in an engaged research project, but the concept of immersed engagement and the recommendations provided for its implementation can be used for other types of participation and engagement projects. The application of immersed engagement to improve collaboration relationships, or implement, test or evaluate projects has the potential to advance collaborative planning while offering an empirical alternative to current participation and engagement frameworks.

From our implementation of the GtG research in Christchurch, the benefits of immersed engagement include:

1. A deeper understanding of our partners' perspectives and needs, which facilitates the grounding of our project, expressed in the suitability of research outcomes in relation to authentic needs and priorities as seen by partnering planners. This evolved understanding has increased benefits for both sides, in joining collaborative efforts to solve or tackle a commonly understood problem or challenge. In this context, immersed engagement offers an advanced approach to engaged research (Mikesell, Bromley, & Khodyakov, 2013), as to other types of organisational collaborations and partnerships.
2. Immersed engagement can help assisting the development of resources and time intensive tasks which are challenging for organisations, authorities, or groups. Co-creation is a new collaborative planning practice, originally introduced in marketing, management and innovation referring to the development processes in which multiple partners work together on a project, strategy or product that addresses distinct interests (Bhalla, 2011; Ramaswamy & Ozcan, 2014). Co-creation has significant potential to overcome some of the shortcomings of public participation in the urban planning, and it is already being applied in urban design, placemaking and strategic planning (Senbel, 2012). It is, however, a time and resources costly collaboration tool that can be implemented through immersed engagement. Sharing time, place and perspectives, nurturing trust, and defining shared goals, the basis of immersed engagement, creates a favourable platform for co-creation and other advanced methods of collaborative planning. The combination of immersed engagement with collaborative planning methods such as co-creation provides a novel approach to participation and engagement.
3. Immersed engagement generates long-lasting and productive relationships across institutions, producing meaningful and useful outcomes for different parties in the course of their practices (i.e. research, planning, community support, etc.). By promoting interconnectedness and interdependency between partners, immersed engagement presents a great potential to develop or reinforce collaborative and organisational resilience (Goldstein, 2012).
4. Our research experiences in Christchurch demonstrated that immersed engagement was the most appropriate technique to develop collaboration for the implementation of our research project, with a focus on urban planning and aiming to provide the support for local governments to engage with local communities. Immersed engagement, not only brought benefits for the implementation of the project, as it enhanced the collaboration capacity of the partners. In New Zealand, collaborative planning places significant focus on the needs of stakeholders and local governments (Margerum, 2011; Montgomery, 2008), and although urban planning frameworks include mechanisms for public participation, there are still many opportunities to improve public and community engagement. Current frameworks often promote public

participation at information and consultation levels, seeking feedback from the public on projects and plans that have been already been developed (Margerum, 2011). In this context, immersed engagement provides an alternative to integrating community perspectives in local councils, authorities and organisations involved in urban planning. An immersed approach where community representatives can be immersed in local planning authorities would be an efficient way to voice and integrate the perspectives of the public in the rationale, design and implementation stages of planning.

5. Discussion

Immersed engagement is a novel engagement technique aimed at supporting and enhancing meaningful, long-lasting and productive collaborations, within trustworthy relationships between planning authorities, local organisations and communities and research teams. The definition of immersed engagement was materialised through the implementation of GtG research project in Christchurch, aimed at delivering geospatial tools to assist urban planning in the rebuild. The engagement techniques available for the implementation of the GtG (i.e. IAP2's participation framework) were not producing the reach and outcomes expected by the researchers and funding agencies. Training workshops proved to be inadequate to integrate the needs of our partners at the council, and it became clear that examining the usability of new geospatial tools was going to require an advanced engagement technique. On the other hand, a critical review of collaborative planning and current participation frameworks has shown that often engagement actions are vulnerable to became part of a procedural step – a 'box to tick' -, instead of being applied to create shared decision-making and build plans from local perspectives and knowledge.

In order to increase the chances of successfully implement the GtG research project, and research for possibilities to overcome some of the current shortcomings in engagement frameworks; we initiated a new engagement practice before it was conceptualised as immersed. It was based on initial observations indicating that longer periods of shared time working with the council teams was positively associated with productive interactions and better alignment between our research and our partners' workflows, tasks and agendas. Once this new engagement practice started to produce visible outcomes in our interactions with council partners, it was then possible to conceptualise immersed engagement as a new technique. Fundamentally, immersed engagement has four key principles: (1) immersing in time, place and perspectives, (2) developing trust, (3) fostering meaningfulness, (4) ensuring continuity. t

This section discusses some of the limitations of immersed engagement while providing recommendations, examines the implications of immersed engagement in collaborative and urban planning, and concludes by exploring the contributions made by this research in New Zealand and the international context.

5.1 Limitations

Associated with the fundamental principles, the practicalities of immersed engagement present a number of limitations that are potentially relevant in future applications. Immersing in time and place requires immersed researchers, professional or representatives to spend extended periods of time, working side by side, in partnering organisations, requiring availability to dedicate time, and adaptability to be reallocated in different work environments. In our immersed engagement experiences, hot desking was an effective manner to create proximity to our partnering planning teams across the council. Initially, it was difficult to book desks just for periods of four to five hours per week, and it proved to be easier to just arrange an initial meeting with the key planner in each team, and use any desk available on the day. Soon it became obvious that Fridays were optimal for immersed engagement, given that there were more available desks in the council offices then in other days of the week, but still with a good attendance of staff. Any difficulties imposed by the context of a specific team or its workplace, in which a project is immersed, must be observed and analysed to study ways to adapt.

Another constraint that we discovered during our experience was that periods of increased pressure for planning teams need continuous assessment by those immersed, to readjust the immersed project in each session. In times of high pressure for teams, immersed engagement should provide either relief to partnering teams or refrain from adding further pressure. Because of this constraint, there were occasions when the immersed researcher would hot desk in the partners' office but have no chance to interact with any members of the partnering teams, due to their heavy workloads. In this case, it was always relevant to continue hot desking and immerse in place, to ensure consistency, dependability, and approachability.

It is likely that immersed engagement may have other compositional and contextual limitations, but awareness, adaptability, and tenacity are features that may considerably help to overcome some of them.

5.2 Implications & Contribution

Immersed engagement makes a significant contribution to participation in urban planning because promoting long-lasting and meaningful relationships between collaborating partners, with a continuity approach, has the potential to enhance equity in the diverse structures of decision-making. Current engagement frameworks remain far too rigid to accommodate the complexities of integrating the inputs of public participation in the different stages of urban planning. In this sense, immersed engagement provides an alternative engagement technique that may prompt urban planners and decision-makers to review current engagement practices and approaches, and maximise the potential of engagement actions to lead shared decision-making or even co-create urban plans. An ideal impact of immersed engagement would be a change in the paradigm of participation and engagement in New Zealand, towards a better implementation of public's perspectives in planning. However, such shift contains intrinsic political and organisational barriers, and it is likely that immersed engagement may only have the capacity (for now) to raise awareness on the potential of deep-rooted forms of engagement to share decisions and plan better in collaboration with communities and organisations.

The application of immersed engagement has the potential to support planning authorities, by developing a deeper understanding of partners' needs and perspectives, and advancing collaborative capabilities within organisations. This can facilitate the production of meaningful outcomes for multiple partners in the planning sector, creating long-lasting collaborative relationships and promoting collaborative and organisational resilience (Goldstein, 2012). Also, when combined with other collaboration tools such as co-creation; immersed engagement provides an improved alternative to current participation frameworks.

In the scope of collaborative planning, immersed engagement advances communicative planning (Forester, 1999; Healey, 2003; Hoch, 2002; J. Innes, 1995), by considering positionality in relation to need for proximity and depth. Immersed engagement establishes a connection between collaborative planning and concepts borrowed from ethnography such as trust, meaning and continuity (Geertz, 1973). By reviewing some criticisms to collaborative planning and attempt to address them in its key principles, immersed engagement advances the theorisation for the integration of public participation and engagement in the practices and frameworks if urban planning, which is relevant in the international context. Also, this research makes a significant contribution to collaborative planning, by providing a set of implementation recommendations based on empirical experiences in which immersed engagement was trialled and validated. However, it remains pertinent to develop additional research on the applications of immersed engagement in different contexts of planning.

In the context of sustainable development, immersed engagement has the potential to enhance a better alignment between development and sustainability agendas by promoting long lasting, meaningful and ongoing collaboration between diverse stakeholders. Interconnectedness and interdependency between partners, as well as organisational and cooperative resilience are features of immersed engagement that support a more equitable construct of governance and social sustainability in the diverse structures of decision-making in urban planning and development.

5.3 Conclusion

This research article presented the concept of immersed engagement, as a new engagement technique that can be applied to develop or reinforce collaborative relationships between diverse partners such as local governments, organisations, research teams, and community representatives. The concept of immersed engagement emerged in the course of implementing the GtG research in Christchurch. The available participation and engagement frameworks were not suitable for the implementation of that research project, prompting the conceptualisation and trial of a new engagement technique. In other words, this research article presents and examines an unexpected outcome of our research. This article builds from empirical observations resulting from the GtG implementation, to tell the conceptualisation story of immersed engagement and provide recommendations for future applications of this novel engagement technique. The main contributions made by this new engagement technique, are related to the improved capacity of planning authorities to collaborate with multiple partners, and advance the integration of public's perspectives in urban planning.

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Waste Management Governance in Colombia: the case of National Alliance for Inclusive Recycling

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Abstract

Waste management is considered to be one of the most important challenges that must be faced by the international sustainable development research community, and also by decision makers responsible for global environmental governance. In Latin American and the Caribbean (LAC) countries this is 4 million waste pickers earn their livelihood by being a part of the recyclables supply chain. Some countries, such as Brazil and Colombia, are adopting pioneering strategies to incorporate these professionals into their waste management models. In Colombia, a collaborative governance arrangement is being developed which involves the government, private companies, waste pickers and society: the Alianza Nacional para el Reciclaje Inclusivo (National Alliance for Inclusive Recycling). This model is obtaining good results not only with recycling, but also with social inclusion. The main purpose of this paper is to comprehend how distinct organizations could work together to build and develop a waste management model that truly includes the waste pickers. The current investigation is being accomplished using a case study research methodology, based on interviews and data analysis. Despite being an ongoing investigation, some initial findings have been determined: (i) the process to Alliance creation had a key stakeholder represented by IRR (Iniciativa Regional para el Reciclaje Inclusivo / Regional Initiative for Inclusive Recycling), that was also formed in a net governance process; (ii) the participation of CEMPRE (Compromiso Empresarial para el Reciclaje / Business Commitment for Recycling) was fundamental to guarantee the pickers empowerment; (iii) the Colombian government was open and receptive to help to design new structures to guarantee inclusiveness in the waste management process in the country; and (iv) there is a necessity for changes in the law and the creation of public policies to make the changes possible. The main conclusion is the necessity of powerful and engaged stakeholders in the governance process having a unified approach to making a difference, involving win-win decision making leading to achievable environmental, social and economic gains.

Keywords: Waste Management Governance, National Alliance for Inclusive Recycling, LAC Countries.

1. Introduction

Waste management is considered to be one of the most important challenges that must be faced by the international sustainable development research community, and also by decision makers responsible for global environmental governance. The impact of waste management can be felt in many areas, particularly those with environmental, economic and social dimensions.

Obviously, in Latin American and the Caribbean (LAC) countries this is no different. However, the region presents a special fact that should not be underestimated: 4 million waste pickers earn their livelihood by being a part of the recyclables supply chain. In some cases, informal waste pickers are responsible for the collection of 90% of the recycled materials in their regions, receiving only 5% of the jobber gain (Accenture, 2013). In most of cases, the waste collection is its only ingress. Even with this contribution, in most cases, the waste pickers are still perceived as a social problem. They don’t have the recognition to its environmental, social and economic contribution.

Some countries, such as Brazil with its national pickers movement, are adopting pioneering strategies to incorporate these professionals into their waste management models, becoming a reference for other countries and regions (Semear and Catação, 2013). Based on political action, manifestations, agreements and collaborative work, Brazilian pickers could reach their professional recognition. As a result, the policy of integrated waste management in the country brings some especial indications to their effective incorporation on the value chain.

Colombia’s groundbreaking experience is also one that demands further analysis. The country had constructed several laws and orders associated to the integral waste management. In 2000, for instance, its was created the waste picker badge of honor, in a recognition to the work done by people who had distinction doing recuperation or waste recycling. A day for the waste picker and for recycling was establish one year before. In 2003, its was created an order (Order 1503/2003) to regulate the waste collection service; on this, the government affirms the waste pickers right to participate on this activities. The Colombian laws support the waste pickers to formalize their work guided on two solidarity conditions: organizations without profit and associations (Semear, 2015).

These advances are deposit to the efforts of a collaborative governance arrangement is being developed which involves the government, private companies, waste pickers and society. It is called Alianza Nacional para el Reciclaje Inclusivo (National Alliance for Inclusive Recycling), formalized in April 2014. This model is obtaining good results not only with recycling, but also with social inclusion.

Governance has been understood by different concepts. The emphasis pass by institutions, legitimacy and power (Rametsteiner, 2009). However, it also can be understood as a series of ‘arrangements’ among various actors, using collaborative approaches to seek problem solving (Kooiman, 1993). So, in more general terms, governance can be understood as the process through which actors collectively solve problems and face the needs of society.

Later, a new concept appears: the collaborative governance. Ansell and Gash (2008, p. 544) define collaborative governance as a “governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented, and deliberative and that aims to make or implement public policy or manage public programs or assets”. It appears in the necessity of governments work with different stakeholders to deliver major projects and services to its communities.

According Donahue (2004), to consider a process of governance a real collaborative governance, its is necessary to observe at least eight aspects:

- Formality: not necessarily a collaborative relationship must be formal, institutionalized through formal contracts. It can operate through informal agreements or even tacit understandings. But, for the author, a minimum of formality seems increasingly imperative. This degree of formalism must be at least sufficient to permit objective descriptions of participants, procedures, and goals. This definition makes possible to distinguish collaborative governance from other categories of public-private interaction.

- Duration: long-lived collaborations seem more consequential, and hence more worthy.
- Focus: its is necessary to meet a single shared challenge, or a range of concerns common to the collaborating parties.
- Institutional Diversity: it is necessary to have a minimum level of diversity among the participating institutions. For instance: at least one public and one private player.
- "Valence": here, the author refers to the number of distinct players linked together in a collaboration and the number of links among them.
- Stability versus Volatility: for he, a collaboration is stable to the extent its members share a normative view of successful governance. In the other hand, volatile is related to the extent members' norms or interests diverge. “The less stable is the collaboration, the larger the share of its energies must be devoted to maintaining the collaboration itself” (p. 3).
- Initiative: it has relation to what instigate the collaborating among actors. Each of the collaborating actors must have some role in setting the goals of the collaboration.
- Problem-driven versus Opportunity-driven: it is necessary to observe the collaboration intention.

As affirmed by Alvarez et al (2016), several studies have highlighted the importance of governance in environmental. Inadequate governance may lead to over-exploitation and degradation of natural resources. On the other hand, sustainable management may increase organizational capacity and cooperation between individuals and institutions as highlighted by Ostrom (1990, 1999).

The main purpose of this paper is to comprehend how distinct organizations could work together to build and develop a waste management model that truly includes the informal waste pickers. This kind of investigation is important because the case can be considered a success in LAC region and therefore could be replicated in other parts of the developing word. The current investigation is being accomplished using a case study research methodology, based on interviews and data analysis.

2. Methods

This article is based upon qualitative methods. As the research topic is context dependent the use of a case study was considered ideal for data collection and knowledge generation (Hudson and Ozanne, 1988).

Primary data was collected during field visits, done in the process of the developing of a social technology: Paso Cierto Web Plataform. As Paso Cierto was construct thought the participation of different actors involved on inclusive recycling, it was possible to do interview and observation with Colombian actors. It also involved the observation and participation in three important Latin American meetings about recycling: (i) the Taller de Intercambio de Conocimientos (Workshop on Knowledge Exchange), in Peru, 2014; (ii) Expocatadores (Waste Pickers Exposition), in Brazil, 2014 and 2015; and (iii) Pregral (Preliminary Conference on Latin America Waste Management), in México, 2016. The field visits led to data collection of informal talks to representatives of IRR, Cempre and waste pickers, both men and women, from Colombia.

Secondary data also were collect, seeking for documents and websites that mention Alianza evolution.

3. Results

Please insert your Results text here. Text alignment is formatted as justified. The Results section can be combined with the Discussion section. In that case, name the section **Results and Discussion**. Tables, like Table 1, should have a self-explanatory caption placed above the table and should be referenced in the main text like in this sentence.

On April 22, 2014, the "Aliança Nacional para el Reciclagem Inclusivo" was signed as an initiative of the National Government, led by Ministerio de Vivienda, Ciudad y Territorio (Ministry of Housing, City and Territory). It aimed to promote the formalization and strengthening of recyclers at a national level, as a strategy for the social, technical and economic development of the use of solid waste; as well as to promote the development of a long-term public policy (Alianza Nacional, 2014).

The main goal of the governance process was to contribute to the knowledge and institutionalization of the Inclusive Recycling in Colombia. To reach this goal, the actor delimited the existent problems in three different dimensions:

- National level – Information systems; articulation for the implementation of public policies that contribute to an inclusive recycling.
- City level - tools for the implementation of urban systems of inclusive recycling.
- Recycler organizations - incidence in the PGIRS, adequacy as providers of the public cleaning service, business development for the commercialization of materials. They could also define the actions that would be developed by the group. Between then, there was the definition of technical criteria for the creation of the Observatório Nacional de Reciclaje (National Observatory on Recycling). This action was established to improve the information collection system about recycling. Other important activity was the accompaniment to the formulation of the Plan de Gestión Integral de Resíduos Sólidos – PGIRS (Integral Solid Waste Management Plan). The actor's objective was to strengthen the application of the PGIRS. It was also necessary to strengthening for the adequacy as providers of the public cleaning service and business development for the commercialization.

They also define to give technical advice in the formulation and execution of PGIRS programs, in accordance with Resolution 754 of 2014.

As expected results of this collaborative governance process they had: information systems, normative instruments to promote inclusive recycling, proposal and observations of the organizations of recyclers for the construction of the PGIRS, organizations of recyclers advancing in their suitability as providers of public cleaning service, and business development for marketing, tools for cities and organizations of recyclers for the implementation of urban systems of inclusive recycling (for instance: guide to formulating PGIRS, guide for Census of Recyclers, guide to turn organizations of recyclers into providers of public cleaning service, guide for the strengthening of organizations such as service providers, and materials marketers, guide to calculate costs and tariffs to the organizations of recyclers, according to the tariff methodology).

For reach these results, the actors determined some lines of action:

1. Encourage inclusive value chains

• Promote agreements for the use of solid waste, with the inclusion of formalized recyclers.

• Promote analysis of existing and potential markets for reusable materials.

• Stimulating technological innovation in industry in order to promote greater use of recyclable materials in their production processes.

2. Promote inclusive urban recycling systems

• Identify and promote strategies to formalize the recycling population, and to establish as public cleaning service providers.

• Promote actions in favour of the recycling population by the local authorities provided for in Decree 2981 of 2013.

• Identify the aspects that should be taken into account in the formulation and updating of the PGIRS and public cleaning service programs.

• Encourage and support comprehensive training activities for the recycling population and local authorities.

• Encourage the construction of a civic culture of Integral Management of Solid Waste.

3. Recycling Center:

• Design and implement a system for collecting, processing and analyzing national recycling information to be included in the variables report to measure progress in the inclusion of the recycler population, the level of utilization in the public cleaning service and the flow of materials recycled in the industry.

• Encourage research into recycling practices at national and international levels. • Support knowledge, experiences and formalization of recyclers and, use of waste as a business activity.

4. To strengthen the Organizations of Recyclers:

• Identify strategies for formalizing the recycling population to establish themselves as providers of public cleaning services.

• Encourage and strengthen organizations of recyclers and their access to social security.

• Promote and strengthen training activities for the recycling population.

• Promote an improvement of living and health conditions of the recycling population.

As initial results of this collaboration process, some goals are reached, in a process described by the director of Waste Pickers National Net as gains from “10 years in one”.

- Seminars and workshops to capacitation
- Creation of a national rule that obligate the municipalities to include the waste pickers on their waste management plans
- Establishment of the “right to receive” for services – recollection and transport (pioneering movement in Bogotá)
- Diagnosis of 25 waste pickers organizations – understand to give support on formalization and construction of business capacities
- Census realization in 2015: Bucaramanga (420 waste pickers), Popayán (327) and Valledupar (465)
- Ongoing activity: second National Study on Inclusive Recycling (42 municipalities; 850 questionnaires)
- Colombian’s laws support the waste pickers to formalize on two solidarity conditions: organizations without profit and associations

The analyses could observe the aspects pointed by Donahue (2004), permitting to consider a process of Alianza Nacional as a real collaborative governance:

- Formality: Alianza was formalized by Colombian government, throughout a memorandum signed by Ministerio de Vivienda, Ciudad y Território (Ministry of Housing, Cities and Territory), Ministerio de Ambiente y Desarrollo Sostenible (Ministry of Environment and Sustainable Development), Ministerio de Comércio, Industria y Turismo (Ministry of Commerce, Industry and Turism), Ministerio de Trabajo (Ministry of Labor), Asociación Nacional de Recicladores (National Association of Waste Pickers), CEMPRE, ANDI (Asociación Nacional de Indústrias/National Industries Association) and Fundación Avina, on April 22th of 2014.
- Duration: there is a clear long term on the collaborations proposal.
- Focus: the focus is specific and aim to meet a single shared challenge; the inclusive recycling promotion on a national level.

- Institutional Diversity: there is an important range of diversity between the organizations, with actors from public, private and third sector.
- "Valence": its was possible to notice an important number of distinct players working together in a collaboration proposal, and important links among them.
- Stability: the collaboration seems to be reach a shared view of the success of the goals.
- Initiative: each actor have some specific role to play in setting the goals.
- Problem-driven: the Alianza seeks to be a real problem-driven strategy.

Even though important results were found, it’s not possible to say at this moment of the investigation that the researchers now comprehend how distinct organizations could work together to build and develop a waste management model that truly includes the informal waste pickers. More interviews and data analysis are necessary.

4. Conclusions

Despite being an ongoing investigation, some initial findings have been determined: (i) the process to Alliance creation had a key stakeholder represented by IRR (Iniciativa Regional para el Reciclaje Inclusivo / Regional Initiative for Inclusive Recycling), that was also formed in a net governance process; (ii) the participation of CEMPRE (Compromiso Empresarial para el Reciclaje / Business Commitment for Recycling) was fundamental to guarantee the pickers empowerment; (iii) the Colombian government was open and receptive to help to design new structures to guarantee inclusiveness in the waste management process in the country; and (iv) there is a necessity for changes in the law and the creation of public policies to make the changes possible.

The main conclusion is the necessity of powerful and engaged stakeholders in the governance process having a unified approach to making a difference, involving win-win decision making leading to achievable environmental, social and economic gains. Further steps of the research will analyze the waste governance in other LAC countries, seeking to enhance the inclusion of waste pickers, using Colombia as the example case.

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The Management Effectiveness of Mico-leão-dourado Mosaic (Mosaico Mico Leão Dourado). RJ/BR

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Abstract

The Protected Area Mosaics (Mosaicos de Áreas Protegidas, MAP) are formed when there are Protected Areas (PA) in close proximity to each other or overlapped in a same territory, even if they are managed by different governmental or private scopes. They aim to improve the management of PA through ecosystem connectivity and also through an integrated and efficient management of both material and human resources of those areas. MAP are managed by councils formed by governmental and civil society entities from the territory. This study refers to Mico-Leão-Dourado Mosaic (Mosaico Mico-Leão-Dourado, MMLD), which has an area of 209,000 hectares, along 8 municipalities. It is composed by 5 Federal, 1 state and 13 private PA, and it's entirely located in Rio de Janeiro state, in a region of coastal lowland. Once it is the Golden Lion Tamarin habitat, this Mosaic has been formed in order to strengthen the integrated management among PA, in such a way to improve the species preservation. Being an instrument of public politics, it is crucial that the efficiency of Mosaics is analyzed and that the principle of continuous improvement is followed. This work intended to analyze the efficiency of Mico-Leão-Dourado Mosaic management, and such analysis has been performed through a protocol designed to this end. This protocol is qualitative and quantitative, presenting 46 indicators divided into 4 scopes: Governance, Management, Sociodiversity and Biodiversity. Each counselor assigns each indicator a score from 0-3: 0 (non occurrent), 1 (rarely occurs), 2 (usually occurs), and 3 (occurs a lot). The mean of each indicator is calculated and the T-Test is applied to verify the effectiveness of the indicator, taking into account those with a mean above 2. The number of effective indicators determines the scopes and mosaic effectiveness in a percentage, being 35% Not Effective, 36%-50% Low Effectiveness, 51%-75% Medium Effectiveness, and 76%-100% High Effectiveness. 39 indicators and 2 scopes were considered effective. From this 39 indicators, 19 presented low but effective means according to the T-Test. The two failed areas were Management and Sociodiversity. The indicators ranged from 76%-100%, but the scopes from 36%-50%, so, we have classified MMLD as a MAP with a Medium Effectiveness, which effective areas were Governance and Biodiversity, requiring greater attention to the Management and Sociodiversity of the territory. In order to do so, it is necessary for the Mosaic Management Council to pay more consideration to issues involving local populations, as well as to provide a better dissemination of the MMLD to them and integration with the public management bureaus that influence the territory. MAP are examples of collaborative governance of the territory, integrating the Government and civil society, so, its proper functioning is crucial for the sustainable development of the territory and protection of both local communities and biodiversity. The study shows how a truly integrated work between government and society, with divided responsibilities and decision power is essential to build scenery of efficient collaborative governance.

Keywords: Mosaic, collaborative governance, management effectiveness.

1. Introduction

Mosaics are an environmental public policy instrument, formed when there is Protected Areas (PA) in close proximity to each other or overlapped in a same territory. Then, they are a group of protected areas that exists in the same territory that agree in work together and help each other to reach their creation reasons. This mutual help occurs by sharing material and human resources in execution of joint operations for environmental oversights or educational activities for example. The mosaics also include the local communities in their environmental management, promoting the discussion about their conflicts with the protected areas, or the changes in the territory that menaces their traditional culture and lifestyle. The Brazilian law for protected areas (Brazil, 2000) gives the definition of mosaics of protected areas (MAP) in their chapter IV, article 26: "When exists a group of protected areas of the same or distinct categories, near or overlapped, public or private, constituting a mosaic, their management will be done in an integrated and participative way, considering their distinct conservation aims, making compatible the presence of biodiversity, the appreciation of sociodiversity and the sustainable development in a regional context.". MAP are managed by councils formed by governmental and civil society entities from the territory and are officially created by an Environment Ministry act. Is the mosaic role to work as an improving instrument for the protected areas management, and also work as a privileged forum to discuss the conflicts between traditional communities and government, represented by the protected areas managers (Costa, 2015).

In Brazil we have 22 mosaics of protected areas. This work refers to Mico-Leão-Dourado Mosaic (Mosaico Mico-Leão-Dourado, MMLD). The MMLD has an area of 209,000 hectares, along 8 municipalities. It is composed by 5 Federal, 1 state and 13 private PA, and it's entirely located in Rio de Janeiro state, in a region of coastal lowland. Figure 1 shows the mosaic's location.

Once it is the Golden Lion Tamarin habitat, this Mosaic has been formed in order to strengthen the integrated management among PA, in such a way to improve the species preservation. The MMLD council is formed by twelve counselors, being six from public protected areas and other government institutions and six from civilian organizations as NGOs, private protected areas owners, land owners, researchers and business representatives, and it has periodic meetings each four months. The main issues in MMLD council meetings are local environmental licensing, forest recovery and restoring, and promoting sustainable nature tourism in private protected areas.

The aim of this study was to verify the Mico-Leão-Dourado Mosaic management effectiveness, identify its mains opportunities and challenges, and propose project ideas and activities to improve their actions to meet their creation reasons.

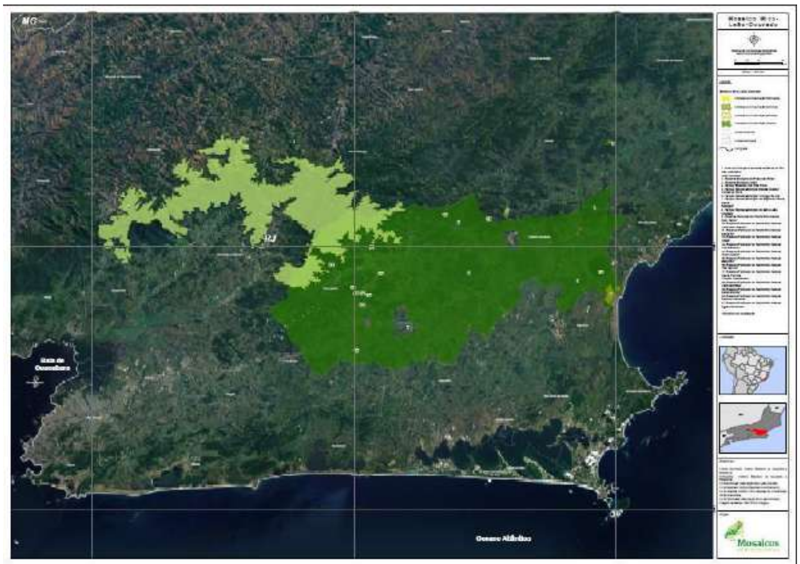

Figure 1. *Mico-Leão-Dourado Mosaic's location in Rio de Janeiro state, Brazil.*

2. Methods

The mosaic's management effectiveness was evaluated by using a protocol developed by Gidsicki (2013) and adapted by Hermmann and Costa (2015). This protocol makes an evaluation both qualitative and quantitative, using 46 indicators divided in 17 criteria, 8 principles and 4 main scopes. These scopes are Governance, Management, Sociodiversity and Biodiversity. Figure 2 shows the protocol structure. The whole protocol can be seen in the appendix.

The effectiveness is determined by the indicators grade. Each mosaic's counselor grade the indicators from 0 to 3, being 0 (non occurrent), 1 (rarely occurs), 2 (usually occurs), and 3 (occurs a lot), or NA (no answer). The final indicator's grade is given by the mean of all counselors grade. Indicators with final grade ≥ 2 were considered effective.

The protocol was applied in a regular council meeting at 2016's march 30th, with the presence of eight counselors. Because the low number of counselors who answered the protocol, the Student's T Test was used to verify if indicators with grade under 2 could be effective. Those were labeled low effectiveness indicators.

The number of effective indicators determines the criteria, principles, scopes and mosaic effectiveness in a percentage, being 0-35% Not Effective, 36%-50% Low Effectiveness, 51%-75% Medium Effectiveness, and 76%-100% High Effectiveness.

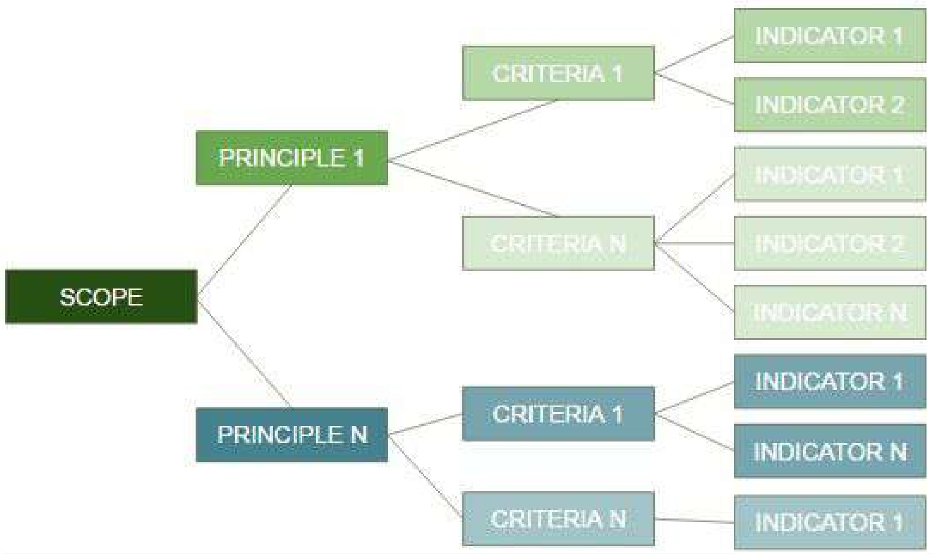

Figure 2. *Structure for the protocol for mosaic's effectiveness evaluation.*

3. Results.

We had 39 indicators, 12 criteria, 4 principles and 2 scopes considered effective. In those 39 indicators, 19 showed low effectiveness, with mean value under 2. The results were separated by scope.

<u>Governance</u>

The governance scope addresses the norms, arrangements and institutional organization that regulates and supports the mosaic for the territorial management. It evaluates if the mosaic has a structured and representative council, if its inner and outer communication is effective, and if it has autonomy to intervene in the territory environmental issues.

In this scope we find effectiveness in 15 indicators, 6 criteria, and 1 principle. The scope itself were considered effective. Four indicators and two criteria showed low effectiveness.

Table 1. *Parameters Effectiveness for governance scope in Mico Leão Dourado Mosaic.*

Parameter	N Total	N Effective	% Effective
Principles	2	1	50%
Criteria	7	6	85,7%
Indicators	18	15	83,3%

Results show that in overall MMLD is capable of realizing an integrated management. All indicators that refers to the structure and representativity on the mosaic's council were considered effective, although the communication with other important regional social figures and society in a general way showed values under 2. The council also seems to be effective to solve conflicts about land use, and to implement their decisions. The monitoring of the outcome of those actions were another indicator that showed low effectiveness and needs improving.

The non effective indicators were the ones about the council's influence in decision government instances, as municipalities, or state government. It shows the necessity of improving the communication with the environmental agencies. The same goes for one indicator that asks if the mosaic is considered in development policies though for the territory, that showed low effectiveness. Those indicators low grades were the key for the non effectiveness of one of the two principles in this scope.

Management

The management scope is about the mosaic's planning and maintenance. It evaluates if there is a long term integrated planning and if it's followed by the PA teams. It also verifies if the mosaic strengthens the protected areas, and if it has operational and economic resources and mechanisms to keep functioning.

The management scope showed curious results. Although 13 of their 15 indicators were considered effective, the scope itself was not. The reason is that 9 of those 13 effective indicators presented low effectiveness, resulting in the scope non effectiveness.

Table 2. *Parameters Effectiveness for management in Mico Leão Dourado Mosaic.*

Parameter	N Total	N Effective	% Effective
Principles	3	2	66,6%
Criteria	6	4	66,6%
Indicators	15	13	86,6%

The mico leão dourado mosaic is establishing as a strong support to their protected areas, especially the private and small ones. Also The PA managers cooperate for the maintaining of this support mechanism.

The main problems are about long term planning and financial resources to keep the mosaic functioning. The high number of low effectiveness parameters show that the mosaic is on a right path, but needs a lot of improving, especially in those two aspects.

Another interesting factor is that the indicators about the mosaic planning presented a big number of “not answering” instead of a grade by the counselor. It shows that the counselors have a difficulty in comprehending the difference in short term planning and long term planning. The appropriation of the mosaic’s planning contents by the counselors is essential , not only for a good managing, but for a truly integrated and participative territorial managing, where everyone are aware of the subjects and has equal capacity in opinion about the mosaics decisions and actions.

Sociodiversity

The sociodiversity scope approaches the appreciation and conservation of the cultural diversity in the territory. The practices that value the different traditions and ways of living and interacting with nature, giving the territory its identity. This scope verifies if the mosaic support the traditional native populations and communities within its limits. It also evaluates if it stimulates sustainable practices and ways of income generation for those people which are consonant with natural conservation and supports the creation of a territorial identity between those groups.

Table 3. *Parameters Effectiveness for sociodiversity in Mico Leão Dourado Mosaic.*

Parameter	N Total	N Effective	% Effective
Principles	2	0	0
Criteria	2	0	0
Indicators	6	4	66,6%

This scope presented as non effective. And all the four effective indicators had mean values under 2.

The non effective indicators refers to the importance given to the territory’s historical and cultural identity. The indicators with low effectiveness were about policies that favor conservation, the support to sustainable economic activities, and the acknowledgement of the local populations about the advantages of being part and participating in the mosaic.

There is no register of indigenous or quilombola populations in MMLD territory. Even so, it would be possible to value the familiar farming and bring people from land reform settlements to participate. It would contribute to improve the indicators with low effectiveness, reaching a greater number of local communities. A bigger effort from the mosaic’s council to stimulate the territory development through sustainable practices, as ecological tourism in private nature reserves and ecological agricultural practices in local farming populations is the key to consolidate the objectives of this scope.

Biodiversity

The biodiversity scope verify the practices of environment conservation, species protection, ecosystems connectivity and environmental services. It evaluates if the mosaic has actions on biodiversity protection, the main function of protected areas and consequently the mosaic’s.

This scope and all its principles, criteria and indicators were effective. Only two of seven indicators showed low effectiveness.

Table 4. *Parameters Effectiveness for biodiversity in Mico Leão Dourado Mosaic.*

Parameter	N Total	N Effective	% Effective
Principles	2	2	100%
Criteria	7	7	100%
Indicators	18	18	100%

The MMLD fulfil its role on ecosystems protection and promoting researches and endangered species preservation in the territory. That because the region is the habitat of the golden lion tamarin, specie who gives name to the mosaic, and reason for the creation of several local protected areas.

Results show the need of accomplishing more environmental education activities, and having a better dialogue with environmental agencies to support the creation of more protected areas. The territory is already known for the high number of private protected areas.

The Mico Leão Dourado Mosaics Management Effectiveness

The Mico Leão Dourado Mosaic resulted effective in two scopes, four principles, twelve criteria and thirty nine indicators.

Table 5. *Effectiveness for all parameters in Mico Leão Dourado Mosaic.*

Parameter	N Total	N Effective	% Effective
Scopes	4	2	50%
Principles	8	4	50%
Criteria	17	12	71%
Indicators	46	39	85%

The indicators indicate high effectiveness, the criteria medium effectiveness, and the scopes and principles the upper end of low effectiveness. Since half of the effective indicators showed grade under two, the MMLD can be classified as having medium effectiveness.

According to Gidsicki's (2013), the medium effectiveness range indicates the the mosaic possess the mechanisms indispensable for the management. It shows effectiveness in governance and biodiversity, but has some serious problems in management and sociodiversity. Those problems makes necessary moe dedication to establish integrated activities in these two late scopes.

The MMLD is well structured and functioning, being efficient in protecting biodiversity and integrating the protected areas and their teams. An improvement in the aspects which showed a low effectiveness would probably be enough to take the mosaic from the actual range to a condition of high effectiveness.

However, for this improvement, is essential that the mosaics council pay more attention to issues involving local farming populations and the local identity. It's also essential to better publicize the mosaic and its actions, and enlarge the dialogue with governmental institutions that have much territorial influence.

4. Discussion

From the identified weakness were elaborated proposals to strengthen the MMLD. These proposals take into account the current scenario in environmental politics in Brazil and in Rio de Janeiro State. The presentation is divided between the scopes.

Table 6. *Proposals to strengthen the governance scope.*

Need	Proposal
Enforce the mosaic participation in local environmental policies.	Signing of a commitment document between municipalities, state and federal environmental entities, recognising the mosaics importance and committing to cooperate. This cooperation can be supporting joint activities, and recognising and accepting the mosaic as a legit destination of resources for projects execution.
Sending, by the mosaic, of projects that aim the execution of the long term planning for state and municipal environmental councils, to get financial resources.	
Increase participation of local communities on mosaics council.	Execution of project for environmental awareness, that identifies the population groups in the territory, and how to approach them. The project should also publicize the mosaic to increase local participation.
Improve communication with local population..	
Improve the mosaics council internal communication.	Establish standard communication procedures for internal communication, keeping counselors always aware of what's happening in the territory, and de the mosaics activities.

Table 7. *Proposals to strengthen the management scope.*

Need	Proposal
Maintenance of a professional team for secretariat.	Seek financial support with the entities signing the commitment document. Insert the secretariat costs in other projects for execution of planning.
Organization of joint activities involving institutions other the protected areas.	Elaboration of proceeding manuals for the different kinds of activities executed.
Elaboration of long term planning.	Having a special group of counselors responsible for the elaboration of the long term planning and its monitoring by the mosaics council. If necessary seek financial support for hiring consultants to this task.
Keeping track of execution of the long term planning.	

Table 8. *Proposals to strengthen the sociodiversity scope.*

Need	Proposal
Knowing the territory's sociodiversity	Can be done in the same project designed for environmental awareness in governance.
Approaching local communities and publicize the mosaic.	

Knowing local policies for sustainable development that can be supported by the mosaic.	Having a special group of counselors responsible for studying municipal laws and policies, and identify the ones that can fit the mosaics purpose.

Since the biodiversity scope were highly effective, no proposals were elaborated. The indicator about environmental educative actions need improvement, but it can be done by the same project set for the sociodiversity and governance scopes.

An issue that must be discussed is the mosaic secretariat. All mosaics of protected areas include it in their regiments, and they have the mission of organize meetings, and organize, systematize and disseminate the materials and decisions produced by the mosaic, in its general meetings or by its coordination, special groups or taskforces. Also, the secretariats function as a cheer unit, avoidind counselors losing interests in the mosaic and skipping meetings. Is common knowledge between all the mosaic counselors that an active secretariat is fundamental for the mosaics well functioning.

The problem here is the lack of financial resources to pay the secretariat, even if it’s a small staff. The governmental agencies don’t have enough staff so they could assign an employee for this task. The immediate solution would be include the secretariat costs in projects related to the mosaic. It could be inserted in environmental awareness, communication and education projects, where it would be simpler to include the activities of the executive secretariat as a product.

Other important proposal for the mosaic strengthening, is the signing of a commitment term or document between the governmental entities responsible for the protected areas that are part of the mosaics. In the procedures for the creation of a mosaic, these institutions must express their support, but this does not create any kind of bond or obligation with the mosaics management. The signature of a commitment term would serve as recognition by these entities that the mosaic is an important conservation tool and a commitment with their management and operation support.

At the present time, it is not possible to require from government the maintaining of a secretariat staff. But they can recognize MAP as eligible figures for project submission in municipal and state environmental funds. They can also support the continued education of their protected areas managers in mosaic and participatory management, including the establishment of partnerships between themselves (federal, state and municipal governments involved) to make those initiatives viable.

5. Conclusions

The mosaics of protected areas are conservation tools that unite government agencies and society in the same arena to discuss the territory. Both sides must assume their responsibility with the maintenance of this tool, acting transparent and in a cooperative way, otherwise, the challenges faced will hardly be defeated.

According to brazilian law, the mosaics exist to execute an integrated and participative management of a group of protected areas that are close or overlapped. Value the participation of local populations is a way to reinforce the relation between these communities and the protected areas. It makes the mosaics the ideal discussion space to promote this conciliation.

Here lies the importance of a structured secretariat and its continuous functioning. Without their efforts to accomplish the interinstitutional articulation, the mosaic stops working. So is easy to see that it has a big influence in the mosaics capacity to fulfil their objectives in bio and sociodiversity conservation. The secretariat maintenance should be the council focus, for the guarantee that the other works keep happening. However, it cannot be a responsibility only for the government or civil entities representations, being multi sectoral partnerships the better way now to achieve efficiency in all mosaic scopes.

The mico leão dourado mosaic accomplish its task in supporting the local protected areas, and integrating some of their activities, but still lacks popular participation. It would be a main secretariat function, identifying the groups that should be on mosaics council and making the first contacts for their integrating. So we can see how a management problem can affect the results in other scopes.

This work shows a different way we are trying to make nature conservation in Brazil, putting together government and civil society. It still needs some adjustments for a perfect functioning, but in the right path that could be replied or even improved by other latin american countries in search for an equal appreciation of their biological and social diversity. The study presents a systematic evaluation of the execution of a public policy, something never made for this mosaic, showing ways it could be improved. All mosaics in Brazil would benefit by passing for this process and having tools for improving their actions and strategies for conservation. This is part of a bigger study that evaluated also other four mosaics in the state of Rio de Janeiro, and for the future those mosaics should be followed close for periodic evaluations and monitoring of their evolution.

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Appendix

Protocol for Evaluation of Mosaics Management Effectiveness (Hermmann & Costa, 2015).

GOVERNANCE	
PRINCIPLE 1. The mosaic has tools to promote integrated and participative management.	
CRITERION 1. The mosaic has a council dedicated to its management.	
INDICATORS	GRADE
1.There is an internal normative that guides the council's actions	
2. The council has regular meetings.	
3. The council meetings count with at least 60% of all counselors.	
4. Issues presented at council meetings are addressed and / or resolved	
CRITERION 2. The mosaic council has a functional management support structure.	
5. Thematic or special work groups solve the mosaics priority issues	
6. The Secretariat, or similar structure, provides technical, administrative and operational support to council	
CRITERION 3. The mosaic council promotes integration among the various social groups in the territory	
7. The council invites other social groups from the territory to participate in discussions and on the development of actions	
CRITERION 4. The mosaic has adequate tools for internal communication and dissemination of its actions	
8. The mosaic council has adequate ways for internal communication	
9. The mosaic communication with the interested society is efficient	
PRINCIPLE 2. The mosaic has mechanisms to deal with the complexity of the environment and of the institutions, addressing, directing and accompanying the solutions.	
CRITERION 5. The council is representative	
10. The main social group from the territory (indigenous, quilombolas, governments, NGOs, universities, business, tourism, farmers, among others) are represented in the council	
11. Counselors are legitimate representatives of their sector, responding to the positioning and demands of whom they represent.	
CRITERION 6. The mosaic council has the autonomy to address, solve and follow the main issues	
12. The main decisions taken by the council are implemented	
13. The mosaic helps the protected areas to solve conflicts related to the use of land and natural resources	
14. Mosaic acts in the licensing processes in the territory	
15. The mosaic council influences the allocation of resources from environmental	

compensation	
16. The mosaic council monitors the results of its interventions and proposals in the territory	
17. There are formal documents and agreements between the protected area management institutions that enable the execution of integrated actions	
CRITERIA 7. The mosaic council influences sectoral public policies established for its territory	
18. The presence and objectives of the mosaic are considered in programs and policies for local development in the territory	
MANAGEMENT	
PRINCIPLE 3. Mosaic actions are planned, executed and monitored in an integrated way	
CRITERION 8. Protected area teams are committed to shared mosaic management	
19. Managers of protected areas meet to discuss the mosaic, in addition to council meetings	
20. Protected area teams act in an integrated way in mosaic actions	
CRITERION 9. The mosaic has planning tools built in an integrated and participative way	
21. The mosaic has a long term planning	
22. The actions defined in the long term planning are consistent with the objective of the mosaic	
23. The goals and indicators from the planning are periodically monitored by the Mosaic Council	
24. The work plan, or plan of action, of the mosaic is based on the long term planning	
25. Strategic planning takes into account other territorial development plans	
26. The long term planning is articulated with the protected areas planning	
CRITERION 10. The mosaic executes the planned actions in an integrated way	
27. There are administrative procedures (with definition of tasks and responsibilities) for the implementation of integrated actions	
28. Institution teams, in addition to the managers of protected areas, invest time and other resources with the shared management of the mosaic	
PRINCIPLE 4. The mosaic has the necessary financial and operational mechanisms to carry out the actions	
CRITERION 11. The financial mechanisms meet the needs of the mosaic	
29. Protected areas budget provides financial resources for integrated actions	
30. The mosaic relies on various forms of raising funds to meet the demands	
CRITERION 12. Operational mechanisms meet the demands of the mosaic	
31. Integrated mosaic actions are incorporated into the protected areas planning tools	
32. Protected areas infrastructure, personnel and equipment are shared for integrated mosaic actions	

PRINCIPLE 5. The mosaic contributes to the achievement of each protected area objectives	
CRITERION 13. The mosaic strengthens the management of its protected areas	
33. There are instruments of cooperation between two or more protected areas that strengthen the operational capacity of both	
SOCIODIVERSITY	
PRINCIPLE 6. The mosaic contributes to the territorial strengthening, the valorization of the regional culture and traditional techniques of sustainable use	
CRITERION 14. The mosaic strengthens the local territorial identity	
34. The mosaic promotes actions for the valorization of traditional techniques for the sustainable use of natural resources	
35. The mosaic has strategies to promote historical, cultural and natural aspects, strengthening territorial identity	
36. Counselors and community members recognize the territorial identity of the mosaic and the advantages of participating in it	
PRINCIPLE 7. The mosaic contributes to the development of a strong regional economy based on the sustainable use of natural resources	
CRITERION 15. Strategies to support conservation and sustainable development are set out in the mosaic	
37. The existence of the mosaic contributes to the establishment of policy instruments and financial support for sustainable actions	
38. The mosaic encourages sustainable economic activities, such as ecotourism, plant extractivism, contributing to income generation	
39. Mosaic planning seeks to encourage sustainable socio-economic activities committed to the development of traditional populations	
BIODIVERSITY	
PRINCIPLE 8. The mosaic promotes the connectivity of ecosystems, contributing to the expansion and conservation of biodiversity and other environmental services provided by them	
CRITERION 16. The mosaic has mechanisms that contribute to the conservation of ecosystems	
40. Mosaic planning seeks to identify priority areas and actions for the restoration and / or maintenance of ecological processes	
41. The mosaic encourages the creation of new protected areas, especially in underrepresented ecosystems	
42. The mosaic contributes to the protection of springs, springs and river basins	
CRITERION 17. The mosaic develops specific actions directed towards the conservation of biodiversity	
43. The mosaic implements joint measures for the protection and recovery of rare, endemic, threatened or reduced species by various pressures	
44. The mosaic develops integrated monitoring and protection actions that assist in the conservation of biodiversity and natural resources	
45. The mosaic develops research programs on biodiversity conservation and restoration of ecosystems in an integrated way	

46. The mosaic promotes integrated actions of environmental education and awareness that stimulate the conservation of natural and cultural resources	

Toward Inclusive and Collaborative Climate Change Governance at the Municipal Level in Costa Rica

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Abstract

In 2007 Costa Rica was the first country committing to become carbon neutral. Two years later it developed its National Strategy for Climate Change and has since generated significant efforts aimed to governmental institutions and the private sector; however, advancements at the local level remain scarce, fragmented and poorly supported, particularly limited by the technical and organizational capacity that local governments have in leading mitigation and adaptation strategies within their territories. Since climate change is a multi-level, multi-sector and multi-term challenge, it asks for a different public governance style, with a higher commitment with civil society and the private sector, and with enhanced human capacities for the collective action. Supported by a research and extension project since 2011, several municipalities have been engaging in the development of collaborative and more inclusive climate change strategies within their territories in tune with local businesses, institutions, and civil society. The main purpose of this project is to support and document the process taken by our different case municipalities in developing and implementing their local strategies, and thus, supporting other local governments in developing their own. For this, the research team has been following a participatory action research approach with three local governments over several years, and during 2016 a structured survey was also conducted to the 81 municipalities of the country regarding the incorporation of the climate change topic into their municipal governance. General results are presented with an analysis of the perceptions from the nation-wide survey; then, with the help of the three cases studied, we explain the process taken in the adoption of such strategies and the challenges emerged. We found that in spite of the existing concern about the climate issue, appropriate mechanisms and information are lacking to enable its more efficient adoption in local governance. Therefore, we conclude that in order to adequately address the issue of climate change in an inclusive and sustainable manner, local governments are required to develop both internal and external capacities —beyond good administrative management— to allow a collaborative interaction with the actors involved, in order to generate and maintain their recognition, involvement, and commitment. Is evident that this project supports an alternative collaborative governance model, through the enhancement of individual and social local capacities leading to a more systemic commitment for collective climate action. This action requires transcending voluntary and isolated initiatives, leading the way to planned, and politically supported mitigation and adaptation strategies for inclusive development.

Keywords: civil society, community participation, inclusive climate action, local government, public administration.

1. Introduction

During the last years, Costa Rica has been managing an active agenda, both national and international, on the issue of climate change (hereinafter CC). In 2007, it acquired a commitment to become a carbon neutral country by 2021. Two years later, it launched a National Climate Change Strategy, which defines the carbon neutrality of the country and reaffirms itself at the international level the commitment to convert the country into a carbon neutral economy, a goal that is still maintained by the current government (Gutierrez, 2016). Due to the commitment made, Costa Rica began working focused on a mitigation strategy, mostly to reduce greenhouse gas (GHG) emissions from the private sector. The year 2013 was characterized by advances in the development and formulation of several Nationally Appropriate Mitigation Actions (NAMA) in various productive industries, with an increasing incorporation of the private sector into the carbon neutrality efforts (Jimenez, 2016) and a low emissions development and climate resilient strategy, mainly with the elaboration of technical guides (Corrales, 2013). At the international level, in the Paris Agreement (2015), Costa Rica presented its Nationally Determined Contribution (NDC), which set the goal of reducing emissions by 25% by 2030 with respect to the year 2012, and to seek the decarbonization of the economy by the end of this century (Gutierrez, 2016).

This set of public policies and initiatives in CC has allowed the generation of various efforts; however, these have been geared mainly toward the private sector or to centralized public institutional, but little at the local level where municipalities have been sparsely encouraged to work specifically on CC in a holistic way. Despite international efforts on this area, such as those lead by the Compact of Mayors, for example, along with a limited number of specific tools to support municipalities in tackling the issue, locally some governments have shown interest and have begun to seek alliances with other actors to incorporate the CC topic into local actions, but there is still little documented and available information on specific initiatives developed here.

According to UNDP's annual report (2014), CC is one of the most pressing issues on the global agenda for development. This asks for a different style of governance in order to overcome the obstacles of global arrangements, including the absence of enforcing mechanisms either at the international or national levels (e.g., Somanathan et al., 2014, Polhmann, 2011). It is required a more systematic engagement with civil society and the private sector, and the strengthening of human capacities for collective action to address climate adversities. Local collaborative governance arrangements or collaborative processes are proposed as alternative options for public policy decision-making and management, where different processes and structures help engage stakeholders from public, private and social sectors in a constructive form to address complex issues such as climate change (Ansell & Gash, 2008; Emerson et al., 2011).

Local collaborative governance is key to address CC for several reasons. First, most concrete actions are executed and the effects are felt at this level (e.g., Tanner et al., 2009); thus, addressing CC is a covering umbrella to address the socio-environmental issues that are dealt with by local governments (Dodman, 2009); thus, an opportunity to articulate the different agendas of waste, water management, mobility, risk management, reforestation, energy efficiency, and others (e.g., Lutsey & Sperling, 2008; Jones et al., 2000). In this regard, local governments have many tools at their disposal for implementing climate policy such as land use planning, residential and commercial regulations, solid waste management, transportation ordinance (Betsill & Bulkeley 2006; Kousky & Schneider, 2003). According to Rosas et al. (2012), institutions and local governments can contribute to reducing emissions (mitigation) or increasing the capacity to adapt to climate change and to climate variability; however, this requires a strengthening of institutional capacities. Second, local governments want and can contribute from their local sphere to the international and national commitments. According to a recent civil society survey, which examines the three most important aspects of implementing the NDCs in Latin America - proposed by each country at COP 21 in Paris - the third point of importance is to work with local governments (Pre-survey to the Regional Seminar on Climate Change for Civil Society Organizations of Latin America 2016). Third, constructive collaborations require according to Ansell & Gash (2008) face-to-face dialogue, trust building, and a shared understanding, factors that are often more easily accomplished at the local level. Similarly, Ostrom et al. (2009) point out that there are higher chances of success to overcome the free rider problem given the nature of common-pool resources, in local settings with lower negotiating cost as a result of higher trust, organization, and leadership.

Although in Costa Rica the incorporation of the CC topic in the municipal governance has been progressive, voluntary, and by the particular interest of some local governments without the mediation of an explicit national policy, it has been influenced by the environmental history of the country over the last several decades, following the conclusion of Sippel & Jenssen (2009), that the national framework conditions is an important determinant of local CC governance. For example, the Integral Waste

Management Law (2010) mandates local governments to promote the creation of an environmental management unit responsible of coordinating such processes (Programa CYMA, 2012, p.17). Another example is Executive Decree No. 36499-S-MINAET-2011, which mandates the develop of an institutional environmental management plans (PGAI) on each entity of the public sector (MINAE, 2011). However, according to the report of the Directorate of Environmental Quality Management (DIGECA, 2016), only 50 local governments had delivered this plan, out of a total of 90 (including 9 District Councils). In addition, the Municipal Performance Index made of 61 indicators, only considers some aspects of environmental management, and does not considers aspects or indicators related to climate action (CGR, 2016). Finally, in 2015 the Blue Flag Ecological Program created a new category directed to certifying municipalities. In its last report 16 municipalities showed as participants (PBAE, 2015), although is too soon to evaluate their performance.

Regulatory, administrative and market incentives have allowed a greater incorporation of environmental and climate related variables in the functioning of public institutions, also influencing the generation of initiatives in local governments. However, for climate management to be in line with national and international commitments, it is necessary to transcend voluntary efforts, and provide political and economic support for local climate action. Vasconcelos et al. (2013) even suggest that an approach with local institutions punishing free-riders will promote the emergence of widespread cooperation. Thus, the main purpose of this project is to support and document the process taken by our different case municipalities in developing and implementing their local strategies tackling climate change, with the aim to support other local governments in developing their own. In this article, we first present an analysis of current perceptions about the incorporation of the climate change topic into the municipal governance considering all the municipalities of Costa Rica; then, we analyze in a more specific way, the approach taken in three municipalities where the research team has been carrying-out the project. Before that, we present the general methodological approach.

2. Methodology

The study has a qualitative research approach. Initially, we present and analyze the efforts that local governments throughout the country have been carrying out in recent years; for that purpose, a questionnaire was designed taking as reference the studies of Molina-Murillo (2013) and Vignola and IPN (2010). The questionnaire was administered via the Internet through the platform SurveyMonkey.com with an additional effort through telephone calls. The information was obtained from all the 81 municipalities of Costa Rica between November 2015 and May 2016, which was mainly supplied by environmental managers or mayors themselves. In general terms, the questions used in the survey referred to levels of concern and responsibility about climate change and its effects, state of local impacts and actions to mitigate or adapt to climate variability and change, as well as the state of knowledge and progress in the development of local climate policy. Once the data were collected, it was recorded in Microsoft Excel for follow-up analyses.

Regarding the case studies, the research team has been following a participatory action research approach over several years with the municipalities under study —San Rafael (2011-present), Grecia (2012-present), and Belen (2014-present)— denominated: "participatory strategies for climate change at the local level". This approach allows to work the issue of CC in a comprehensive manner. The execution and analysis involves a mixed-methods approach that combines many field visits, personal interviews, participant observations, analysis of records, stakeholder workshops, teaching activities, development and execution of projects, participation in fairs, and others. The municipalities (counties) included in the study present differences in their economic, social, and environmental settings; however, they all showed high self-interest in participating in the project. After this contextualization, we discuss the component of local governance and participation based on the dimensions reported by Rosas et al. (2012) on the institutional capacities of local governments to address CC. We point general challenges and opportunities to strengthen local climate governance.

3. Results and Discussion

3.1 An overview of the integration of climate change aspects into local governance in Costa Rica

In recent years, the issue of CC has become more relevant in social spheres because of the availability of information and its perceived impacts. Thus, 85% of the staff consulted indicated being very familiar or familiar with the concept. When asked about the level of concern about the possible consequences of climate change in the territory of its local government, in the first place and with 83.5% the problems of water scarcity are mentioned. Infrastructure problems for water supply and potability, pollution, and increased demand, are linked to the effects of droughts that in recent years have occurred in much of the country, this being the second climatic effect of concern by municipal officials. **Figure 1** below shows the negative impacts that these effects can produce such as loss of agricultural productivity, disappearance of biodiversity, diseases and others. Although it is still worrying, it is particularly noteworthy that the consequences on public infrastructure are not yet a major concern in local governments, a key aspect of their management and responsibility in Costa Rica.

Figure 2 shows that the management of local governments is primarily focused on land use planning, which is the priority action for more than a third of municipalities (38%). This aspect should concern us if we consider that 62% of the municipalities do not have an official land use management plan (Programa Estado de la Nación, 2014). The same report indicates that management of solid wastes and providing water in good quantity and quality are elements that the population perceives as services that local governments are responsible to attend given their greater involvement and control over them. Although management of the above-mentioned aspects is linked to climate actions, at least at present, only one tenth of local governments prioritize the issue of climate change, placing it in fifth place in the list of priorities.

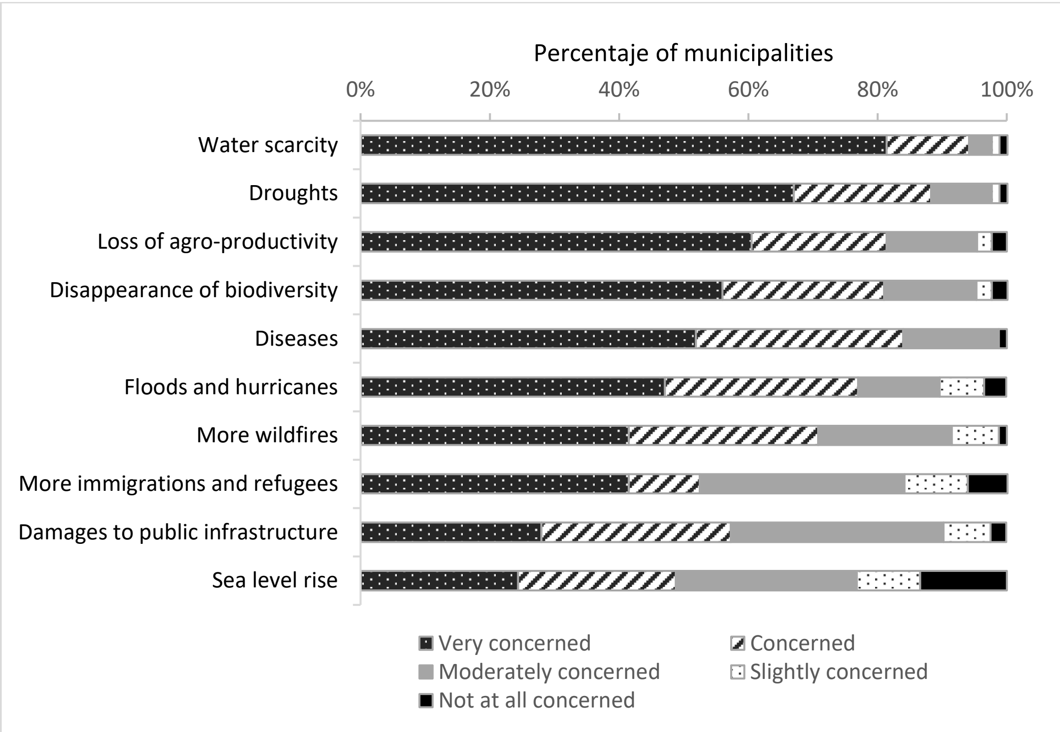

***Figure 1**. Level of concern with possible consequences of climate change in the territory under local government management.*

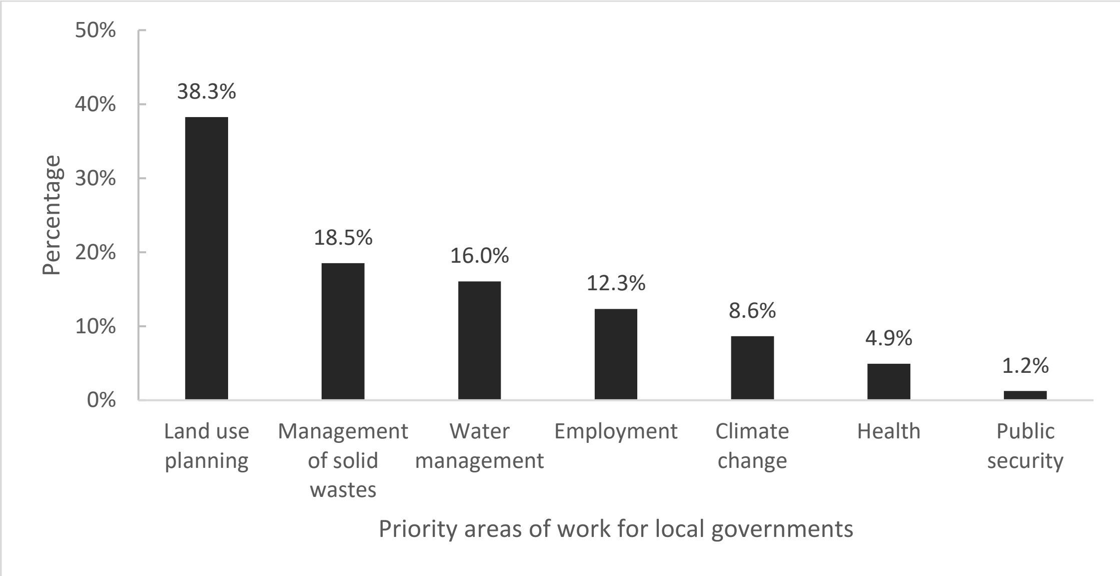

Figure 2. *Priority themes where local authorities (municipalities) in Costa Rica consider they should pay more attention.*

Of the total staff consulted, it is encouraging that 90% of them consider that it is the municipal responsibility to reduce the negative effects of climate change; although they stated that this responsibility is shared mainly with national governments but also with communities and individuals. Given the strategic positioning of municipalities between national governance institutions and local organizations and citizens, it is necessary to strengthen mutual cooperation mechanisms to translate global and national policy to local territories and their inhabitants. In this sense, only 64% of respondents indicated being knowledgeable with national climate change policies that promote and encourage their work at the local level.

Among the actions currently being carried out by the municipalities, three out of four of them already have a municipal recycling program that includes a separation facility, and also, they actively promote actions to avoid flooding through drainage, cleaning campaigns, or prohibition of constructions in the margins of rivers or other zones of protection. In general, of the 10 actions considered, only one third of the municipalities are implementing more than five of them. Unfortunately, only 21.3% of municipalities have a CC commission (or its equivalent) and 18% have carried out an inventory of GHG emissions (see **Figure 3**), essential activities, and often the starting point, to plan appropriately any local climate strategy. Consequently, 56% of the municipalities do not have a CC strategy at all, 37% are in the process of developing one, and only 7% of them —5 municipalities— have it formalized.

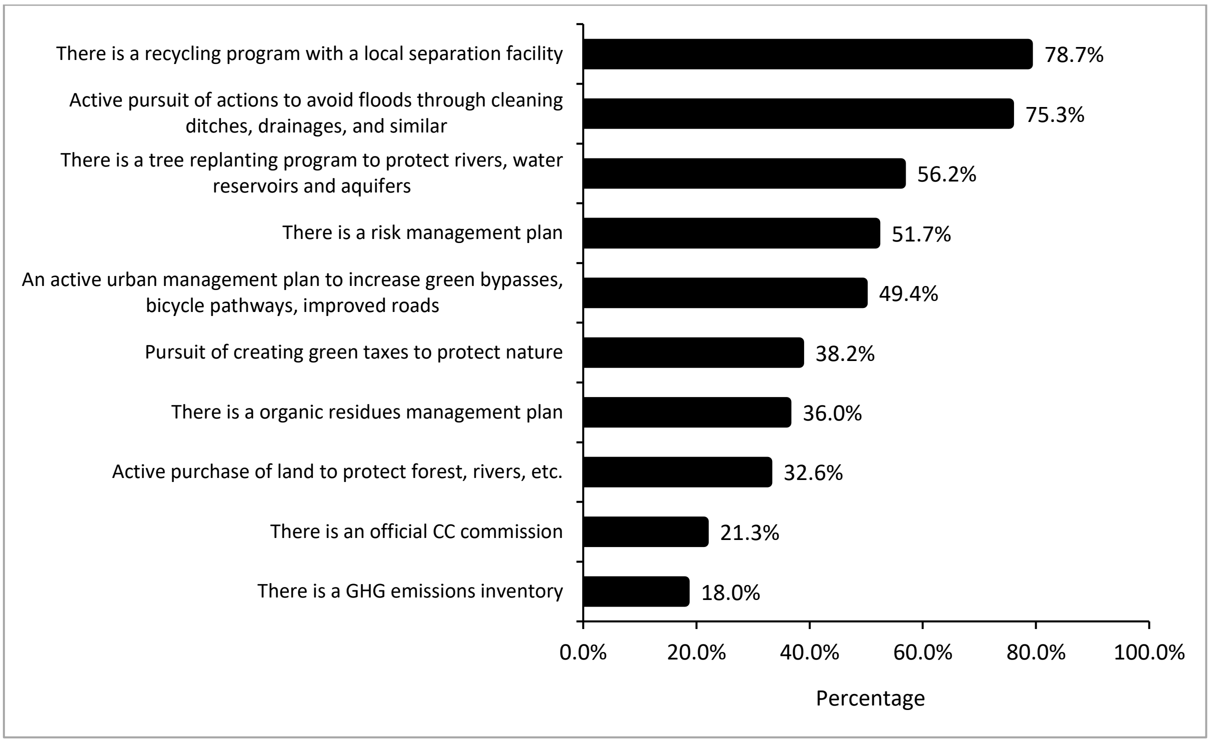

Figure 3. *Climate related actions that are currently being developed by local governments.*

3.2 The work with three municipalities

The approach took with our case municipalities is shown in **Figure 4**. Although the process is presented in phases, some of them take place simultaneously and little variations occurred across local governments. Initially our aim was to map as best as possible in a cooperative manner the current situation in order to create a baseline and more deeply understand the socioeconomic, political, and environmental characteristics, and levels of risk. On this first stage, we also aimed at creating an inter-institutional climate change commission —organized, trained and empowered with a wide participatory level. Members of this commission function as representatives from the multiple sectors, districts, and businesses within the municipal territory. Having them engaged from the beginning of the process is paramount to have an active and committed participation. Second, an official municipal climate change strategy was developed cooperatively, one that is executed and monitored by the inter-institutional commission. With such a strategy, climate policies, objectives and key projects are established along with climate risk management actions. Climate scenarios and the perceptions from organized groups, institutions, private sector, local development associations, producer associations, and other key actors were key inputs here. Third, projects are approved for key sectors on each county, informed by the diagnostic and the analysis of future risk. A goal with these projects has been also to document lessons to benchmark in other counties. Projects relate to water use, agricultural production, emission reduction, waste management, transportation, and others according to the priorities and possibilities of each county. Hence, one assume that these local territories are more adapted to the treats of climate change, becoming more resilient and with higher opportunities for development. Off course, none of this could be possible without a cross-cutting process for building capacities on local actors through awareness, education, and their empowerment. The educational component is conducted formally with school teachers of the public system and informally with members of the CC commission, municipal personnel, private actors and civil society in general.

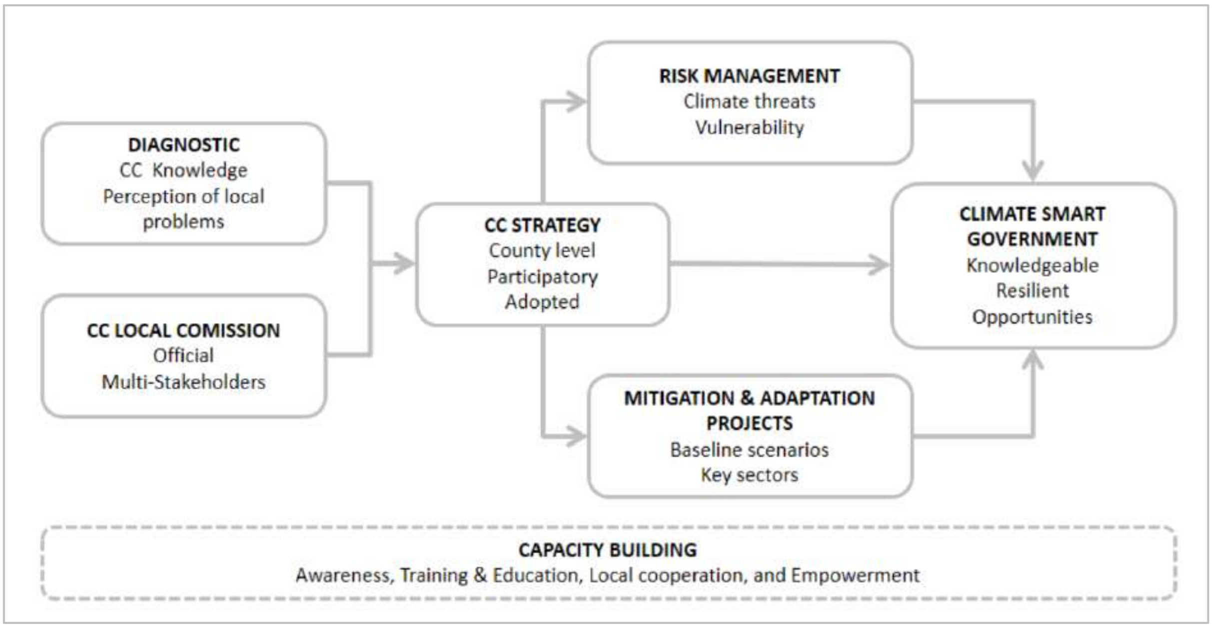

Figure 3. *Approach taken in order to help municipalities incorporate climate change into their governance.*

In order to create a context to the reader about the proposed analysis for the three municipalities (counties), first we provide a brief description of the territories and initiatives developed there. Although the three counties are located within the Greater Metropolitan Area or Central Valley, their biophysical and socioeconomic characteristics vary, generating different challenges for the incorporation of the climate topic into their local governance.

San Rafael is an urban-agricultural county with an area of 48.3 km^2 and 45 965 people, rich in natural resources, forests, and with great importance for the supply of water to a high percentage of the population in the Central Valley. Originated through a pilot project for carbon management in 2011, the committed participation of the local government and various sectors of the community made possible the prioritization of areas of work. As a result, today there is a community organized and represented by different sectors, with an established environmental education process, with a well-defined working agenda lead by an official climate change commission, working in areas such as organic waste management, recovery of protection zones through reforestation campaigns, and baseline information of GHG emissions and carbon storage, paramount for local climate decision making.

The experience acquired in San Rafael allowed the transition of the project to the urban-agricultural municipality of Grecia in 2012. Grecia has 76 898 inhabitants (as of 2011) and an extension of 254.2 Km^2, with a large forests reserves, an intensive agricultural activity, mainly coffee, sugar cane and pineapple crops, which are important sources of employment, but at the same time, GHG generators. As part of the project, efforts have been made to raise awareness in the different sectors of the county, as well as the collection of technical information, metrics for GHG emissions and carbon storage to support the decision-making of the climate change commission, which was developed and has been trained and empowered since.

Finally, we began the work with the municipality of Belen in 2014. This urban-industrial zone is strategically located between the urban center of the capital city and the main international airport of the country. With abundant water in the subsoil, has allowed the concentration of a large number of industries in its territory of 11.8 km^2, which also houses a population of 21 633 inhabitants and an additional floating population of about 25 000 people, resulting on real estate pressure, increased motor transportation along with congestions, air pollution, among other environmental problems. In view of this situation, a strategy is presented to address the effects of the climate, which has led to the development of an inventory of GHG emissions and carbon storage which happen to be the key motivator of subsequent actions. Such balance of emissions comparing the years

2006-2013 let the actors of Belen understand that they are the emitters of 2.78 million tonCO2-eq annually, representing approximately 23% of all the emissions of Costa Rica. This generated a sense of preoccupation and urgency that evolved in the discussion and development of projects around organic residues, transportation, and construction permitting, all under the guidance of a municipal climate change commission, which is highly trained, representative, and committed.

3.2.3 Dimensions that affect the capacities of local governments to meet the challenges of climate change

According to Rosas et al. (2012), the factors that can influence the capacity of local governments that address climate change are: shared responsibility, institutional work, governmental and social transcendence, social interaction, and government responsibility. These dimensions are briefly analyzed for the three municipalities under study, recognizing that they are relevant and helpful to identify weakness and strengths to improve the local climate governance.

The dimension of *shared responsibility*, i.e., the commitment or obligation to be assumed by both government authorities and members of a society, is visualized in all three case studies. The methodological approach of the research project contemplates the organization and citizen participation since the initial stages of the process. On one hand, the development of climate capacities and education is sought for local government officials and for other local actors; and on the other hand, this wide participation ensures the sustainability of the initiative. The assessment of this dimension favors cases 1 and 2, since they have a greater interaction with society, resources are allocated for research, and there is a commitment between the parties for the development of joint climate actions. Case 3 still requires strengthening organizational capabilities and integrating other social actors to achieve greater representativeness. We noticed that in communities with a stronger bottom-up governance approach for environmental issues where municipal officials are not the main actors but another participants, climate actions are easier to develop and maintain over time.

In the dimension of *institutional work*, which has to do with the internal capacities of local governments, the three local governments show a different behaviour. Although in the previous dimension we mentioned that municipal officials are just another actor in the overall set of participants, their formal and active participation is key in the process since they represent official voice of the local territory. Therefore, all meetings, projects, and budget allocations are officially approved by the CC commission established officially within the formal structure. Case 1 for example, has the best evaluation regarding having public policies on the subject, allocation of public resources and training, although it presents some deficiency in prepared personnel in the subject and incidence of internal procedures and regulations, both intimately related aspects. For case 2, the decision-making process is acceptable, but it presents shortcomings in prepared personnel in different areas and thus, their incidence of internal procedures. Finally, case 3 is working its way on the allocation of public resources, although it is evaluated positively on the topics of qualified personnel, training, and incidence on internal procedures.

The third dimension, *governmental and social transcendence*, considers how important and urgent is climate change to both, the local government and the citizens. Cases 1 and 3 present similar positive levels of coordination intra and inter-institutional on climate change; there is evidence of decision making around the issue, and there are people assigned to the coordination of the CC topic. Case 2 has a less focused approach on the issue of CC as a matter of public interest.

Social interaction considers relationships that show the importance of society for the success of climate policy, and is related to the acceptance by citizens, entrepreneurs, and non-governmental organizations. The analysis of this dimension shows that case 1 and case 2 have a very similar assessment, with an acceptance of the topic by key actors with important levels of participation. Although overtime Case 3 is showing a higher importance to the subject, its acceptance is not obvious by some actors, particularly companies who might be viewing climate actions as restriction to the production.

The last dimension is *government responsibility*, manifested in the need to have an organization responsible for the CC issue and entrust the institutionalization of CC as a public problem. This dimension is well-valued in all three cases, since it has a commission —conformed and official— dedicated to the topic, with an important experience (more than 3 years), and integrated by different social actors.

5. Key take-away messages

Formal political support on the part of the City Council and the Municipal Administration is essential for the development of the climate change strategy at the local level. Likewise, strengthening the political capital of community members is important to obtain the endorsement and participation of the formal political structures. Thus, robust municipal internal and external capacities —beyond good administrative management— are required to allow collaborative interactions and a systemic commitment for collective climate action. An official climate change commission is a fertile ground to generate within a formal structure the much-needed legitimacy, involvement, and commitment across actors. Unfortunately, both streams are often weak in local governing settings, limiting the potential and desirable success.

A local climate strategy requires highly motivated, trained and committed actors in order to provide a room for analysis, reflection, creativity and innovation in order to develop climate smart actions. Local socio-environmental problems are often threated in the same usual ways, disconnected from development opportunities and lacking a long-term vision. As discussed by Molina-Murillo (2016), the changing climate provides opportunities beyond just mitigation or adaptation, but most importantly, it provides an opportunity for sustainable development by changing many of the long-time problems that developing countries confront rooted on poor governance. Addressing climate change locally requires a clear planning strategy (designing, planning, execution, and evaluation) that provides concrete, evident and relevant results for a wide spectrum of actors, especially those more vulnerable.

Climate change education has served as a dynamic driver for strengthening the local environmental system and local development initiatives. This component must be conceived from the beginning as a continuous process, sometimes as an end, or sometimes as a means, to achieve greater governance and community wellbeing. Members of the CC committees later on became facilitators of processes of formal and non-formal environmental education, which promoted their empowerment. This type of initiative linking research, extension and teaching, contributes with a more comprehensive training, where we all learn from each other becoming more climate-smart agents.

Working with multiple actors in groups such as the CC commissions entails on itself a structure with roles, positions, and norms. Regardless of the good intentions we all might have; the participation and commitment depends on the legitimacy, leadership, and capacity of actors to solve internal problems. After all, the group is itself a psychosocial phenomenon that evolves, and needs to be flexible and open. Working cooperatively and empowering members through training, decision making, overseeing initiatives, public speaking, and others, happen to be fundamental. An alternative governance style with al systemic participation and commitment from multiple actors will result in more and better cooperative climate actions.

6. Conclusions

We found that in spite of the existing concern about the climate issue, appropriate mechanisms and information are lacking to enable its more efficient adoption in local governance. Therefore, we conclude that in order to adequately address the issue of climate change in an inclusive and sustainable manner, local governments are required to develop both internal and external capacities —beyond good administrative management— to allow a collaborative interaction with the actors involved, in order to generate and maintain their recognition, involvement, and commitment. Is evident that this project supports an alternative collaborative governance model, through the enhancement of individual and social local capacities leading to a more systemic commitment for collective climate action. This action requires transcending voluntary and isolated initiatives, leading the way to planned, and politically supported mitigation and adaptation strategies for inclusive development. According to the subsidiarity principle, government functions are assigned to the lowest level capable of efficiently undertaking the task; thus, local governments should be supported to fully and efficiently address the climate change challenges in order to properly deliver in a sustainable manner the expected array of public goods and services on their territories.

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Immersed Engagement: A new approach to collaborative planning in Aotearoa - New Zealand

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Abstract

This paper aims to introduce the concept of immersed engagement in urban planning, a engagement technique used to support and enhance collaboration between different organisations and communities involved in processes of urban planning. The need for collaboration, cooperation, and co-creation in urban planning is becoming increasingly recognised in many countries including New Zealand. In recent decades, significant collaborative work has taken place between local government planning authorities and industry, research institutes and universities to engage local communities in broader decision-making processes. Collaboration can take many forms, from information exchange to consultation partnerships, and these often occurs in the urban planning process. However, current engagement and participation frameworks have limitations in integrating information, feedback, and advice from the public into the core of decision-making in urban planning. The concept of immersed engagement emerged in this context, and is aimed at promoting long-lasting, trustworthy and ongoing engagement between government and a range of stakeholders. This paper focuses on the concept of immersed engagement and the potential it offers to advance co-creation and shared decision-making, as an alternative to conventional participatory approaches used in urban planning. Additionally, this paper looks at how best to implement immersed engagement, and examines the benefits of this new engagement technique, through lessons drawn from two research projects in New Zealand. The paper concludes by discussing the implications of advancing this engagement technique in the international context of urban and collaborative planning.

Keywords: Immersed Engagement, Urban Planning, Collaboration, Collaborative Planning, Decision-making.

1. Introduction

The emergence of public and citizen participation principles in the 60s (see, for example, Arnstein, 1969; Reynolds, 1969) prompted public participation to gain traction in urban planning. Governmental and planning processes have progressively embraced participatory models, attempting to include the voices of citizens and communities in decision-making (Brownill & Carpenter, 2007). Conventional planning approaches, in which decision-making is mostly centred on planners expertise, have loosened to accommodate opportunities for public participation in single or multiple stages of planning (Campbell & Marshall, 1999; Carr & Dionisio, 2017). However, the extent to which expert-led frameworks accommodate participation in planning is often related to political desire (Albrechts, 2003; Arnstein, 1969; Forester, 1999). This raises the concern that in many cases, public participation and engagement may be just another ‘box to tick’ in the urban planning process, instead of being a genuine attempt to take on board public opinion.

To address some of the systemic complexities of public participation and engagement in urban planning, a number of theories and techniques have been developed and trialled, with a particular focus on developing consensus (Forester, 1999; Healey, 1997; J. Innes, 1995), and ensure better integration of participation outcomes in decision-making. These have included and range of approaches including intensive communication, collaboration, and deliberation processes (Anderson, Cissna, & Clune, 2003; Campbell & Marshall, 1999; Dennis, 2006; Forester, 1999). In New Zealand, there has been significant recent effort to establish meaningful collaborations between local governments, local industry, research institutes, universities, and other local institutions and NGOs to broaden decision-making processes across wider institutional landscapes (Higgins, 2010; Montgomery, 2008). The emerging emphasis on partnering and collaborating with local industry and local governments, for the distribution of government research funds is another clear example of this. These efforts for collaboration pose significant opportunities for better integration of public participation and engagement in urban planning (Dionisio, Kingham, Banwell, & Neville, 2016), allowing a diverse range of organisations, including community groups, and local NGOs representing specific communities, to collaborate in the processes of decision-making and monitoring of local plans.

Collaborative planning approaches present an alternative to established participation processes, which often put the public through exhausting consultation processes to generate feedback on planning processes that may or not be considered in planning and policy (Carr, 2012). ‘Share an Idea’ was a consultation campaign organised by the Christchurch City Council in May 2011, after the February 2011 earthquake, to collect ideas on how the public envisioned the rebuild of the city. The consultation was very successful, with approximately 106,000 ideas shared, showing the willingness of citizens and communities to engage in the debate about the future of Christchurch (Bennett, 2014; Christchurch City Council, 2012; Kingham, Dionisio, & Newman, 2016). Despite the achievements of collecting the visions of the community and generating real momentum for engagement, the outcomes of ‘Share an Idea’ as integrated into the Draft Central City Plan, have since been overlooked in further planning decisions made by the Canterbury Earthquake Recovery Authority (CERA)[1] (Bennett, 2014). The non-integration of the consultation outcomes in the Central City Recovery Plan (CCRP) developed by CERA, meant that the ‘public participation’ box was ticked in the procedures of urban planning, but the opportunity for sustained engagement about the future of the city has been lost. This is a strong case in point to which collaborative approaches could have supported the integration of consultation outcomes in further planning decisions.

Collaboration can take many forms, from remote information exchange to consultation partnerships, active cooperation, co-creation, or rooted operational relationships between different organisations and groups. It was in this context that the idea of immersed engagement was developed, with the aim to build long-lasting and ongoing collaboration to improve public participation and community engagement in urban planning. The concept of immersed engagement emerged in the course of another research project – Greening the Greyfields (GtG) – which aimed at incorporating new geospatial tools into urban planning decision-making in the Christchurch post-earthquake rebuild. Immersed engagement was, in fact, an unexpected outcome of the GtG research project. This article builds on empirical observations resulting from the GtG implementation, to tell the story of immersed engagement and provide recommendations for future applications of this novel engagement technique.

This paper focuses on the concept of immersed engagement to advance collaboration and shared decision-making in urban planning, as an alternative to conventional participatory approaches. It discusses implementation issues of immersed engagement and its practicalities, through the experiences of two research experiences in Christchurch, focused on urban regeneration; one in the Christchurch City Council and another in Regenerate Christchurch[2]. This paper also examines the broader benefits of this novel engagement technique to assist urban planning and concludes by discussing possible implications and contributions in the New Zealand and internationally.

[1] The Canterbury Earthquake Recovery Authority (CERA) was central government authority established in 2011 following the Christchurch earthquakes to coordinate and manage the rebuild of the city.

[2] Regenerate Christchurch was one of three entities established in April 2016 to replace CERA (which only ever had a 5 year lifespan); its role was specifically to lead the regeneration of Christchurch.

2. The basis for Immersed Engagement

Immersed engagement is designed to support and enhance meaningful collaborations, and trustworthy relationships between planning authorities, organisations, local communities and research teams. It is compatible with collaborative planning, because both are built on the notion that planning involves human interaction to develop interconnections between different people and organisations in the construct of a shared outcome to solve or tackle a problem that involves multiple actors, in other words, the construct of governance (Bogason, 2000; Healey, 2003, 2003). Similar to communicative planning, immersed engagement integrates the concept of communicative rationality as a core principle to build, moderate and evaluate interactions in the course of planning (Forester, 1999; Hoch, 2002; J. E. Innes, 1996).

The origins of collaborative planning are deep-rooted in social theory, with key research embedding Habermas' notion of interactive relationships to develop governance processes (1984), Giddens' conception of interaction between different actors in the mutual construction of 'structure and agency' (1979, 1984), and also Bourdieu's theory of symbolic power (1977) (Healey, 2003). Some of the theoretical ramifications of collaborative planning diverted towards the inclusion of cultural theories, such as Foucault's theory of disciplinary power (1979) (Healey, 2003). The foundations of collaborative planning focus on the design of processes to integrate governance in the transformation and management of places and landscapes; an alternative to conspiratorial politics, expert-led planning, top-down decision-making, and bureaucratically driven deliberation (Healey, 2003; J. Innes & Booher, 2000). In the 1990s, collaborative planning and consensus building became largely accepted in the U.S. and Europe, with the emergence of new forms of collaboration and partnership between local governments, planning authorities, institutions, and community groups (Healey, 1998). The designation 'collaborative planning', however, has been misapplied by planners, decision-makers and politicians attempting to define arising governance trends that are deeply entrenched in business management literature (see Huxhman, 1996) (Healey, 2003). Also, some of the new collaboration and partnering schemes, developed at that time, had critical shortcomings in the integration of features promoting equity, jeopardising the reputation of collaborative planning's original concept (Healey, 1997). In the late 1990s, a number of critiques from planning theorists to collaborative planning were supported by the empirics of collaboration and partnering schemes which extensively misdirected the principals of collaborative planning (Healey, 2003). Nevertheless, there is also a significant repertoire of collaborative planning initiatives in Europe and U.S. that advanced the integration of public participation and engagement in the practices and frameworks of urban planning (Innes & Booher, 2004). Co-design, shared decision-making, and the emergence of community-led initiatives in urban planning (Carr & Dionisio, 2017) are examples of advances made in collaborative planning. However, it remains critical to address some of the criticisms of the late 1990s for better integration of equity in planning decision-making, to improve the practicalities of collaborative planning. It is in this context, that improved engagement techniques are necessary to guarantee the appropriate representation and embeddedness of communities and citizens' perspectives in the processes of deliberation, design and implementation stages of urban planning.

The spectrum of public participation, as defined by the International Association of Public Participation (IAP2), integrates several levels in which varying participation rights ranging from information, consultation, and involvement, to engagement and empowerment, are conferred to the public (Fig.1) (International Association of Public Participation, 2017). The decision on the levels to which the public has the right to participate in urban planning, however, remains a discretionary power of politicians and decision-makers. Also, the integration of information, feedback, input, or advice provided by the public in urban planning decision-making rests merely as a 'promise' to the public, which can be discretionarily altered to fit into political agendas, processual frameworks led by experts, and bureaucratic procedures (Carr & Dionisio, 2017). Due to the shortcomings of current engagement frameworks, public participation and engagement are still vulnerable to become just another 'box to tick' in the processes of decision-making in urban planning. These limitations exacerbate and substantiate criticisms to collaborative planning, regarding the need to ensure better equity and transparency in the processes of decision-making.

	Inform	Consult	Involve	Collaborate	Empower
Public Participation **Goal**	**Provide the public with information** on issues underlying urban planning decision	**Obtain public feedback** on urban planning decisions	**Work with the public** to ensure that public concerns and aspirations are considered	**Partner with the public** in the different stages of decision-making	**Place final decision-making in the hands of the public**
Promise to the Public	**Keep the public informed** about urban planning decisions	**Inform and provide feedback to the public** on how the public input influenced decisions	**Integrate the perspectives of the public** in alternative decisions and provide feedback to the public how decisions integrate their perspectives	**Search for public advice and innovation** in the formulation of decisions and development of urban plans	**Implement what the public decides**
Level of engagement between authorities, organisations, and communities	**Superficial:** information exchange	**Moderate:** casual opportunities to get/provide feedback	**Participative:** opportunity to be part of decision-making	**Engaged:** opportunity to actively be involved in decision-making	**Leading:** opportunity to make decisions

Figure 1. *The spectrum of public participation, as defined by the International Association of Public Participation (IAP2, 2017).*

It was in this context that immersed engagement was conceptualised as a novel technique to promote long-lasting, meaningful and ongoing collaborations or partnerships for a shared and evolving construct of decision-making in urban planning. The implementation of another research project focused on urban regeneration in Christchurch, with the aim of assisting the post-earthquake rebuild – the GtG research project -, led to a series of observations in the attempt to apply current engagement frameworks. In this initial experience, the engagement objective was to implement two geospatial tools, developed within the GtG project, to assist urban planning decision-making amongst decision-makers, urban planners and designers; and support the city council in engaging with local communities. In engaging with the city council, with urban planning and community development teams as our research partners, it was observed that shared time (between researcher and council staff) was crucial. These interactions resulted in increased capacity to align our research outcomes more efficiently within the planners' workflows. It was also observed that our engagement at the council had multiple levels of depth (reflected in shared time), at different points in time or with different council teams, which then influenced the capacity to align our research with the partners' practices and activities (Fig.2).

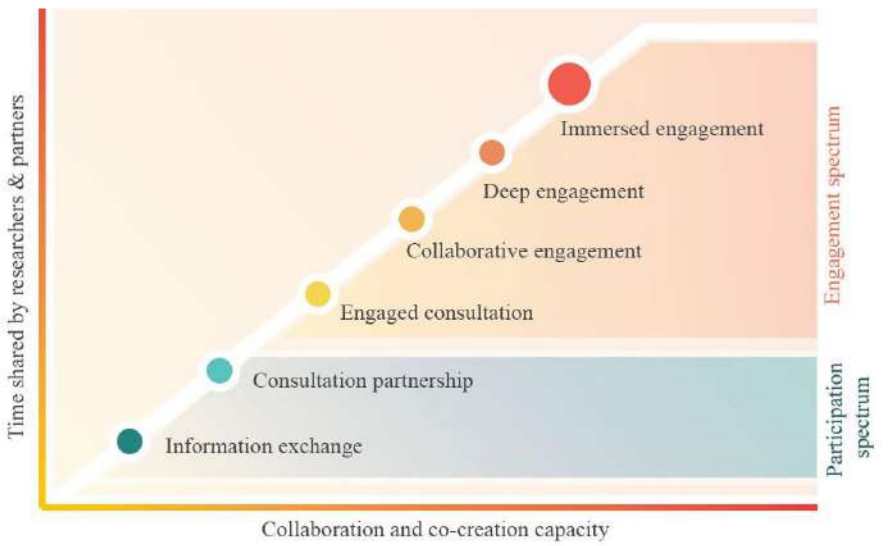

Figure 2. *Immersed Engagement and the multiple levels of participation and engagement.*

The more time researchers spent working side by side with planners, often in local council offices (immersed in the partners' environments), the more efficient was communication, and more meaningful were the produced outcomes. Immersed engagement aligns with the fundamentals of collaborative planning, regarding the construction of interactive relationships to develop governance processes (Giddens, 1984; Habermas, 1984; Healey, 1997) with application in urban planning. Additionally, it may also provide an advanced alternative to current participation frameworks to overcome some lingering shortcomings.

As our engagement in the Christchurch City Council progressed, it became clear that the implementation of new geospatial tools to assist decision-making in urban planning was far more complex than anticipated. At the time that the GtG research was initiated in Christchurch, only three years had passed since the 2011 earthquakes and there were, as there are currently, undergoing changes to political and organisational structures at the local and regional levels, which has been reflected in increased pressure on planning teams at the council. Additionally, the geospatial tools being implemented in Christchurch were created to assist urban regeneration in mid-suburban areas in Australian cities, which was not the same situation as that in Christchurch where the focus was post-disaster rebuild and recovery. In attempting to implement the geospatial tools and investigate the implications of their usability in planning teams in the specific context of Christchurch, it became apparent that it was required to advance current participation and engagement practices, such as IAP2' framework. The engagement techniques that were available to implement our research at the council were not producing the desired outcomes. This was the main rationale for reviewing the collaborative planning approach, and initiate a new engagement practice (unnamed at that time). This was based on our initial observations, that longer periods of shared time working with council teams was positively associated with productive interactions and better alignment between our research and planners' workflows. The name, immersed engagement, came later, once the implementation of GtG research and the new geospatial tools gained a more productive momentum amidst several planning teams across the council by virtue of our new engagement technique. The term 'immersed' was the most appropriate to encompass the nature of our new engagement practice, and to express the importance of sharing time, place, and perspectives with our partners at the council.

3. Implementing Immersed Engagement

To ensure meaningful, long-lasting and trustworthy relationships between the different actors, this research proposes four key implementation principles built from our experiences in trialling immersed engagement: (1) Immersing in time, place and perspectives, (2) developing trust, (3) fostering meaning, and (4) ensuring continuity. This section examines these four key principles through the analysis of our experiences in trialling immersed engagement, to provide recommendations for future applications.

3.1 *Immersing in time, place and perspectives*

Immersed engagement requires close proximity between partners, to create a favourable environment to develop trust, foster meaning and ensure continuity of the engagement relationships (Glackin & Dionisio, 2016). Partners may include practitioners, planners, designers, decision-makers, or community representatives, with distinct affiliations, interests and perspectives. In our experience, it was fundamental to share significant periods of time with key partners (immersing in time) – up to 5 hours per week – and working in their office (immersed in place), to overcome possible shortcomings resulting from different perspectives and positionalities. Spending significant periods of time with our partners in their office, allowed the partners to get to know our research team, informally inquire about the project during morning tea, and develop a relationship with the GtG research. Before initiating the immersed engagement, the GtG engagement methodology was trialled to implement new geospatial tools through training workshops with planning teams in the council, which proved to be an inefficient approach because either the council teams had only short periods of time available to book formal meetings such as workshops, or if the workshops progressed for longer periods, most participants would either arrive or leave in the middle of the workshops. This experience revealed that the implementation of the geospatial tools required informal gatherings and casual chatter about the project, as an alternative to formal, rigid, and time restricted meetings. Hot desking in partners' usual working places, in their comfort zone, once or twice a week usually on a regular basis, implied the willingness to understand their perspectives and incorporate them in the GtG research. This perceived willingness generated more openness, empathy, and better connectedness between the researchers and the council partners. This was a favourable environment to immerse the research in the partners' perspective and further develop a deepening trust between researchers and council teams. These created conditions also allowed a more positive perception on the accountability of the researchers in the council, fostering the beginning of what is now a trustworthy, long-lasting engaged collaboration.

3.2 *Developing trust*

Immersed engagement is based on relationships built on trust. In the organisational context, trust implies reliability, openness, confidence in the competency of partners, and perceived transparency and fairness (Farrar, 2005). In the context of engagement, however, the trust may be mutual between partners but it extensively relies on the performance of a trustee to earn a position of trust in the perspective of a trustor (Misztal, 1996). In the experience of the GtG research project, the research team was the trustee and the diverse partnering council teams were the trustors. Initiating and nurturing trust with our council partners was not a difficult task, it occurred spontaneously by sharing time together in diverse situations, such as hot desking, informal or some formal meetings, and catch-ups on progress reporting in the desks of partners. Spending time together in diverse situations, as an alternative to solely formal meetings and workshops, provided opportunities for researchers and partners to know each other better, exchange perspectives, and develop trust. This is a common feature of ethnographic studies, in which researchers need to gain proximity and trust from communities in order to understand their customs and perspectives (Geertz, 1973).

The quest for proximity – in sharing time, place, and perspective – to develop trust with partners, raises critical issues that need consideration in the application of immersed engagement. First, there are a number of ethical issues in conducting research on, or implementing, immersed engagement. These include human ethical considerations regarding individuals working, collaborating or volunteering in partnering organisations, aiming to guarantee the personal and professional integrity, safety, and wellbeing of participants. There are also organisational ethical considerations regarding the structures of information, confidentiality, reporting, supervising and cohort (McDaniel, 2004) that must be considered in implementing immersed engagement. In our experience, both at the Christchurch City Council and at Regenerate Christchurch, it was useful to have induction activities provided to the immersed researcher, informing about required or preferred conduct regarding organisational ethics. In case the induction information is not provided, it is fundamental that the immersed party seeks for this type of information prior to initiating the engagement, to ensure the compliance to organisational ethics and the preservation of trust.

Secondly, it is relevant to consider positionality when implementing immersed engagement. The exchange of perspectives between the immersed parties and partners must be monitored and managed frequently, through engagement reports or journals. This practice is relevant to ensure that each party involved in immersed engagement is capable of maintaining an autonomous position with ethical and professional integrity without exposing the position and integrity of other involved parties.

3.3 *Fostering meaningfulness*

The application of immersed engagement requires the promotion of meaningful interactions, activities and outcomes that are equally relevant to all partners involved. Meaningfulness nurtures the relationships and interactions between partners, by a shared focus and resource in the activities of engagement that are developed to create beneficial outcomes for the hosting organisations and immersed parties. The immersed time, hot desking at the council and at Regenerate Christchurch, is spent in activities and tasks directly related to the project we aim to implement while putting the geospatial tools to use according to the specific needs of different teams. During our immersed engagement with the council urban regeneration team, we had the chance to test the usability of both geospatial tools because two planners requested assistance in specific projects they were working on at the time. Similarly, in Regenerate Christchurch, our research and expertise are being put into practice in a specific project that is a priority for the urban design team. The alignment of the immersed research with the specific needs of different teams, or the same teams in different points in time, allows the establishment of common objectives, where perspectives and outcomes line up in a collaborative effort, maintaining all partners actively engaged.

To align an immersed project within an organisation, to put the immersed project to use addressing the specific needs of teams (fostering meaningfulness), it is fundamental to maintain active communication lines with key partners within teams. In our immersed engagement experiences, this occurred spontaneously because of the planners, specifically seeking for the support of our project, were those working in a specific task or workflow that related with the capabilities of the new geospatial tools and applied research. For each application of the GtG research with the council and Regenerate Christchurch partners, there was a specific key planner, which fundamental to the success of the immersed engagement and the research project.

Another relevant aspect to fostering meaningfulness is the creation of outcomes that are useful for all partners. Outcomes can be presented in diverse means, such as reports, assessments, maps, tables, or can also be provided in the form of advice and feedback, to meet the specific needs of partners within the immersed project. In our immersed engagement experiences, the outcomes were defined according to the specific needs of planning teams and determined jointly with key planners directing the collaboration. Maps were one appropriate outcome to assist a specific key planner in the identification of areas ripe for urban regeneration across the city, whereas others requested summary tables and brief reports to compare diverse urban development scenarios. Readiness and adaptability are fundamental to immersed engagement to ensure the capacity to execute tasks meeting the needs of partners and maintain reliability for the continuation of collaborations.

3.4 *Ensuring continuity*

Continuity should be promoted in immersed engagement to allow partners to have an ongoing role in the project to assist their workflows (trust) while generating common goals between partners (meaningfulness). Continuity implies consistency, dependability, and approachability. In our immersed engagement experience, it has been fundamental to hot desk at the partners' offices on a regular basis, to create a routine to which the planning teams can expect the immersed researcher at a given time of the day and day of the week. This regularity facilitates collaborative interactions, discarding the need to schedule meetings, and allowing partners to plan ahead for specific tasks or actions to put the immersed project to use for the support of their workflows. The consistency of time spent at partnering organisations also allows partners to consider time in the management and execution of tasks, increasing the capacity to incorporate the immersed project in current workflows. It is relevant to maintain consistency, even throughout periods where there are fewer interactions during the immersed time due to the increased workloads of partners. Our experience revealed that hot desking at our partners' offices generates a positive expectation from planners in relation to the immersed project.

Dependability is another key feature to ensure the continuity of immersed engagement. It is relevant to meet deadlines in delivering agreed outcomes, and show readiness, interest and openness to expanding the application of the immersed engagement. Dependability will generate trust from partners, which is crucial to forming new ideas to put the immersed project to use again within future workflows or tasks. Dependability and consistency are braided in the construct of trust and meaningfulness in the implementation of engagement. Our experiences showed that this is possible to develop stable dependability and consistency within planning teams, throughout time and with enduring performance. The immersed engagement of GtG at the Christchurch City Council lasted for about ten months and supported three distinct case studies developed in the urban regeneration team. For the past three months, the project is immersed at Regenerate Christchurch to help with scenario development for the regeneration of the central city. In moving the engagement from the council to another local planning authority, it is relevant to note that most of the staff members of both organisations work closely together and there was a general understanding amongst our council partners that GtG would timely to assist Regenerate Christchurch. After this shift of partners, the GtG research project continues to communicate with council partners on a regular basis in a collaborative engagement level (Fig.2). This shows that the quality of the relationships and interactions established through immersed engagement, may allow for the potential to give continuity to collaboration beyond the time or objectives of a specific project.

To implement immersed engagement it is also relevant to consider the approachability of the immersed researchers, and the openness of the immersed project. Approachability allows partners to be curious about the project, its current and potential applications, which may generate a positive debate about its opportunities and challenges. Implementing the GtG's geospatial tools to assess their usability at the council required immersed researchers to develop an approachable attitude to maximise feedback from multiple teams across the council. Advancing current methods or tools, or whatever project outcomes are being implemented or tested through immersed engagement, will require an 'open door' to consider new possibilities for future collaboration. With efficient approachability, immersed engagement can go beyond the time and focus constraints of current projects and ensure the continuity of collaborations.

4. The benefits and potential of Immersed Engagement

The many benefits observed in trialling immersed engagement in the Christchurch City Council and at Regenerate Christchurch, shows that it has the potential for other applications across the public sector, with involvement of multiple partners, organisations, authorities, and community representatives. Our experiences and empirical observations were engrained in an engaged research project, but the concept of immersed engagement and the recommendations provided for its implementation can be used for other types of participation and engagement projects. The application of immersed engagement to improve collaboration relationships, or implement, test or evaluate projects has the potential to advance collaborative planning while offering an empirical alternative to current participation and engagement frameworks.

From our implementation of the GtG research in Christchurch, the benefits of immersed engagement include:

1. A deeper understanding of our partners' perspectives and needs, which facilitates the grounding of our project, expressed in the suitability of research outcomes in relation to authentic needs and priorities as seen by partnering planners. This evolved understanding has increased benefits for both sides, in joining collaborative efforts to solve or tackle a commonly understood problem or challenge. In this context, immersed engagement offers an advanced approach to engaged research (Mikesell, Bromley, & Khodyakov, 2013), as to other types of organisational collaborations and partnerships.
2. Immersed engagement can help assisting the development of resources and time intensive tasks which are challenging for organisations, authorities, or groups. Co-creation is a new collaborative planning practice, originally introduced in marketing, management and innovation referring to the development processes in which multiple partners work together on a project, strategy or product that addresses distinct interests (Bhalla, 2011; Ramaswamy & Ozcan, 2014). Co-creation has significant potential to overcome some of the shortcomings of public participation in the urban planning, and it is already being applied in urban design, placemaking and strategic planning (Senbel, 2012). It is, however, a time and resources costly collaboration tool that can be implemented through immersed engagement. Sharing time, place and perspectives, nurturing trust, and defining shared goals, the basis of immersed engagement, creates a favourable platform for co-creation and other advanced methods of collaborative planning. The combination of immersed engagement with collaborative planning methods such as co-creation provides a novel approach to participation and engagement.
3. Immersed engagement generates long-lasting and productive relationships across institutions, producing meaningful and useful outcomes for different parties in the course of their practices (i.e. research, planning, community support, etc.). By promoting interconnectedness and interdependency between partners, immersed engagement presents a great potential to develop or reinforce collaborative and organisational resilience (Goldstein, 2012).
4. Our research experiences in Christchurch demonstrated that immersed engagement was the most appropriate technique to develop collaboration for the implementation of our research project, with a focus on urban planning and aiming to provide the support for local governments to engage with local communities. Immersed engagement, not only brought benefits for the implementation of the project, as it enhanced the collaboration capacity of the partners. In New Zealand, collaborative planning places significant focus on the needs of stakeholders and local governments (Margerum, 2011; Montgomery, 2008), and although urban planning frameworks include mechanisms for public participation, there are still many opportunities to improve public and community engagement. Current frameworks often promote public

participation at information and consultation levels, seeking feedback from the public on projects and plans that have been already been developed (Margerum, 2011). In this context, immersed engagement provides an alternative to integrating community perspectives in local councils, authorities and organisations involved in urban planning. An immersed approach where community representatives can be immersed in local planning authorities would be an efficient way to voice and integrate the perspectives of the public in the rationale, design and implementation stages of planning.

5. Discussion

Immersed engagement is a novel engagement technique aimed at supporting and enhancing meaningful, long-lasting and productive collaborations, within trustworthy relationships between planning authorities, local organisations and communities and research teams. The definition of immersed engagement was materialised through the implementation of GtG research project in Christchurch, aimed at delivering geospatial tools to assist urban planning in the rebuild. The engagement techniques available for the implementation of the GtG (i.e. IAP2's participation framework) were not producing the reach and outcomes expected by the researchers and funding agencies. Training workshops proved to be inadequate to integrate the needs of our partners at the council, and it became clear that examining the usability of new geospatial tools was going to require an advanced engagement technique. On the other hand, a critical review of collaborative planning and current participation frameworks has shown that often engagement actions are vulnerable to became part of a procedural step – a 'box to tick' -, instead of being applied to create shared decision-making and build plans from local perspectives and knowledge.

In order to increase the chances of successfully implement the GtG research project, and research for possibilities to overcome some of the current shortcomings in engagement frameworks; we initiated a new engagement practice before it was conceptualised as immersed. It was based on initial observations indicating that longer periods of shared time working with the council teams was positively associated with productive interactions and better alignment between our research and our partners' workflows, tasks and agendas. Once this new engagement practice started to produce visible outcomes in our interactions with council partners, it was then possible to conceptualise immersed engagement as a new technique. Fundamentally, immersed engagement has four key principles: (1) immersing in time, place and perspectives, (2) developing trust, (3) fostering meaningfulness, (4) ensuring continuity. t

This section discusses some of the limitations of immersed engagement while providing recommendations, examines the implications of immersed engagement in collaborative and urban planning, and concludes by exploring the contributions made by this research in New Zealand and the international context.

5.1 Limitations

Associated with the fundamental principles, the practicalities of immersed engagement present a number of limitations that are potentially relevant in future applications. Immersing in time and place requires immersed researchers, professional or representatives to spend extended periods of time, working side by side, in partnering organisations, requiring availability to dedicate time, and adaptability to be reallocated in different work environments. In our immersed engagement experiences, hot desking was an effective manner to create proximity to our partnering planning teams across the council. Initially, it was difficult to book desks just for periods of four to five hours per week, and it proved to be easier to just arrange an initial meeting with the key planner in each team, and use any desk available on the day. Soon it became obvious that Fridays were optimal for immersed engagement, given that there were more available desks in the council offices then in other days of the week, but still with a good attendance of staff. Any difficulties imposed by the context of a specific team or its workplace, in which a project is immersed, must be observed and analysed to study ways to adapt.

Another constraint that we discovered during our experience was that periods of increased pressure for planning teams need continuous assessment by those immersed, to readjust the immersed project in each session. In times of high pressure for teams, immersed engagement should provide either relief to partnering teams or refrain from adding further pressure. Because of this constraint, there were occasions when the immersed researcher would hot desk in the partners' office but have no chance to interact with any members of the partnering teams, due to their heavy workloads. In this case, it was always relevant to continue hot desking and immerse in place, to ensure consistency, dependability, and approachability.

It is likely that immersed engagement may have other compositional and contextual limitations, but awareness, adaptability, and tenacity are features that may considerably help to overcome some of them.

5.2 Implications & Contribution

Immersed engagement makes a significant contribution to participation in urban planning because promoting long-lasting and meaningful relationships between collaborating partners, with a continuity approach, has the potential to enhance equity in the diverse structures of decision-making. Current engagement frameworks remain far too rigid to accommodate the complexities of integrating the inputs of public participation in the different stages of urban planning. In this sense, immersed engagement provides an alternative engagement technique that may prompt urban planners and decision-makers to review current engagement practices and approaches, and maximise the potential of engagement actions to lead shared decision-making or even co-create urban plans. An ideal impact of immersed engagement would be a change in the paradigm of participation and engagement in New Zealand, towards a better implementation of public's perspectives in planning. However, such shift contains intrinsic political and organisational barriers, and it is likely that immersed engagement may only have the capacity (for now) to raise awareness on the potential of deep-rooted forms of engagement to share decisions and plan better in collaboration with communities and organisations.

The application of immersed engagement has the potential to support planning authorities, by developing a deeper understanding of partners' needs and perspectives, and advancing collaborative capabilities within organisations. This can facilitate the production of meaningful outcomes for multiple partners in the planning sector, creating long-lasting collaborative relationships and promoting collaborative and organisational resilience (Goldstein, 2012). Also, when combined with other collaboration tools such as co-creation; immersed engagement provides an improved alternative to current participation frameworks.

In the scope of collaborative planning, immersed engagement advances communicative planning (Forester, 1999; Healey, 2003; Hoch, 2002; J. Innes, 1995), by considering positionality in relation to need for proximity and depth. Immersed engagement establishes a connection between collaborative planning and concepts borrowed from ethnography such as trust, meaning and continuity (Geertz, 1973). By reviewing some criticisms to collaborative planning and attempt to address them in its key principles, immersed engagement advances the theorisation for the integration of public participation and engagement in the practices and frameworks if urban planning, which is relevant in the international context. Also, this research makes a significant contribution to collaborative planning, by providing a set of implementation recommendations based on empirical experiences in which immersed engagement was trialled and validated. However, it remains pertinent to develop additional research on the applications of immersed engagement in different contexts of planning.

In the context of sustainable development, immersed engagement has the potential to enhance a better alignment between development and sustainability agendas by promoting long lasting, meaningful and ongoing collaboration between diverse stakeholders. Interconnectedness and interdependency between partners, as well as organisational and cooperative resilience are features of immersed engagement that support a more equitable construct of governance and social sustainability in the diverse structures of decision-making in urban planning and development.

5.3 Conclusion

This research article presented the concept of immersed engagement, as a new engagement technique that can be applied to develop or reinforce collaborative relationships between diverse partners such as local governments, organisations, research teams, and community representatives. The concept of immersed engagement emerged in the course of implementing the GtG research in Christchurch. The available participation and engagement frameworks were not suitable for the implementation of that research project, prompting the conceptualisation and trial of a new engagement technique. In other words, this research article presents and examines an unexpected outcome of our research. This article builds from empirical observations resulting from the GtG implementation, to tell the conceptualisation story of immersed engagement and provide recommendations for future applications of this novel engagement technique. The main contributions made by this new engagement technique, are related to the improved capacity of planning authorities to collaborate with multiple partners, and advance the integration of public's perspectives in urban planning.

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Waste Management Governance in Colombia: the case of National Alliance for Inclusive Recycling

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Abstract

Waste management is considered to be one of the most important challenges that must be faced by the international sustainable development research community, and also by decision makers responsible for global environmental governance. In Latin American and the Caribbean (LAC) countries this is 4 million waste pickers earn their livelihood by being a part of the recyclables supply chain. Some countries, such as Brazil and Colombia, are adopting pioneering strategies to incorporate these professionals into their waste management models. In Colombia, a collaborative governance arrangement is being developed which involves the government, private companies, waste pickers and society: the Alianza Nacional para el Reciclaje Inclusivo (National Alliance for Inclusive Recycling). This model is obtaining good results not only with recycling, but also with social inclusion. The main purpose of this paper is to comprehend how distinct organizations could work together to build and develop a waste management model that truly includes the waste pickers. The current investigation is being accomplished using a case study research methodology, based on interviews and data analysis. Despite being an ongoing investigation, some initial findings have been determined: (i) the process to Alliance creation had a key stakeholder represented by IRR (Iniciativa Regional para el Reciclaje Inclusivo / Regional Initiative for Inclusive Recycling), that was also formed in a net governance process; (ii) the participation of CEMPRE (Compromiso Empresarial para el Reciclaje / Business Commitment for Recycling) was fundamental to guarantee the pickers empowerment; (iii) the Colombian government was open and receptive to help to design new structures to guarantee inclusiveness in the waste management process in the country; and (iv) there is a necessity for changes in the law and the creation of public policies to make the changes possible. The main conclusion is the necessity of powerful and engaged stakeholders in the governance process having a unified approach to making a difference, involving win-win decision making leading to achievable environmental, social and economic gains.

Keywords: Waste Management Governance, National Alliance for Inclusive Recycling, LAC Countries.

1. Introduction

Waste management is considered to be one of the most important challenges that must be faced by the international sustainable development research community, and also by decision makers responsible for global environmental governance. The impact of waste management can be felt in many areas, particularly those with environmental, economic and social dimensions.

Obviously, in Latin American and the Caribbean (LAC) countries this is no different. However, the region presents a special fact that should not be underestimated: 4 million waste pickers earn their livelihood by being a part of the recyclables supply chain. In some cases, informal waste pickers are responsible for the collection of 90% of the recycled materials in their regions, receiving only 5% of the jobber gain (Accenture, 2013). In most of cases, the waste collection is its only ingress. Even with this contribution, in most cases, the waste pickers are still perceived as a social problem. They don't have the recognition to its environmental, social and economic contribution.

Some countries, such as Brazil with its national pickers movement, are adopting pioneering strategies to incorporate these professionals into their waste management models, becoming a reference for other countries and regions (Semear and Catação, 2013). Based on political action, manifestations, agreements and collaborative work, Brazilian pickers could reach their professional recognition. As a result, the policy of integrated waste management in the country brings some especial indications to their effective incorporation on the value chain.

Colombia's groundbreaking experience is also one that demands further analysis. The country had constructed several laws and orders associated to the integral waste management. In 2000, for instance, its was created the waste picker badge of honor, in a recognition to the work done by people who had distinction doing recuperation or waste recycling. A day for the waste picker and for recycling was establish one year before. In 2003, its was created an order (Order 1503/2003) to regulate the waste collection service; on this, the government affirms the waste pickers right to participate on this activities. The Colombian laws support the waste pickers to formalize their work guided on two solidarity conditions: organizations without profit and associations (Semear, 2015).

These advances are deposit to the efforts of a collaborative governance arrangement is being developed which involves the government, private companies, waste pickers and society. It is called Alianza Nacional para el Reciclaje Inclusivo (National Alliance for Inclusive Recycling), formalized in April 2014. This model is obtaining good results not only with recycling, but also with social inclusion.

Governance has been understood by different concepts. The emphasis pass by institutions, legitimacy and power (Rametsteiner, 2009). However, it also can be understood as a series of 'arrangements' among various actors, using collaborative approaches to seek problem solving (Kooiman, 1993). So, in more general terms, governance can be understood as the process through which actors collectively solve problems and face the needs of society.

Later, a new concept appears: the collaborative governance. Ansell and Gash (2008, p. 544) define collaborative governance as a "governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented, and deliberative and that aims to make or implement public policy or manage public programs or assets". It appears in the necessity of governments work with different stakeholders to deliver major projects and services to its communities.

According Donahue (2004), to consider a process of governance a real collaborative governance, its is necessary to observe at least eight aspects:

- Formality: not necessarily a collaborative relationship must be formal, institutionalized through formal contracts. It can operate through informal agreements or even tacit understandings. But, for the author, a minimum of formality seems increasingly imperative. This degree of formalism must be at least sufficient to permit objective descriptions of participants, procedures, and goals. This definition makes possible to distinguish collaborative governance from other categories of public-private interaction.

- Duration: long-lived collaborations seem more consequential, and hence more worthy.
- Focus: its is necessary to meet a single shared challenge, or a range of concerns common to the collaborating parties.
- Institutional Diversity: it is necessary to have a minimum level of diversity among the participating institutions. For instance: at least one public and one private player.
- "Valence": here, the author refers to the number of distinct players linked together in a collaboration and the number of links among them.
- Stability versus Volatility: for he, a collaboration is stable to the extent its members share a normative view of successful governance. In the other hand, volatile is related to the extent members' norms or interests diverge. “The less stable is the collaboration, the larger the share of its energies must be devoted to maintaining the collaboration itself” (p. 3).
- Initiative: it has relation to what instigate the collaborating among actors. Each of the collaborating actors must have some role in setting the goals of the collaboration.
- Problem-driven versus Opportunity-driven: it is necessary to observe the collaboration intention.

As affirmed by Alvarez et al (2016), several studies have highlighted the importance of governance in environmental. Inadequate governance may lead to over-exploitation and degradation of natural resources. On the other hand, sustainable management may increase organizational capacity and cooperation between individuals and institutions as highlighted by Ostrom (1990, 1999).

The main purpose of this paper is to comprehend how distinct organizations could work together to build and develop a waste management model that truly includes the informal waste pickers. This kind of investigation is important because the case can be considered a success in LAC region and therefore could be replicated in other parts of the developing word. The current investigation is being accomplished using a case study research methodology, based on interviews and data analysis.

2. Methods

This article is based upon qualitative methods. As the research topic is context dependent the use of a case study was considered ideal for data collection and knowledge generation (Hudson and Ozanne, 1988).

Primary data was collected during field visits, done in the process of the developing of a social technology: Paso Cierto Web Plataform. As Paso Cierto was construct thought the participation of different actors involved on inclusive recycling, it was possible to do interview and observation with Colombian actors. It also involved the observation and participation in three important Latin American meetings about recycling: (i) the Taller de Intercambio de Conocimientos (Workshop on Knowledge Exchange), in Peru, 2014; (ii) Expocatadores (Waste Pickers Exposition), in Brazil, 2014 and 2015; and (iii) Pregral (Preliminary Conference on Latin America Waste Management), in México, 2016. The field visits led to data collection of informal talks to representatives of IRR, Cempre and waste pickers, both men and women, from Colombia.

Secondary data also were collect, seeking for documents and websites that mention Alianza evolution.

3. Results

Please insert your Results text here. Text alignment is formatted as justified. The Results section can be combined with the Discussion section. In that case, name the section **Results and Discussion**. Tables, like Table 1, should have a self-explanatory caption placed above the table and should be referenced in the main text like in this sentence.

On April 22, 2014, the "Aliança Nacional para el Reciclagem Inclusivo" was signed as an initiative of the National Government, led by Ministerio de Vivienda, Ciudad y Territorio (Ministry of Housing, City and Territory). It aimed to promote the formalization and strengthening of recyclers at a national level, as a strategy for the social, technical and economic development of the use of solid waste; as well as to promote the development of a long-term public policy (Alianza Nacional, 2014).

The main goal of the governance process was to contribute to the knowledge and institutionalization of the Inclusive Recycling in Colombia. To reach this goal, the actor delimited the existent problems in three different dimensions:

- National level – Information systems; articulation for the implementation of public policies that contribute to an inclusive recycling.
- City level - tools for the implementation of urban systems of inclusive recycling.
- Recycler organizations - incidence in the PGIRS, adequacy as providers of the public cleaning service, business development for the commercialization of materials. They could also define the actions that would be developed by the group. Between then, there was the definition of technical criteria for the creation of the Observatório Nacional de Reciclaje (National Observatory on Recycling). This action was established to improve the information collection system about recycling. Other important activity was the accompaniment to the formulation of the Plan de Gestión Integral de Resíduos Sólidos – PGIRS (Integral Solid Waste Management Plan). The actor's objective was to strengthen the application of the PGIRS. It was also necessary to strengthening for the adequacy as providers of the public cleaning service and business development for the commercialization.

They also define to give technical advice in the formulation and execution of PGIRS programs, in accordance with Resolution 754 of 2014.

As expected results of this collaborative governance process they had: information systems, normative instruments to promote inclusive recycling, proposal and observations of the organizations of recyclers for the construction of the PGIRS, organizations of recyclers advancing in their suitability as providers of public cleaning service, and business development for marketing, tools for cities and organizations of recyclers for the implementation of urban systems of inclusive recycling (for instance: guide to formulating PGIRS, guide for Census of Recyclers, guide to turn organizations of recyclers into providers of public cleaning service, guide for the strengthening of organizations such as service providers, and materials marketers, guide to calculate costs and tariffs to the organizations of recyclers, according to the tariff methodology).

For reach these results, the actors determined some lines of action:

1. Encourage inclusive value chains

• Promote agreements for the use of solid waste, with the inclusion of formalized recyclers.

• Promote analysis of existing and potential markets for reusable materials.

• Stimulating technological innovation in industry in order to promote greater use of recyclable materials in their production processes.

2. Promote inclusive urban recycling systems

• Identify and promote strategies to formalize the recycling population, and to establish as public cleaning service providers.

• Promote actions in favour of the recycling population by the local authorities provided for in Decree 2981 of 2013.

• Identify the aspects that should be taken into account in the formulation and updating of the PGIRS and public cleaning service programs.

• Encourage and support comprehensive training activities for the recycling population and local authorities.

• Encourage the construction of a civic culture of Integral Management of Solid Waste.

3. Recycling Center:

• Design and implement a system for collecting, processing and analyzing national recycling information to be included in the variables report to measure progress in the inclusion of the recycler population, the level of utilization in the public cleaning service and the flow of materials recycled in the industry.

• Encourage research into recycling practices at national and international levels. • Support knowledge, experiences and formalization of recyclers and, use of waste as a business activity.

4. To strengthen the Organizations of Recyclers:

• Identify strategies for formalizing the recycling population to establish themselves as providers of public cleaning services.

• Encourage and strengthen organizations of recyclers and their access to social security.

• Promote and strengthen training activities for the recycling population.

• Promote an improvement of living and health conditions of the recycling population.

As initial results of this collaboration process, some goals are reached, in a process described by the director of Waste Pickers National Net as gains from “10 years in one”.

- Seminars and workshops to capacitation
- Creation of a national rule that obligate the municipalities to include the waste pickers on their waste management plans
- Establishment of the “right to receive” for services – recollection and transport (pioneering movement in Bogotá)
- Diagnosis of 25 waste pickers organizations – understand to give support on formalization and construction of business capacities
- Census realization in 2015: Bucaramanga (420 waste pickers), Popayán (327) and Valledupar (465)
- Ongoing activity: second National Study on Inclusive Recycling (42 municipalities; 850 questionnaires)
- Colombian’s laws support the waste pickers to formalize on two solidarity conditions: organizations without profit and associations

The analyses could observe the aspects pointed by Donahue (2004), permitting to consider a process of Alianza Nacional as a real collaborative governance:

- Formality: Alianza was formalized by Colombian government, throughout a memorandum signed by Ministerio de Vivienda, Ciudad y Território (Ministry of Housing, Cities and Territory), Ministerio de Ambiente y Desarrollo Sostenible (Ministry of Environment and Sustainable Development), Ministerio de Comércio, Industria y Turismo (Ministry of Commerce, Industry and Turism), Ministerio de Trabajo (Ministry of Labor), Asociación Nacional de Recicladores (National Association of Waste Pickers), CEMPRE, ANDI (Asociación Nacional de Indústrias/National Industries Association) and Fundación Avina, on April 22th of 2014.
- Duration: there is a clear long term on the collaborations proposal.
- Focus: the focus is specific and aim to meet a single shared challenge; the inclusive recycling promotion on a national level.

- Institutional Diversity: there is an important range of diversity between the organizations, with actors from public, private and third sector.
- "Valence": its was possible to notice an important number of distinct players working together in a collaboration proposal, and important links among them.
- Stability: the collaboration seems to be reach a shared view of the success of the goals.
- Initiative: each actor have some specific role to play in setting the goals.
- Problem-driven: the Alianza seeks to be a real problem-driven strategy.

Even though important results were found, it’s not possible to say at this moment of the investigation that the researchers now comprehend how distinct organizations could work together to build and develop a waste management model that truly includes the informal waste pickers. More interviews and data analysis are necessary.

4. Conclusions

Despite being an ongoing investigation, some initial findings have been determined: (i) the process to Alliance creation had a key stakeholder represented by IRR (Iniciativa Regional para el Reciclaje Inclusivo / Regional Initiative for Inclusive Recycling), that was also formed in a net governance process; (ii) the participation of CEMPRE (Compromiso Empresarial para el Reciclaje / Business Commitment for Recycling) was fundamental to guarantee the pickers empowerment; (iii) the Colombian government was open and receptive to help to design new structures to guarantee inclusiveness in the waste management process in the country; and (iv) there is a necessity for changes in the law and the creation of public policies to make the changes possible.

The main conclusion is the necessity of powerful and engaged stakeholders in the governance process having a unified approach to making a difference, involving win-win decision making leading to achievable environmental, social and economic gains. Further steps of the research will analyze the waste governance in other LAC countries, seeking to enhance the inclusion of waste pickers, using Colombia as the example case.

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The Management Effectiveness of Mico-leão-dourado Mosaic (Mosaico Mico Leão Dourado). RJ/BR

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Abstract

The Protected Area Mosaics (Mosaicos de Áreas Protegidas, MAP) are formed when there are Protected Areas (PA) in close proximity to each other or overlapped in a same territory, even if they are managed by different governmental or private scopes. They aim to improve the management of PA through ecosystem connectivity and also through an integrated and efficient management of both material and human resources of those areas. MAP are managed by councils formed by governmental and civil society entities from the territory. This study refers to Mico-Leão-Dourado Mosaic (Mosaico Mico-Leão-Dourado, MMLD), which has an area of 209,000 hectares, along 8 municipalities. It is composed by 5 Federal, 1 state and 13 private PA, and it's entirely located in Rio de Janeiro state, in a region of coastal lowland. Once it is the Golden Lion Tamarin habitat, this Mosaic has been formed in order to strengthen the integrated management among PA, in such a way to improve the species preservation. Being an instrument of public politics, it is crucial that the efficiency of Mosaics is analyzed and that the principle of continuous improvement is followed. This work intended to analyze the efficiency of Mico-Leão-Dourado Mosaic management, and such analysis has been performed through a protocol designed to this end. This protocol is qualitative and quantitative, presenting 46 indicators divided into 4 scopes: Governance, Management, Sociodiversity and Biodiversity. Each counselor assigns each indicator a score from 0-3: 0 (non occurrent), 1 (rarely occurs), 2 (usually occurs), and 3 (occurs a lot). The mean of each indicator is calculated and the T-Test is applied to verify the effectiveness of the indicator, taking into account those with a mean above 2. The number of effective indicators determines the scopes and mosaic effectiveness in a percentage, being 35% Not Effective, 36%-50% Low Effectiveness, 51%-75% Medium Effectiveness, and 76%-100% High Effectiveness. 39 indicators and 2 scopes were considered effective. From this 39 indicators, 19 presented low but effective means according to the T-Test. The two failed areas were Management and Sociodiversity. The indicators ranged from 76%-100%, but the scopes from 36%-50%, so, we have classified MMLD as a MAP with a Medium Effectiveness, which effective areas were Governance and Biodiversity, requiring greater attention to the Management and Sociodiversity of the territory. In order to do so, it is necessary for the Mosaic Management Council to pay more consideration to issues involving local populations, as well as to provide a better dissemination of the MMLD to them and integration with the public management bureaus that influence the territory. MAP are examples of collaborative governance of the territory, integrating the Government and civil society, so, its proper functioning is crucial for the sustainable development of the territory and protection of both local communities and biodiversity. The study shows how a truly integrated work between government and society, with divided responsibilities and decision power is essential to build scenery of efficient collaborative governance.

Keywords: Mosaic, collaborative governance, management effectiveness.

1. Introduction

Mosaics are an environmental public policy instrument, formed when there is Protected Areas (PA) in close proximity to each other or overlapped in a same territory. Then, they are a group of protected areas that exists in the same territory that agree in work together and help each other to reach their creation reasons. This mutual help occurs by sharing material and human resources in execution of joint operations for environmental oversights or educational activities for example. The mosaics also include the local communities in their environmental management, promoting the discussion about their conflicts with the protected areas, or the changes in the territory that menaces their traditional culture and lifestyle. The Brazilian law for protected areas (Brazil, 2000) gives the definition of mosaics of protected areas (MAP) in their chapter IV, article 26: “When exists a group of protected areas of the same or distinct categories, near or overlapped, public or private, constituting a mosaic, their management will be done in an integrated and participative way, considering their distinct conservation aims, making compatible the presence of biodiversity, the appreciation of sociodiversity and the sustainable development in a regional context.”. MAP are managed by councils formed by governmental and civil society entities from the territory and are officially created by an Environment Ministry act. Is the mosaic role to work as an improving instrument for the protected areas management, and also work as a privileged forum to discuss the conflicts between traditional communities and government, represented by the protected areas managers (Costa, 2015).

In Brazil we have 22 mosaics of protected areas. This work refers to Mico-Leão-Dourado Mosaic (Mosaico Mico-Leão-Dourado, MMLD). The MMLD has an area of 209,000 hectares, along 8 municipalities. It is composed by 5 Federal, 1 state and 13 private PA, and it’s entirely located in Rio de Janeiro state, in a region of coastal lowland. Figure 1 shows the mosaic’s location.

Once it is the Golden Lion Tamarin habitat, this Mosaic has been formed in order to strengthen the integrated management among PA, in such a way to improve the species preservation. The MMLD council is formed by twelve counselors, being six from public protected areas and other government institutions and six from civilian organizations as NGOs, private protected areas owners, land owners, researchers and business representatives, and it has periodic meetings each four months. The main issues in MMLD council meetings are local environmental licensing, forest recovery and restoring, and promoting sustainable nature tourism in private protected areas.

The aim of this study was to verify the Mico-Leão-Dourado Mosaic management effectiveness, identify its mains opportunities and challenges, and propose project ideas and activities to improve their actions to meet their creation reasons.

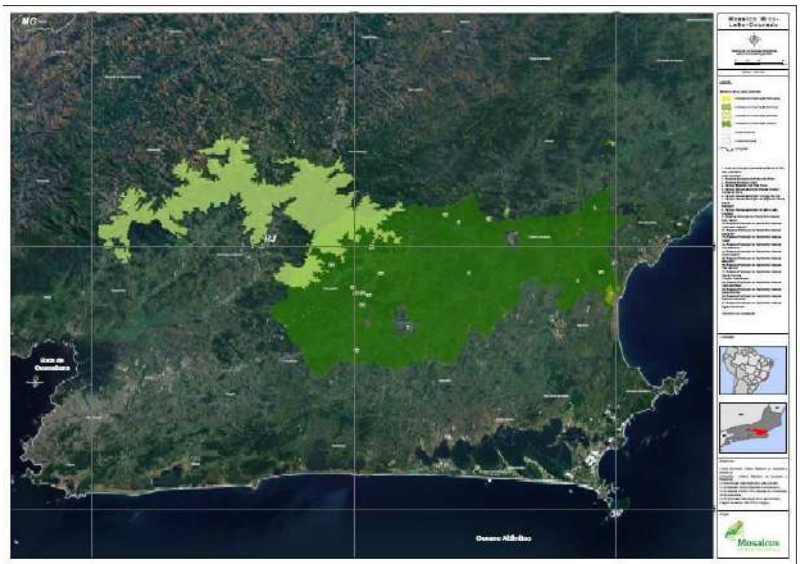

Figure 1. *Mico-Leão-Dourado Mosaic’s location in Rio de Janeiro state, Brazil.*

2. Methods

The mosaic's management effectiveness was evaluated by using a protocol developed by Gidsicki (2013) and adapted by Hermmann and Costa (2015). This protocol makes an evaluation both qualitative and quantitative, using 46 indicators divided in 17 criteria, 8 principles and 4 main scopes. These scopes are Governance, Management, Sociodiversity and Biodiversity. Figure 2 shows the protocol structure. The whole protocol can be seen in the appendix.

The effectiveness is determined by the indicators grade. Each mosaic's counselor grade the indicators from 0 to 3, being 0 (non occurrent), 1 (rarely occurs), 2 (usually occurs), and 3 (occurs a lot), or NA (no answer). The final indicator's grade is given by the mean of all counselors grade. Indicators with final grade ≥ 2 were considered effective.

The protocol was applied in a regular council meeting at 2016's march 30th, with the presence of eight counselors. Because the low number of counselors who answered the protocol, the Student's T Test was used to verify if indicators with grade under 2 could be effective. Those were labeled low effectiveness indicators.

The number of effective indicators determines the criteria, principles, scopes and mosaic effectiveness in a percentage, being 0-35% Not Effective, 36%-50% Low Effectiveness, 51%-75% Medium Effectiveness, and 76%-100% High Effectiveness.

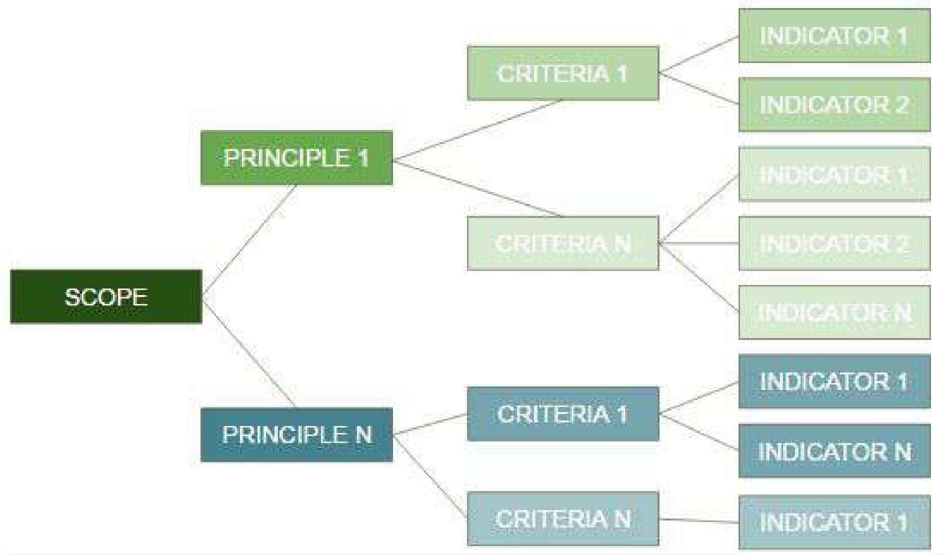

Figure 2. *Structure for the protocol for mosaic's effectiveness evaluation.*

3. Results.
We had 39 indicators, 12 criteria, 4 principles and 2 scopes considered effective. In those 39 indicators, 19 showed low effectiveness, with mean value under 2. The results were separated by scope.

<u>Governance</u>

The governance scope addresses the norms, arrangements and institutional organization that regulates and supports the mosaic for the territorial management. It evaluates if the mosaic has a structured and representative council, if its inner and outer communication is effective, and if it has autonomy to intervene in the territory environmental issues.

In this scope we find effectiveness in 15 indicators, 6 criteria, and 1 principle. The scope itself were considered effective. Four indicators and two criteria showed low effectiveness.

Table 1. *Parameters Effectiveness for governance scope in Mico Leão Dourado Mosaic.*

Parameter	N Total	N Effective	% Effective
Principles	2	1	50%
Criteria	7	6	85,7%
Indicators	18	15	83,3%

Results show that in overall MMLD is capable of realizing an integrated management. All indicators that refers to the structure and representativity on the mosaic's council were considered effective, although the communication with other important regional social figures and society in a general way showed values under 2. The council also seems to be effective to solve conflicts about land use, and to implement their decisions. The monitoring of the outcome of those actions were another indicator that showed low effectiveness and needs improving.

The non effective indicators were the ones about the council's influence in decision government instances, as municipalities, or state government. It shows the necessity of improving the communication with the environmental agencies. The same goes for one indicator that asks if the mosaic is considered in development policies though for the territory, that showed low effectiveness. Those indicators low grades were the key for the non effectiveness of one of the two principles in this scope.

<u>Management</u>

The management scope is about the mosaic's planning and maintenance. It evaluates if there is a long term integrated planning and if it's followed by the PA teams. It also verifies if the mosaic strengthens the protected areas, and if it has operational and economic resources and mechanisms to keep functioning.

The management scope showed curious results. Although 13 of their 15 indicators were considered effective, the scope itself was not. The reason is that 9 of those 13 effective indicators presented low effectiveness, resulting in the scope non effectiveness.

Table 2. *Parameters Effectiveness for management in Mico Leão Dourado Mosaic.*

Parameter	N Total	N Effective	% Effective
Principles	3	2	66,6%
Criteria	6	4	66,6%
Indicators	15	13	86,6%

The mico leão dourado mosaic is establishing as a strong support to their protected areas, especially the private and small ones. Also The PA managers cooperate for the maintaining of this support mechanism.

The main problems are about long term planning and financial resources to keep the mosaic functioning. The high number of low effectiveness parameters show that the mosaic is on a right path, but needs a lot of improving, especially in those two aspects.

Another interesting factor is that the indicators about the mosaic planning presented a big number of “not answering” instead of a grade by the counselor. It shows that the counselors have a difficulty in comprehending the difference in short term planning and long term planning. The appropriation of the mosaic’s planning contents by the counselors is essential , not only for a good managing, but for a truly integrated and participative territorial managing, where everyone are aware of the subjects and has equal capacity in opinion about the mosaics decisions and actions.

Sociodiversity

The sociodiversity scope approaches the appreciation and conservation of the cultural diversity in the territory. The practices that value the different traditions and ways of living and interacting with nature, giving the territory its identity. This scope verifies if the mosaic support the traditional native populations and communities within its limits. It also evaluates if it stimulates sustainable practices and ways of income generation for those people which are consonant with natural conservation and supports the creation of a territorial identity between those groups.

Table 3. *Parameters Effectiveness for sociodiversity in Mico Leão Dourado Mosaic.*

Parameter	N Total	N Effective	% Effective
Principles	2	0	0
Criteria	2	0	0
Indicators	6	4	66,6%

This scope presented as non effective. And all the four effective indicators had mean values under 2.

The non effective indicators refers to the importance given to the territory’s historical and cultural identity. The indicators with low effectiveness were about policies that favor conservation, the support to sustainable economic activities, and the acknowledgement of the local populations about the advantages of being part and participating in the mosaic.

There is no register of indigenous or quilombola populations in MMLD territory. Even so, it would be possible to value the familiar farming and bring people from land reform settlements to participate. It would contribute to improve the indicators with low effectiveness, reaching a greater number of local communities. A bigger effort from the mosaic’s council to stimulate the territory development through sustainable practices, as ecological tourism in private nature reserves and ecological agricultural practices in local farming populations is the key to consolidate the objectives of this scope.

Biodiversity

The biodiversity scope verify the practices of environment conservation, species protection, ecosystems connectivity and environmental services. It evaluates if the mosaic has actions on biodiversity protection, the main function of protected areas and consequently the mosaic’s.

This scope and all its principles, criteria and indicators were effective. Only two of seven indicators showed low effectiveness.

Table 4. *Parameters Effectiveness for biodiversity in Mico Leão Dourado Mosaic.*

Parameter	N Total	N Effective	% Effective
Principles	2	2	100%
Criteria	7	7	100%
Indicators	18	18	100%

The MMLD fulfil its role on ecosystems protection and promoting researches and endangered species preservation in the territory. That because the region is the habitat of the golden lion tamarin, specie who gives name to the mosaic, and reason for the creation of several local protected areas.

Results show the need of accomplishing more environmental education activities, and having a better dialogue with environmental agencies to support the creation of more protected areas. The territory is already known for the high number of private protected areas.

<u>The Mico Leão Dourado Mosaics Management Effectiveness</u>

The Mico Leão Dourado Mosaic resulted effective in two scopes, four principles, twelve criteria and thirty nine indicators.

Table 5. *Effectiveness for all parameters in Mico Leão Dourado Mosaic.*

Parameter	N Total	N Effective	% Effective
Scopes	4	2	50%
Principles	8	4	50%
Criteria	17	12	71%
Indicators	46	39	85%

The indicators indicate high effectiveness, the criteria medium effectiveness, and the scopes and principles the upper end of low effectiveness. Since half of the effective indicators showed grade under two, the MMLD can be classified as having medium effectiveness.

According to Gidsicki's (2013), the medium effectiveness range indicates the the mosaic possess the mechanisms indispensable for the management. It shows effectiveness in governance and biodiversity, but has some serious problems in management and sociodiversity. Those problems makes necessary moe dedication to establish integrated activities in these two late scopes.

The MMLD is well structured and functioning, being efficient in protecting biodiversity and integrating the protected areas and their teams. An improvement in the aspects which showed a low effectiveness would probably be enough to take the mosaic from the actual range to a condition of high effectiveness.

However, for this improvement, is essential that the mosaics council pay more attention to issues involving local farming populations and the local identity. It's also essential to better publicize the mosaic and its actions, and enlarge the dialogue with governmental institutions that have much territorial influence.

4. Discussion

From the identified weakness were elaborated proposals to strengthen the MMLD. These proposals take into account the current scenario in environmental politics in Brazil and in Rio de Janeiro State. The presentation is divided between the scopes.

Table 6. *Proposals to strengthen the governance scope.*

Need	Proposal
Enforce the mosaic participation in local environmental policies.	Signing of a commitment document between municipalities, state and federal environmental entities, recognising the mosaics importance and committing to cooperate. This cooperation can be supporting joint activities, and recognising and accepting the mosaic as a legit destination of resources for projects execution.
Sending, by the mosaic, of projects that aim the execution of the long term planning for state and municipal environmental councils, to get financial resources.	
Increase participation of local communities on mosaics council.	Execution of project for environmental awareness, that identifies the population groups in the territory, and how to approach them. The project should also publicize the mosaic to increase local participation.
Improve communication with local population..	
Improve the mosaics council internal communication.	Establish standard communication procedures for internal communication, keeping counselors always aware of what’s happening in the territory, and de the mosaics activities.

Table 7. *Proposals to strengthen the management scope.*

Need	Proposal
Maintenance of a professional team for secretariat.	Seek financial support with the entities signing the commitment document. Insert the secretariat costs in other projects for execution of planning.
Organization of joint activities involving institutions other the protected areas.	Elaboration of proceeding manuals for the different kinds of activities executed.
Elaboration of long term planning.	Having a special group of counselors responsible for the elaboration of the long term planning and its monitoring by the mosaics council. If necessary seek financial support for hiring consultants to this task.
Keeping track of execution of the long term planning.	

Table 8. *Proposals to strengthen the sociodiversity scope.*

Need	Proposal
Knowing the territory's sociodiversity	Can be done in the same project designed for environmental awareness in governance.
Approaching local communities and publicize the mosaic.	

Knowing local policies for sustainable development that can be supported by the mosaic.	Having a special group of counselors responsible for studying municipal laws and policies, and identify the ones that can fit the mosaics purpose.

Since the biodiversity scope were highly effective, no proposals were elaborated. The indicator about environmental educative actions need improvement, but it can be done by the same project set for the sociodiversity and governance scopes.

An issue that must be discussed is the mosaic secretariat. All mosaics of protected areas include it in their regiments, and they have the mission of organize meetings, and organize, systematize and disseminate the materials and decisions produced by the mosaic, in its general meetings or by its coordination, special groups or taskforces. Also, the secretariats function as a cheer unit, avoidind counselors losing interests in the mosaic and skipping meetings. Is common knowledge between all the mosaic counselors that an active secretariat is fundamental for the mosaics well functioning.

The problem here is the lack of financial resources to pay the secretariat, even if it's a small staff. The governmental agencies don't have enough staff so they could assign an employee for this task. The immediate solution would be include the secretariat costs in projects related to the mosaic. It could be inserted in environmental awareness, communication and education projects, where it would be simpler to include the activities of the executive secretariat as a product.

Other important proposal for the mosaic strengthening, is the signing of a commitment term or document between the governmental entities responsible for the protected areas that are part of the mosaics. In the procedures for the creation of a mosaic, these institutions must express their support, but this does not create any kind of bond or obligation with the mosaics management. The signature of a commitment term would serve as recognition by these entities that the mosaic is an important conservation tool and a commitment with their management and operation support.

At the present time, it is not possible to require from government the maintaining of a secretariat staff. But they can recognize MAP as eligible figures for project submission in municipal and state environmental funds. They can also support the continued education of their protected areas managers in mosaic and participatory management, including the establishment of partnerships between themselves (federal, state and municipal governments involved) to make those initiatives viable.

5. Conclusions

The mosaics of protected areas are conservation tools that unite government agencies and society in the same arena to discuss the territory. Both sides must assume their responsibility with the maintenance of this tool, acting transparent and in a cooperative way, otherwise, the challenges faced will hardly be defeated.

According to brazilian law, the mosaics exist to execute an integrated and participative management of a group of protected areas that are close or overlapped. Value the participation of local populations is a way to reinforce the relation between these communities and the protected areas. It makes the mosaics the ideal discussion space to promote this conciliation.

Here lies the importance of a structured secretariat and its continuous functioning. Without their efforts to accomplish the interinstitutional articulation, the mosaic stops working. So is easy to see that it has a big influence in the mosaics capacity to fulfil their objectives in bio and sociodiversity conservation. The secretariat maintenance should be the council focus, for the guarantee that the other works keep happening. However, it cannot be a responsibility only for the government or civil entities representations, being multi sectoral partnerships the better way now to achieve efficiency in all mosaic scopes.

The mico leão dourado mosaic accomplish its task in supporting the local protected areas, and integrating some of their activities, but still lacks popular participation. It would be a main secretariat function, identifying the groups that should be on mosaics council and making the first contacts for their integrating. So we can see how a management problem can affect the results in other scopes.

This work shows a different way we are trying to make nature conservation in Brazil, putting together government and civil society. It still needs some adjustments for a perfect functioning, but in the right path that could be replied or even improved by other latin american countries in search for an equal appreciation of their biological and social diversity. The study presents a systematic evaluation of the execution of a public policy, something never made for this mosaic, showing ways it could be improved. All mosaics in Brazil would benefit by passing for this process and having tools for improving their actions and strategies for conservation. This is part of a bigger study that evaluated also other four mosaics in the state of Rio de Janeiro, and for the future those mosaics should be followed close for periodic evaluations and monitoring of their evolution.

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Appendix

Protocol for Evaluation of Mosaics Management Effectiveness (Hermmann & Costa, 2015).

GOVERNANCE	
PRINCIPLE 1. The mosaic has tools to promote integrated and participative management.	
CRITERION 1. The mosaic has a council dedicated to its management.	
INDICATORS	GRADE
1.There is an internal normative that guides the council's actions	
2. The council has regular meetings.	
3. The council meetings count with at least 60% of all counselors.	
4. Issues presented at council meetings are addressed and / or resolved	
CRITERION 2. The mosaic council has a functional management support structure.	
5. Thematic or special work groups solve the mosaics priority issues	
6. The Secretariat, or similar structure, provides technical, administrative and operational support to council	
CRITERION 3. The mosaic council promotes integration among the various social groups in the territory	
7. The council invites other social groups from the territory to participate in discussions and on the development of actions	
CRITERION 4. The mosaic has adequate tools for internal communication and dissemination of its actions	
8. The mosaic council has adequate ways for internal communication	
9. The mosaic communication with the interested society is efficient	
PRINCIPLE 2. The mosaic has mechanisms to deal with the complexity of the environment and of the institutions, addressing, directing and accompanying the solutions.	
CRITERION 5. The council is representative	
10. The main social group from the territory (indigenous, quilombolas, governments, NGOs, universities, business, tourism, farmers, among others) are represented in the council	
11. Counselors are legitimate representatives of their sector, responding to the positioning and demands of whom they represent.	
CRITERION 6. The mosaic council has the autonomy to address, solve and follow the main issues	
12. The main decisions taken by the council are implemented	
13. The mosaic helps the protected areas to solve conflicts related to the use of land and natural resources	
14. Mosaic acts in the licensing processes in the territory	
15. The mosaic council influences the allocation of resources from environmental	

compensation	
16. The mosaic council monitors the results of its interventions and proposals in the territory	
17. There are formal documents and agreements between the protected area management institutions that enable the execution of integrated actions	
CRITERIA 7. The mosaic council influences sectoral public policies established for its territory	
18. The presence and objectives of the mosaic are considered in programs and policies for local development in the territory	
MANAGEMENT	
PRINCIPLE 3. Mosaic actions are planned, executed and monitored in an integrated way	
CRITERION 8. Protected area teams are committed to shared mosaic management	
19. Managers of protected areas meet to discuss the mosaic, in addition to council meetings	
20. Protected area teams act in an integrated way in mosaic actions	
CRITERION 9. The mosaic has planning tools built in an integrated and participative way	
21. The mosaic has a long term planning	
22. The actions defined in the long term planning are consistent with the objective of the mosaic	
23. The goals and indicators from the planning are periodically monitored by the Mosaic Council	
24. The work plan, or plan of action, of the mosaic is based on the long term planning	
25. Strategic planning takes into account other territorial development plans	
26. The long term planning is articulated with the protected areas planning	
CRITERION 10. The mosaic executes the planned actions in an integrated way	
27. There are administrative procedures (with definition of tasks and responsibilities) for the implementation of integrated actions	
28. Institution teams, in addition to the managers of protected areas, invest time and other resources with the shared management of the mosaic	
PRINCIPLE 4. The mosaic has the necessary financial and operational mechanisms to carry out the actions	
CRITERION 11. The financial mechanisms meet the needs of the mosaic	
29. Protected areas budget provides financial resources for integrated actions	
30. The mosaic relies on various forms of raising funds to meet the demands	
CRITERION 12. Operational mechanisms meet the demands of the mosaic	
31. Integrated mosaic actions are incorporated into the protected areas planning tools	
32. Protected areas infrastructure, personnel and equipment are shared for integrated mosaic actions	

PRINCIPLE 5. The mosaic contributes to the achievement of each protected area objectives	
CRITERION 13. The mosaic strengthens the management of its protected areas	
33. There are instruments of cooperation between two or more protected areas that strengthen the operational capacity of both	
SOCIODIVERSITY	
PRINCIPLE 6. The mosaic contributes to the territorial strengthening, the valorization of the regional culture and traditional techniques of sustainable use	
CRITERION 14. The mosaic strengthens the local territorial identity	
34. The mosaic promotes actions for the valorization of traditional techniques for the sustainable use of natural resources	
35. The mosaic has strategies to promote historical, cultural and natural aspects, strengthening territorial identity	
36. Counselors and community members recognize the territorial identity of the mosaic and the advantages of participating in it	
PRINCIPLE 7. The mosaic contributes to the development of a strong regional economy based on the sustainable use of natural resources	
CRITERION 15. Strategies to support conservation and sustainable development are set out in the mosaic	
37. The existence of the mosaic contributes to the establishment of policy instruments and financial support for sustainable actions	
38. The mosaic encourages sustainable economic activities, such as ecotourism, plant extractivism, contributing to income generation	
39. Mosaic planning seeks to encourage sustainable socio-economic activities committed to the development of traditional populations	
BIODIVERSITY	
PRINCIPLE 8. The mosaic promotes the connectivity of ecosystems, contributing to the expansion and conservation of biodiversity and other environmental services provided by them	
CRITERION 16. The mosaic has mechanisms that contribute to the conservation of ecosystems	
40. Mosaic planning seeks to identify priority areas and actions for the restoration and / or maintenance of ecological processes	
41. The mosaic encourages the creation of new protected areas, especially in underrepresented ecosystems	
42. The mosaic contributes to the protection of springs, springs and river basins	
CRITERION 17. The mosaic develops specific actions directed towards the conservation of biodiversity	
43. The mosaic implements joint measures for the protection and recovery of rare, endemic, threatened or reduced species by various pressures	
44. The mosaic develops integrated monitoring and protection actions that assist in the conservation of biodiversity and natural resources	
45. The mosaic develops research programs on biodiversity conservation and restoration of ecosystems in an integrated way	

46. The mosaic promotes integrated actions of environmental education and awareness that stimulate the conservation of natural and cultural resources	

Toward Inclusive and Collaborative Climate Change Governance at the Municipal Level in Costa Rica

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Abstract

In 2007 Costa Rica was the first country committing to become carbon neutral. Two years later it developed its National Strategy for Climate Change and has since generated significant efforts aimed to governmental institutions and the private sector; however, advancements at the local level remain scarce, fragmented and poorly supported, particularly limited by the technical and organizational capacity that local governments have in leading mitigation and adaptation strategies within their territories. Since climate change is a multi-level, multi-sector and multi-term challenge, it asks for a different public governance style, with a higher commitment with civil society and the private sector, and with enhanced human capacities for the collective action. Supported by a research and extension project since 2011, several municipalities have been engaging in the development of collaborative and more inclusive climate change strategies within their territories in tune with local businesses, institutions, and civil society. The main purpose of this project is to support and document the process taken by our different case municipalities in developing and implementing their local strategies, and thus, supporting other local governments in developing their own. For this, the research team has been following a participatory action research approach with three local governments over several years, and during 2016 a structured survey was also conducted to the 81 municipalities of the country regarding the incorporation of the climate change topic into their municipal governance. General results are presented with an analysis of the perceptions from the nation-wide survey; then, with the help of the three cases studied, we explain the process taken in the adoption of such strategies and the challenges emerged. We found that in spite of the existing concern about the climate issue, appropriate mechanisms and information are lacking to enable its more efficient adoption in local governance. Therefore, we conclude that in order to adequately address the issue of climate change in an inclusive and sustainable manner, local governments are required to develop both internal and external capacities —beyond good administrative management— to allow a collaborative interaction with the actors involved, in order to generate and maintain their recognition, involvement, and commitment. Is evident that this project supports an alternative collaborative governance model, through the enhancement of individual and social local capacities leading to a more systemic commitment for collective climate action. This action requires transcending voluntary and isolated initiatives, leading the way to planned, and politically supported mitigation and adaptation strategies for inclusive development.

Keywords: civil society, community participation, inclusive climate action, local government, public administration.

1. Introduction

During the last years, Costa Rica has been managing an active agenda, both national and international, on the issue of climate change (hereinafter CC). In 2007, it acquired a commitment to become a carbon neutral country by 2021. Two years later, it launched a National Climate Change Strategy, which defines the carbon neutrality of the country and reaffirms itself at the international level the commitment to convert the country into a carbon neutral economy, a goal that is still maintained by the current government (Gutierrez, 2016). Due to the commitment made, Costa Rica began working focused on a mitigation strategy, mostly to reduce greenhouse gas (GHG) emissions from the private sector. The year 2013 was characterized by advances in the development and formulation of several Nationally Appropriate Mitigation Actions (NAMA) in various productive industries, with an increasing incorporation of the private sector into the carbon neutrality efforts (Jimenez, 2016) and a low emissions development and climate resilient strategy, mainly with the elaboration of technical guides (Corrales, 2013). At the international level, in the Paris Agreement (2015), Costa Rica presented its Nationally Determined Contribution (NDC), which set the goal of reducing emissions by 25% by 2030 with respect to the year 2012, and to seek the decarbonization of the economy by the end of this century (Gutierrez, 2016).

This set of public policies and initiatives in CC has allowed the generation of various efforts; however, these have been geared mainly toward the private sector or to centralized public institutional, but little at the local level where municipalities have been sparsely encouraged to work specifically on CC in a holistic way. Despite international efforts on this area, such as those lead by the Compact of Mayors, for example, along with a limited number of specific tools to support municipalities in tackling the issue, locally some governments have shown interest and have begun to seek alliances with other actors to incorporate the CC topic into local actions, but there is still little documented and available information on specific initiatives developed here.

According to UNDP's annual report (2014), CC is one of the most pressing issues on the global agenda for development. This asks for a different style of governance in order to overcome the obstacles of global arrangements, including the absence of enforcing mechanisms either at the international or national levels (e.g., Somanathan et al., 2014, Polhmann, 2011). It is required a more systematic engagement with civil society and the private sector, and the strengthening of human capacities for collective action to address climate adversities. Local collaborative governance arrangements or collaborative processes are proposed as alternative options for public policy decision-making and management, where different processes and structures help engage stakeholders from public, private and social sectors in a constructive form to address complex issues such as climate change (Ansell & Gash, 2008; Emerson et al., 2011).

Local collaborative governance is key to address CC for several reasons. First, most concrete actions are executed and the effects are felt at this level (e.g., Tanner et al., 2009); thus, addressing CC is a covering umbrella to address the socio-environmental issues that are dealt with by local governments (Dodman, 2009); thus, an opportunity to articulate the different agendas of waste, water management, mobility, risk management, reforestation, energy efficiency, and others (e.g., Lutsey & Sperling, 2008; Jones et al., 2000). In this regard, local governments have many tools at their disposal for implementing climate policy such as land use planning, residential and commercial regulations, solid waste management, transportation ordinance (Betsill & Bulkeley 2006; Kousky & Schneider, 2003). According to Rosas et al. (2012), institutions and local governments can contribute to reducing emissions (mitigation) or increasing the capacity to adapt to climate change and to climate variability; however, this requires a strengthening of institutional capacities. Second, local governments want and can contribute from their local sphere to the international and national commitments. According to a recent civil society survey, which examines the three most important aspects of implementing the NDCs in Latin America - proposed by each country at COP 21 in Paris - the third point of importance is to work with local governments (Pre-survey to the Regional Seminar on Climate Change for Civil Society Organizations of Latin America 2016). Third, constructive collaborations require according to Ansell & Gash (2008) face-to-face dialogue, trust building, and a shared understanding, factors that are often more easily accomplished at the local level. Similarly, Ostrom et al. (2009) point out that there are higher chances of success to overcome the free rider problem given the nature of common-pool resources, in local settings with lower negotiating cost as a result of higher trust, organization, and leadership.

Although in Costa Rica the incorporation of the CC topic in the municipal governance has been progressive, voluntary, and by the particular interest of some local governments without the mediation of an explicit national policy, it has been influenced by the environmental history of the country over the last several decades, following the conclusion of Sippel & Jenssen (2009), that the national framework conditions is an important determinant of local CC governance. For example, the Integral Waste

Management Law (2010) mandates local governments to promote the creation of an environmental management unit responsible of coordinating such processes (Programa CYMA, 2012, p.17). Another example is Executive Decree No. 36499-S-MINAET-2011, which mandates the develop of an institutional environmental management plans (PGAI) on each entity of the public sector (MINAE, 2011). However, according to the report of the Directorate of Environmental Quality Management (DIGECA, 2016), only 50 local governments had delivered this plan, out of a total of 90 (including 9 District Councils). In addition, the Municipal Performance Index made of 61 indicators, only considers some aspects of environmental management, and does not considers aspects or indicators related to climate action (CGR, 2016). Finally, in 2015 the Blue Flag Ecological Program created a new category directed to certifying municipalities. In its last report 16 municipalities showed as participants (PBAE, 2015), although is too soon to evaluate their performance.

Regulatory, administrative and market incentives have allowed a greater incorporation of environmental and climate related variables in the functioning of public institutions, also influencing the generation of initiatives in local governments. However, for climate management to be in line with national and international commitments, it is necessary to transcend voluntary efforts, and provide political and economic support for local climate action. Vasconcelos et al. (2013) even suggest that an approach with local institutions punishing free-riders will promote the emergence of widespread cooperation. Thus, the main purpose of this project is to support and document the process taken by our different case municipalities in developing and implementing their local strategies tackling climate change, with the aim to support other local governments in developing their own. In this article, we first present an analysis of current perceptions about the incorporation of the climate change topic into the municipal governance considering all the municipalities of Costa Rica; then, we analyze in a more specific way, the approach taken in three municipalities where the research team has been carrying-out the project. Before that, we present the general methodological approach.

2. Methodology

The study has a qualitative research approach. Initially, we present and analyze the efforts that local governments throughout the country have been carrying out in recent years; for that purpose, a questionnaire was designed taking as reference the studies of Molina-Murillo (2013) and Vignola and IPN (2010). The questionnaire was administered via the Internet through the platform SurveyMonkey.com with an additional effort through telephone calls. The information was obtained from all the 81 municipalities of Costa Rica between November 2015 and May 2016, which was mainly supplied by environmental managers or mayors themselves. In general terms, the questions used in the survey referred to levels of concern and responsibility about climate change and its effects, state of local impacts and actions to mitigate or adapt to climate variability and change, as well as the state of knowledge and progress in the development of local climate policy. Once the data were collected, it was recorded in Microsoft Excel for follow-up analyses.

Regarding the case studies, the research team has been following a participatory action research approach over several years with the municipalities under study —San Rafael (2011-present), Grecia (2012-present), and Belen (2014-present)— denominated: "participatory strategies for climate change at the local level". This approach allows to work the issue of CC in a comprehensive manner. The execution and analysis involves a mixed-methods approach that combines many field visits, personal interviews, participant observations, analysis of records, stakeholder workshops, teaching activities, development and execution of projects, participation in fairs, and others. The municipalities (counties) included in the study present differences in their economic, social, and environmental settings; however, they all showed high self-interest in participating in the project. After this contextualization, we discuss the component of local governance and participation based on the dimensions reported by Rosas et al. (2012) on the institutional capacities of local governments to address CC. We point general challenges and opportunities to strengthen local climate governance.

3. Results and Discussion

3.1 An overview of the integration of climate change aspects into local governance in Costa Rica

In recent years, the issue of CC has become more relevant in social spheres because of the availability of information and its perceived impacts. Thus, 85% of the staff consulted indicated being very familiar or familiar with the concept. When asked about the level of concern about the possible consequences of climate change in the territory of its local government, in the first place and with 83.5% the problems of water scarcity are mentioned. Infrastructure problems for water supply and potability, pollution, and increased demand, are linked to the effects of droughts that in recent years have occurred in much of the country, this being the second climatic effect of concern by municipal officials. **Figure 1** below shows the negative impacts that these effects can produce such as loss of agricultural productivity, disappearance of biodiversity, diseases and others. Although it is still worrying, it is particularly noteworthy that the consequences on public infrastructure are not yet a major concern in local governments, a key aspect of their management and responsibility in Costa Rica.

Figure 2 shows that the management of local governments is primarily focused on land use planning, which is the priority action for more than a third of municipalities (38%). This aspect should concern us if we consider that 62% of the municipalities do not have an official land use management plan (Programa Estado de la Nación, 2014). The same report indicates that management of solid wastes and providing water in good quantity and quality are elements that the population perceives as services that local governments are responsible to attend given their greater involvement and control over them. Although management of the above-mentioned aspects is linked to climate actions, at least at present, only one tenth of local governments prioritize the issue of climate change, placing it in fifth place in the list of priorities.

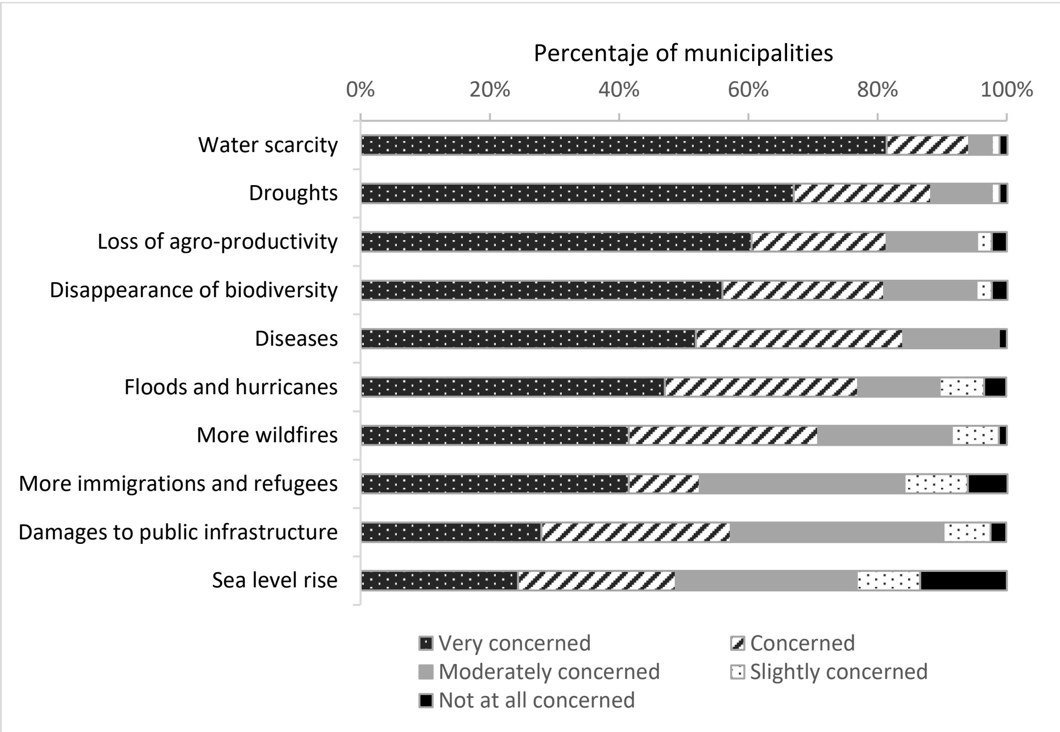

Figure 1. *Level of concern with possible consequences of climate change in the territory under local government management.*

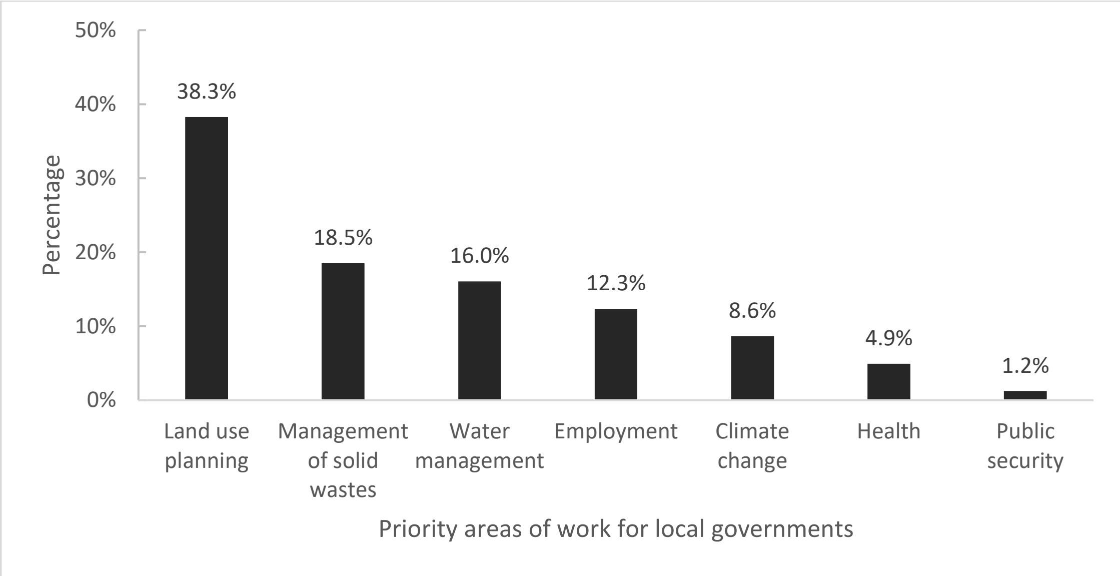

Figure 2. *Priority themes where local authorities (municipalities) in Costa Rica consider they should pay more attention.*

Of the total staff consulted, it is encouraging that 90% of them consider that it is the municipal responsibility to reduce the negative effects of climate change; although they stated that this responsibility is shared mainly with national governments but also with communities and individuals. Given the strategic positioning of municipalities between national governance institutions and local organizations and citizens, it is necessary to strengthen mutual cooperation mechanisms to translate global and national policy to local territories and their inhabitants. In this sense, only 64% of respondents indicated being knowledgeable with national climate change policies that promote and encourage their work at the local level.

Among the actions currently being carried out by the municipalities, three out of four of them already have a municipal recycling program that includes a separation facility, and also, they actively promote actions to avoid flooding through drainage, cleaning campaigns, or prohibition of constructions in the margins of rivers or other zones of protection. In general, of the 10 actions considered, only one third of the municipalities are implementing more than five of them. Unfortunately, only 21.3% of municipalities have a CC commission (or its equivalent) and 18% have carried out an inventory of GHG emissions (see **Figure 3**), essential activities, and often the starting point, to plan appropriately any local climate strategy. Consequently, 56% of the municipalities do not have a CC strategy at all, 37% are in the process of developing one, and only 7% of them —5 municipalities— have it formalized.

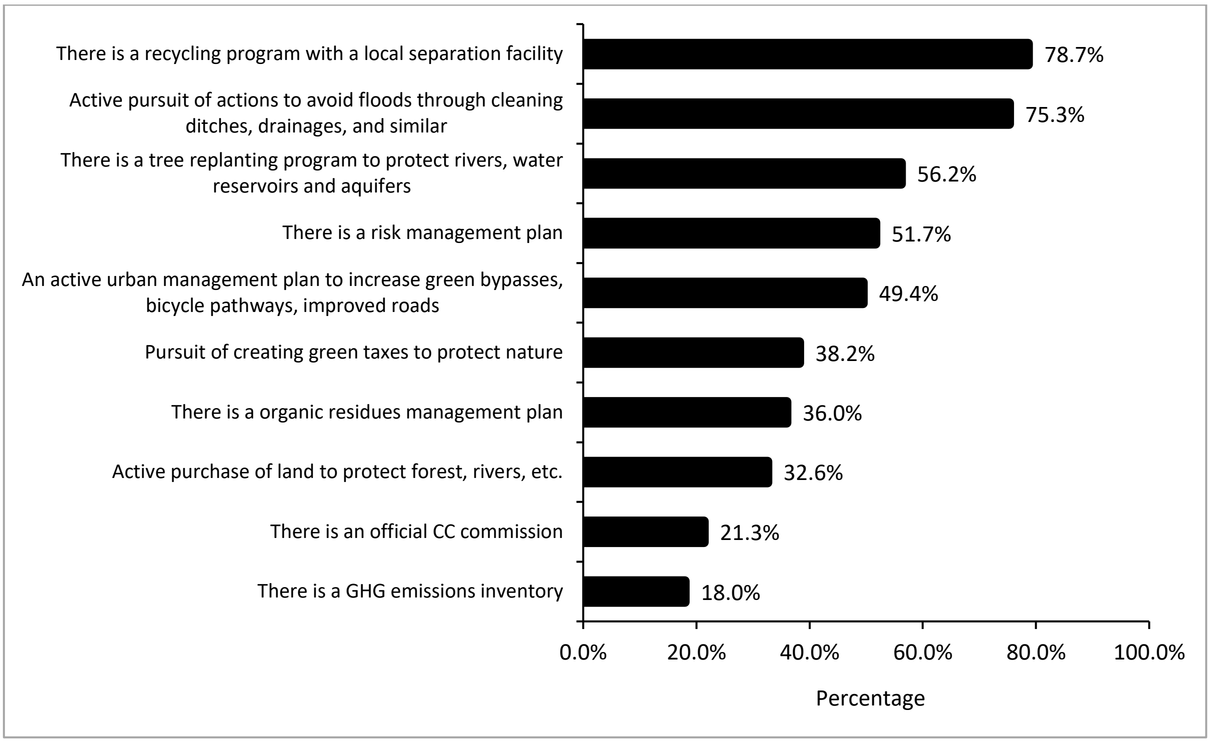

Figure 3. *Climate related actions that are currently being developed by local governments.*

3.2 The work with three municipalities

The approach took with our case municipalities is shown in **Figure 4**. Although the process is presented in phases, some of them take place simultaneously and little variations occurred across local governments. Initially our aim was to map as best as possible in a cooperative manner the current situation in order to create a baseline and more deeply understand the socioeconomic, political, and environmental characteristics, and levels of risk. On this first stage, we also aimed at creating an inter-institutional climate change commission —organized, trained and empowered with a wide participatory level. Members of this commission function as representatives from the multiple sectors, districts, and businesses within the municipal territory. Having them engaged from the beginning of the process is paramount to have an active and committed participation. Second, an official municipal climate change strategy was developed cooperatively, one that is executed and monitored by the inter-institutional commission. With such a strategy, climate policies, objectives and key projects are established along with climate risk management actions. Climate scenarios and the perceptions from organized groups, institutions, private sector, local development associations, producer associations, and other key actors were key inputs here. Third, projects are approved for key sectors on each county, informed by the diagnostic and the analysis of future risk. A goal with these projects has been also to document lessons to benchmark in other counties. Projects relate to water use, agricultural production, emission reduction, waste management, transportation, and others according to the priorities and possibilities of each county. Hence, one assume that these local territories are more adapted to the treats of climate change, becoming more resilient and with higher opportunities for development. Off course, none of this could be possible without a cross-cutting process for building capacities on local actors through awareness, education, and their empowerment. The educational component is conducted formally with school teachers of the public system and informally with members of the CC commission, municipal personnel, private actors and civil society in general.

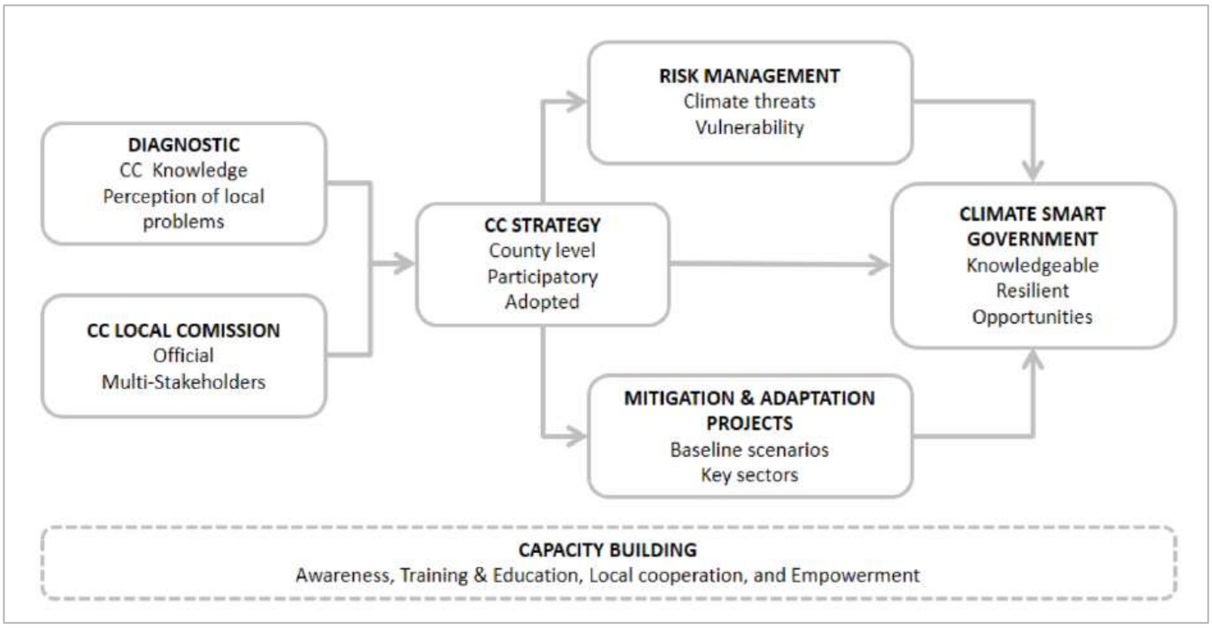

Figure 3. *Approach taken in order to help municipalities incorporate climate change into their governance.*

In order to create a context to the reader about the proposed analysis for the three municipalities (counties), first we provide a brief description of the territories and initiatives developed there. Although the three counties are located within the Greater Metropolitan Area or Central Valley, their biophysical and socioeconomic characteristics vary, generating different challenges for the incorporation of the climate topic into their local governance.

San Rafael is an urban-agricultural county with an area of 48.3 km^2 and 45 965 people, rich in natural resources, forests, and with great importance for the supply of water to a high percentage of the population in the Central Valley. Originated through a pilot project for carbon management in 2011, the committed participation of the local government and various sectors of the community made possible the prioritization of areas of work. As a result, today there is a community organized and represented by different sectors, with an established environmental education process, with a well-defined working agenda lead by an official climate change commission, working in areas such as organic waste management, recovery of protection zones through reforestation campaigns, and baseline information of GHG emissions and carbon storage, paramount for local climate decision making.

The experience acquired in San Rafael allowed the transition of the project to the urban-agricultural municipality of Grecia in 2012. Grecia has 76 898 inhabitants (as of 2011) and an extension of 254.2 Km^2, with a large forests reserves, an intensive agricultural activity, mainly coffee, sugar cane and pineapple crops, which are important sources of employment, but at the same time, GHG generators. As part of the project, efforts have been made to raise awareness in the different sectors of the county, as well as the collection of technical information, metrics for GHG emissions and carbon storage to support the decision-making of the climate change commission, which was developed and has been trained and empowered since.

Finally, we began the work with the municipality of Belen in 2014. This urban-industrial zone is strategically located between the urban center of the capital city and the main international airport of the country. With abundant water in the subsoil, has allowed the concentration of a large number of industries in its territory of 11.8 km^2, which also houses a population of 21 633 inhabitants and an additional floating population of about 25 000 people, resulting on real estate pressure, increased motor transportation along with congestions, air pollution, among other environmental problems. In view of this situation, a strategy is presented to address the effects of the climate, which has led to the development of an inventory of GHG emissions and carbon storage which happen to be the key motivator of subsequent actions. Such balance of emissions comparing the years

2006-2013 let the actors of Belen understand that they are the emitters of 2.78 million tonCO2-eq annually, representing approximately 23% of all the emissions of Costa Rica. This generated a sense of preoccupation and urgency that evolved in the discussion and development of projects around organic residues, transportation, and construction permitting, all under the guidance of a municipal climate change commission, which is highly trained, representative, and committed.

3.2.3 Dimensions that affect the capacities of local governments to meet the challenges of climate change

According to Rosas et al. (2012), the factors that can influence the capacity of local governments that address climate change are: shared responsibility, institutional work, governmental and social transcendence, social interaction, and government responsibility. These dimensions are briefly analyzed for the three municipalities under study, recognizing that they are relevant and helpful to identify weakness and strengths to improve the local climate governance.

The dimension of *shared responsibility*, i.e., the commitment or obligation to be assumed by both government authorities and members of a society, is visualized in all three case studies. The methodological approach of the research project contemplates the organization and citizen participation since the initial stages of the process. On one hand, the development of climate capacities and education is sought for local government officials and for other local actors; and on the other hand, this wide participation ensures the sustainability of the initiative. The assessment of this dimension favors cases 1 and 2, since they have a greater interaction with society, resources are allocated for research, and there is a commitment between the parties for the development of joint climate actions. Case 3 still requires strengthening organizational capabilities and integrating other social actors to achieve greater representativeness. We noticed that in communities with a stronger bottom-up governance approach for environmental issues where municipal officials are not the main actors but another participants, climate actions are easier to develop and maintain over time.

In the dimension of *institutional work*, which has to do with the internal capacities of local governments, the three local governments show a different behaviour. Although in the previous dimension we mentioned that municipal officials are just another actor in the overall set of participants, their formal and active participation is key in the process since they represent official voice of the local territory. Therefore, all meetings, projects, and budget allocations are officially approved by the CC commission established officially within the formal structure. Case 1 for example, has the best evaluation regarding having public policies on the subject, allocation of public resources and training, although it presents some deficiency in prepared personnel in the subject and incidence of internal procedures and regulations, both intimately related aspects. For case 2, the decision-making process is acceptable, but it presents shortcomings in prepared personnel in different areas and thus, their incidence of internal procedures. Finally, case 3 is working its way on the allocation of public resources, although it is evaluated positively on the topics of qualified personnel, training, and incidence on internal procedures.

The third dimension, *governmental and social transcendence*, considers how important and urgent is climate change to both, the local government and the citizens. Cases 1 and 3 present similar positive levels of coordination intra and inter-institutional on climate change; there is evidence of decision making around the issue, and there are people assigned to the coordination of the CC topic. Case 2 has a less focused approach on the issue of CC as a matter of public interest.

Social interaction considers relationships that show the importance of society for the success of climate policy, and is related to the acceptance by citizens, entrepreneurs, and non-governmental organizations. The analysis of this dimension shows that case 1 and case 2 have a very similar assessment, with an acceptance of the topic by key actors with important levels of participation. Although overtime Case 3 is showing a higher importance to the subject, its acceptance is not obvious by some actors, particularly companies who might be viewing climate actions as restriction to the production.

The last dimension is *government responsibility*, manifested in the need to have an organization responsible for the CC issue and entrust the institutionalization of CC as a public problem. This dimension is well-valued in all three cases, since it has a commission —conformed and official— dedicated to the topic, with an important experience (more than 3 years), and integrated by different social actors.

5. Key take-away messages

Formal political support on the part of the City Council and the Municipal Administration is essential for the development of the climate change strategy at the local level. Likewise, strengthening the political capital of community members is important to obtain the endorsement and participation of the formal political structures. Thus, robust municipal internal and external capacities —beyond good administrative management— are required to allow collaborative interactions and a systemic commitment for collective climate action. An official climate change commission is a fertile ground to generate within a formal structure the much-needed legitimacy, involvement, and commitment across actors. Unfortunately, both streams are often weak in local governing settings, limiting the potential and desirable success.

A local climate strategy requires highly motivated, trained and committed actors in order to provide a room for analysis, reflection, creativity and innovation in order to develop climate smart actions. Local socio-environmental problems are often threated in the same usual ways, disconnected from development opportunities and lacking a long-term vision. As discussed by Molina-Murillo (2016), the changing climate provides opportunities beyond just mitigation or adaptation, but most importantly, it provides an opportunity for sustainable development by changing many of the long-time problems that developing countries confront rooted on poor governance. Addressing climate change locally requires a clear planning strategy (designing, planning, execution, and evaluation) that provides concrete, evident and relevant results for a wide spectrum of actors, especially those more vulnerable.

Climate change education has served as a dynamic driver for strengthening the local environmental system and local development initiatives. This component must be conceived from the beginning as a continuous process, sometimes as an end, or sometimes as a means, to achieve greater governance and community wellbeing. Members of the CC committees later on became facilitators of processes of formal and non-formal environmental education, which promoted their empowerment. This type of initiative linking research, extension and teaching, contributes with a more comprehensive training, where we all learn from each other becoming more climate-smart agents.

Working with multiple actors in groups such as the CC commissions entails on itself a structure with roles, positions, and norms. Regardless of the good intentions we all might have; the participation and commitment depends on the legitimacy, leadership, and capacity of actors to solve internal problems. After all, the group is itself a psychosocial phenomenon that evolves, and needs to be flexible and open. Working cooperatively and empowering members through training, decision making, overseeing initiatives, public speaking, and others, happen to be fundamental. An alternative governance style with al systemic participation and commitment from multiple actors will result in more and better cooperative climate actions.

6. Conclusions

We found that in spite of the existing concern about the climate issue, appropriate mechanisms and information are lacking to enable its more efficient adoption in local governance. Therefore, we conclude that in order to adequately address the issue of climate change in an inclusive and sustainable manner, local governments are required to develop both internal and external capacities —beyond good administrative management— to allow a collaborative interaction with the actors involved, in order to generate and maintain their recognition, involvement, and commitment. Is evident that this project supports an alternative collaborative governance model, through the enhancement of individual and social local capacities leading to a more systemic commitment for collective climate action. This action requires transcending voluntary and isolated initiatives, leading the way to planned, and politically supported mitigation and adaptation strategies for inclusive development. According to the subsidiarity principle, government functions are assigned to the lowest level capable of efficiently undertaking the task; thus, local governments should be supported to fully and efficiently address the climate change challenges in order to properly deliver in a sustainable manner the expected array of public goods and services on their territories.

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