World Sustainability Series

Walter Leal Filho
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Universities and Sustainable Communities: Meeting the Goals of the Agenda 2030

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Due to its scope and nature, sustainable development is a matter which is very interdisciplinary, and draws from knowledge and inputs from the social sciences and environmental sciences on the one hand, but also from physical sciences and arts on the other. As such, there is a perceived need to foster integrative approaches, whereby the combination of inputs from various fields may contribute to a better understanding of what sustainability is, and means to people. But despite the need for and the relevance of integrative approaches towards sustainable development, there is a paucity of literature which address matters related to sustainability in an integrated way.

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Universities and Sustainable Communities: Meeting the Goals of the Agenda 2030

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Preface

The implementation of the UN Agenda 2030 as a whole, and the Sustainable Development Goals (SDGs) in particular, requires actions at all levels: international, national, regional and local.

At the local level, it is believed that university–community partnerships may be useful in three main ways: firstly, by helping to contextualise and by offering a broader understanding of the many issues concerning and the challenges which people face in their communities; secondly, by demonstrating the role of collaboration in contributing to the search for problems seen at the community level; and finally, by supporting communities in implementing local action towards sustainability goals connected with community life.

But despite the relevance of the theme, there is a dearth of specialist publications which address the many issues related to universities and communities, in a SDG context. The book *Universities and Sustainable Communities: Meeting the Goals of the Agenda 2030* is an attempt to address this needs. It contains a set of papers presented and discussed during the 2nd World Sustainability Symposium, which was held in Curitiba, Brazil, in April 2019. The papers here compiled to look at matters related to sustainable development under different perspectives and across a variety of audiences. It contains experiences from empirical research, practical projects and teaching methods being deployed around the world, all with the aim of bringing sustainable development closer to communities. Moreover, the book also entails contributions on how to promote local sustainability efforts at the local level.

Thanks to its scope, this is a truly interdisciplinary publication. We thank the many authors who contributed to this volume and for their willingness to share their knowledge and expertise.

We hope it will be useful to scholars, social movements, practitioners and members of governmental agencies, undertaking research and/or executing projects on sustainable development at the local level.

Hamburg, Germany — Walter Leal Filho
Curitiba, Brazil — Ubiratã Tortato
Curitiba, Brazil — Fernanda Frankenberger
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Economic Complexity and the Environment: Evidence from Brazil

Julia Swart and Lisa Brinkmann

Abstract Brazil is a heterogenous country with respect to, among others, economic complexity, economic development and environmental quality. This paper examines the relationship between economic complexity and key environmental variables in Brazil. We deviate from the Environmental Kuznets Curve (EKC) literature by focusing on economic complexity instead of economic development alone to explain cross-section and time-series variation in a range of environmental variables. Our motivation for considering economic complexity as a main explanatory variable lies on the consideration that low economic complexity is associated to products which are peripheral on the product space. These are products which are less connected to other products, limiting the opportunities for other economic activities, and therefore limiting the impact on the environment. As economic complexity increases more opportunities are created, the product space becomes denser, and pollution increases. However, at a high enough level of economic complexity, the structural changes bring knowledge-intensive industries, which demands higher-skilled labour force and wider skills of occupations. At this point, economic complexity is associated to decreasing environmental degradation. Using panel data for Brazil we find that waste generation decreases, but forest fires increase with rising complexity. Complexity is not associated to more deforestation or air pollution.

Keywords Economic complexity · Brazil · Environmental degradation · Solid waste generation · Deforestation · Forest fires · Air pollution

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1 Introduction

In September 2015 the Heads of State and Government met at the United Nations Headquarters in New York, when they agreed on 17 Sustainable Development Goals (United Nations 2015). These goals linked sustainable development to three perspectives: economic, social and environmental; and emphasized the challenge to alleviate poverty and environmental degradation. Brazil is an upper-middle-income economy, with a GDP per capita of around 11,000 dollars in 2016 (World Bank WDI). It ranked 44 out of 85 countries in terms of Economic Complexity in the same year (Observatory of Economic Complexity). Brazil is also a country of inequalities, where close to 13% of the population was unemployment in 2017 (World Bank, WDI) and poverty reached 8% of the population in 2015 (World Bank, WDI).[1] Embracing the Sustainable Development Goals is vital for Brazil, given these economic and social challenges, but also given the pressure that economic development places on the environment. In 2016 around 40 percent of the Brazilian population lived in urban agglomerations of more than 1 million people (World Bank, WDI). As in many developing countries, people agglomerate in big cities in search for better opportunities. This agglomeration can create a coordination challenge at the cost of inadequate provisions of services and infrastructure, which contributes to environmental problems (such as air pollution, and open-air waste disposal).

At the same time United Nations (2015) argues that we live in a "time of immense opportunity". A time in which "the spread of information and communications technology and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies, as does scientific and technological innovation across areas as diverse as medicine and energy" (p. 5). In this sense, economic agglomeration, when tied to technological advances and access to knowledge can stimulate the adoption of cleaner production methods and infrastructure.

The empirical literature analysing economic factors driving environmental degradation set a central role on economic growth (Stern 2017). Nonetheless, Stern (2017) argues that for truly understanding what reduces pollution, we need to understand "the nature of the factors that are not related to economic growth" (p. 8). The Environmental Kuznets Curve (EKC) hypothesis suggests an inverted U-shaped relationship between various indicators of environmental degradation and income. Accordingly, environmental degradation increases during the early stages of economic development, until a turning point level of income is reached. From this point, with rising incomes, economic development ultimately leads to enhanced environmental quality. The EKC is, however, silent with respect to how income level affects environmental quality. Economic development could be capturing institutional quality, preferences, education, economic structures (e.g. sectoral composition), among others. An empirical analysis, should thus try to include these direct determinants of environmental quality. Leaving them out could wrongly indicate that economic growth is all it needs

[1] Poverty headcount ratio at $3.20 a day (2011 PP) (% of population).

to improve environmental indicators (see also IBRD 1992; Arrow et al. 1995; Stern 2002 and Dasgupta et al. 2002).

Concomitantly with the debate in the policy sphere, the empirical evidence has been far from unambiguous. Numerous researchers have tested the EKC hypothesis for a variety of countries, environmental degradation indicators and econometric techniques. Some studies find evidence for an inverted U-shaped relationship between urban pollution—for instance due to sulphur dioxide and suspended particles—and income (e.g. Grossman and Krueger 1991; Shafik and Bandyopadhyay 1992; Panayotou 1993; Selden and Song 1994). Other studies, however, find these local pollutants to be positively correlated with income (e.g. Stern and Common 2001; Stern 2002; Perman and Stern 2003; Liu et al. 2017). A positive relationship with economic development is also found for carbon dioxide emissions, deforestation, and alternative indicators of environmental degradation (e.g. Shafik and Bandyopadhyay 1992; Holtz-Eakin and Selden 1995).

This paper adds to the EKC literature by considering a new possible driving force of environmental quality: economic complexity. The underlying motivation for analysing the relationship between economic complexity and the environment is the consideration proposed by Hausmann et al. (2014) that economic development is driven by knowledge. Hausmann et al. (2014) show that economic complexity is a highly accurate predictor of growth. According to the authors, economic complexity reflects the amount of knowledge that is embedded in societies, consequently mirroring the productive structure of an economy. Differences in economic complexity account for the diversity and sophistication of the products exported by each country. In complex economies, individuals build large networks that enable them to combine knowledge more easily and ultimately produce an extensive variety of knowledge-intensive goods.

Contrary to the traditional EKC hypothesis, which relies on the notion that environmental quality is a luxury good, the rationale for exploring the relationship between economic complexity and the environment relates closely to the technical capabilities of a country's industry. We hypothesize that, after a threshold level of economic complexity has been reached, increasing economic complexity is accompanied by knowledge embedded in technology and human capital which is necessary to limit environmental degradation. Simple economies usually focus on the production of raw minerals or elementary agricultural goods and, accordingly, cause only limited environmental degradation. With the take-off of industrialisation and the diversification of production, economies become gradually more complex. At the same time, however, environmental degradation soars. Finally, at higher levels of economic complexity, structural changes towards knowledge-intensive industries takes place. This rise in economic complexity provides the knowledge and, hence, the technology needed for economies to become "green". Examples are the production of energy-efficient goods and electric cars; the generation of energy with renewable resources such as photovoltaics, wind, or biomass; or innovations such as recycling, energy grid integration, and cradle-to-cradle design. A high level of productive knowledge is necessary for technological breakthroughs like these to get

under way. When economies eventually reach such a level of complexity, environmental degradation will level off and start to decline.

This paper investigates the validity of the complexity-environment nexus for the case of Brazil. More precisely, we analyse the extent to which the productive structure in different Brazilian municipalities, states and metropolitan regions influences the quality of the environment. Brazil's recent economic history, marked by the transition from a closed to an open economy in less than three decades; the importance of the environment for the industry and society; and regional diversity provide a strong case to conduct a study specifically for Brazil.

Until the 1980s and early 1990s, Brazil's economy was characterised by strong import substitution policies, macroeconomic policies aimed at stabilising the prevalent hyperinflation, and an industry producing almost exclusively for the domestic market. With the creation of the free trade area Mercosur in 1991, subsequent privatisations, and the withdrawal of the state from production, Brazil experienced a period of relatively high growth rates (Lo and Hiscock 2014). Figure 1 shows that Brazil experienced positive growth throughout the mid-1990s and early 2000s. Higher competitiveness and an ensuing export boom—especially of agricultural products such as soybean and cocoa—helped the country position itself as a promising emerging market. During the same period, however, Brazil's economy became steadily less complex, a fact that can certainly be attributed to the relevance of agriculture as a driver of its economic development. Ranking as the world's 29th in terms of economic

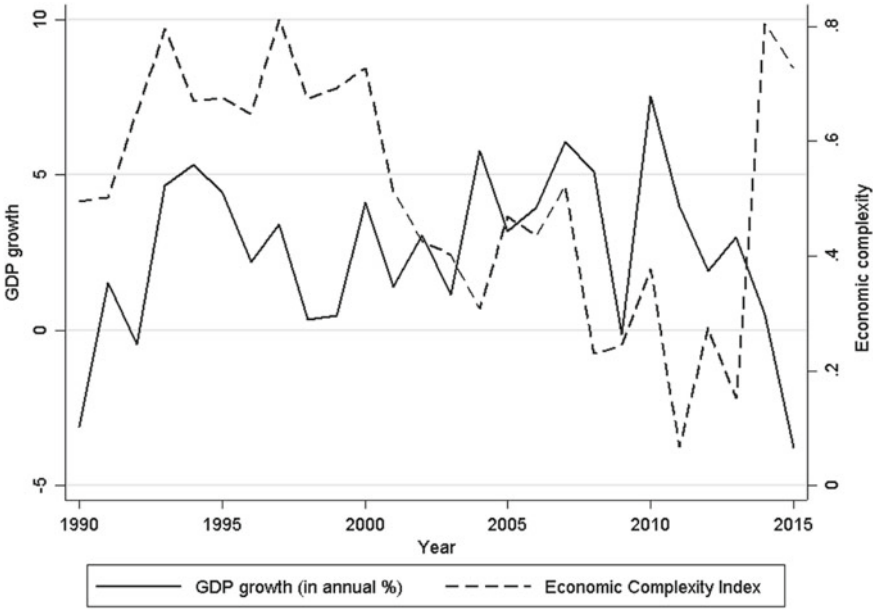

Fig. 1 Economic growth and economic complexity in Brazil (1990–2015). *Data sources* World Bank, Observatory of Economic Complexity

complexity in 1995, the country ranked 54th in 2014 (Observatory of Economic Complexity 2017). Interestingly, while Brazil's current economic and political crisis has stopped this positive growth trend altogether, the country has seen its position in the global economic complexity ranking strengthen simultaneously.

Alongside the prosperity brought about by Brazil opening up to international trade, severe environmental problems emanated during this period. The country's most notorious environmental problem is the deforestation of its rain forests. Deforestation in Brazil has been mainly driven by the expansion of agriculture. Hundred hectares of the Amazon forest have been cut or burnt down each year for the large-scale settlement of farmlands designated for cocoa, coffee, soybeans, sugarcane and cattle pastures. By no means exclusive to the Amazon basin, these practices have also reached other regions in Brazil (e.g. the tropical savanna of the Cerrado).

Moreover, urbanisation rates have risen dramatically in the last two decades. According to the World Bank (2017), approximately 85% of the more than 200 million inhabitants in Brazil lived in urban areas in 2015. Particularly in the economic hubs of São Paulo, Brazil's largest city and one of the largest urban areas worldwide, Rio de Janeiro and Belo Horizonte, air pollution as well as waste generation represent serious environmental problems.

The paper is structured as follows. Section 2 briefly reviews the EKC literature, first summarising the findings on the world or specific subsets of countries, and secondly summarising Brazil-specific findings. Section 3 describes the proposed model, the data used and the methodology chosen. Section 4 presents the empirical results for four environmental degradation indicators analysed: Section 4.1 for solid waste generation, Sect. 4.2 for deforestation, Sect. 4.3 for forest fires, and Sect. 4.4 for air pollution. Section 5 concludes by outlining the implications of our results and the possible scope for improvement and extension.

2 Literature Review

The EKC has its roots on the seminal work by Grossman and Krueger (1991), the first authors to explicitly find evidence for an inverted U-shaped relationship between indicators of environmental degradation and income. Following their work other empirical papers found evidence for an EKC (see e.g. Shafik and Bandyopadhyay 1992; Panayotou 1993; and Selden and Song 1994). Notwithstanding the empirical evidence of the first EKC studies, Stern et al. (1996) examine the concept of the EKC critically on both theoretical and empirical grounds. In a later review, Stern (2004) argues that most of the EKC literature of the 1990s is empirically weak, as it fails to take into account statistical properties likely to influence the estimation results (such as heteroskedasticity, serial correlation and cointegration), and the possible existence of simultaneity and omitted variables bias. Furthermore, the coefficients estimated in the first EKC studies differ substantially depending on the subsample used. Stern (2004) notes that no or only weak evidence for the EKC hypothesis can be found when accounting for diagnostic statistics, using appropriate techniques, and

performing specification tests. In addition, studies using more representative data find sulphur dioxide emissions and concentrations—traditionally a showcase for the EKC hypothesis—to be positively correlated with income, a finding that is in line with the estimation results for other environmental degradation indicators.

Stern and Common (2001) reduce misspecification problems by using first-differenced data when estimating the EKC. The authors find that the relationship between sulphur dioxide emissions and income is positive in both high- and low-income countries. Stern (2002) applies an emission-decomposition model and finds that sulphur emissions rise with increasing income at all levels of income. Many other test the EKC hypothesis and find mixed results (e.g. Suri and Chapman 1998; Perman and Stern 2003; Tao et al. 2008; Managi and Jena 2008; Mills and Waite 2009; Jalil and Mahmud 2009; Iwata et al. 2010; Fodha and Zaghdoud 2010; Fosten et al. 2012; Saboori and Sulaiman 2013; Al-Mulali et al. 2015).

The empirical evidence is not more compelling in Brazil-specific studies. The empirical literature investigating the possible existence of an EKC for Brazil focus on the link between deforestation and economic development in Brazil. Santos et al. (2008), for instance, analyse 782 municipalities of the Amazon basin from 2000 to 2005, and find support for the EKC hypothesis. Oliveira et al. (2011) analyse these same municipalities for 2001–2006, but do not find evidence for a deforestation EKC. The authors include a rich set of additional explanatory variables, such as cattle, agricultural activity, vegetable extraction, forestry, population density, rural credit, annual dummies, and deforestation rate in the previous year. Gomes and Braga (2008) also analyse deforestation rates in the Amazon region and find fairly mixed evidence for the EKC. Depending on the functional form applied, the authors find either an inverted U-shaped or an N-shaped relationship between the deforestation rate and income.

Teixeira et al. (2012) investigate the existence of a deforestation EKC in 139 municipalities of the state of Mato Grosso in 2006, one of nine states constituting the Amazon River basin region. The authors control for spatial effects and add a rich set of additional explanatory variables, including per capita wood extraction and a ratio of cattle units over area destined for cattle. The findings depend strongly on the functional form chosen, thus suggesting a weak relationship between deforestation and income. Also controlling for spatial effects, Colusso et al. (2015) analyse data for the year 2008 related to 1306 municipalities constituting the Cerrado biome. The empirical evidence of this study is similarly mixed, ranging from an inverted U-shaped to a U-shaped or N-shaped relationship.

To the best of our knowledge, besides the abovementioned papers focusing on deforestation there is only one paper which examines alternative indicators of environmental degradation to test for an EKC for Brazil. Sousa et al. (2008) proxy environmental degradation by defining the deficit in drinking water, in basic sanitation, and in waste collection as dependent variables. Using a dataset containing 5507 municipalities in the years 1991 and 2000, the empirical evidence suggests that the relationship between each one of these three indicators and income per capita is U-shaped.

3 Model, Data and Methodology

3.1 Model and Data Description

The aim of this paper is to examine the extent to which the economic complexity of municipalities, states and metropolitan regions in Brazil affects the quality of their environment. We hypothesize that initially environmental degradation rises with economic complexity, but subsequently falls as structural change towards knowledge-intensive industries takes place, allowing for environmental-friendly technologies and products. We expect the relationship between environmental degradation—in terms of pollution or the extraction of natural resources such as forest resources—and economic complexity to be quadratic. In order to test this hypothesis, we estimate the following baseline specification:

$$ENV_{it} = \alpha_i + \beta_1 ECI_{it} + \beta_2 (ECI_{it})^2 + \varepsilon_{it} \quad (1)$$

Our dependent variable, *ENV*, denotes four indicators of environmental degradation in Brazil, available at various disaggregation levels. We selected the regional level of the data based on its availability. Data on domestic solid waste generation is available for the municipalities in the state of São Paulo, the most economic complex Brazilian state. Deforestation rates are available for municipalities in nine states constituting the Amazon basin region. Data on forest fires is available at the state-level. Lastly, air pollution data is available for Brazilian metropolitan regions.

We employ panel regression techniques to estimate Eq. (1). Accordingly, $i = 1, \ldots, N$ indexes each municipality, state or metropolitan region, and $t = 1, \ldots, T$ refers to the time periods covered in the different panels. Parameter α_i allows for the possibility of time-invariant effects specific to the respective municipalities, states or metropolitan regions, and ε_{it} is the stochastic error term.

Solid Waste Generation

First, we analyse the relationship between solid domestic waste generation and economic complexity in the municipalities constituting the Brazilian state of São Paulo. Yearly, the Companhia Ambiental do Estado de São Paulo (CETESB), the state's agency for the control and monitoring of polluting activities, publishes estimates on the average solid waste generated domestically in each municipality in total tons per day. For our analysis, we converted these estimates into solid waste generated per capita in kilograms per day. Our panel contains data on up to 455 municipalities and covers the period from 2003 to 2011.

Deforestation

The second environmental degradation indicator we examine is the deforestation of the Amazon rainforest, based on the PRODES database. PRODES is a project by the Instituto Nacional de Pesquisas Espaciais (INPE), Brazil's National Institute

for Space Research, which monitors the deforestation of the Amazon via satellite. PRODES has been publishing the annual deforestation rates (in square kilometers) of the municipalities constituting the Amazônia Legal region since 1988, and has played an important role as guidance for the Brazilian government in terms of environmental policies. Our panel comprises 760 municipalities in the nine states constituting the Amazon basin region and ranges from 2002 to 2014.

Forest Fires

We further examine the relationship between forest fires and economic complexity. Yearly, vast forest areas are burnt in Brazil to obtain free space for agricultural production and pasture (cf. Watts 2012; Mazzetti 2016). The Instituto Brasileiro de Geografia e Estatística (hereafter IBGE), Brazil's Institute of Geography and Statistics, provides data on the annual number of forest fires (measured in number of heat sources) for the 26 Brazilian states and the federal district between 2002 and 2009.

Air Pollution

Lastly, the IBGE provides data on various air pollutants for the Brazilian metropolitan regions of Belo Horizonte, Curitiba, Grande Vitória, Porto Alegre, Recife, Rio de Janeiro, Salvador and São Paulo. The air pollution indicators, measured in micrograms per cubic meter, include the annually observed maximum and average concentrations of sulphur dioxide, nitrogen dioxide, total suspended particles (TSP), and ultrafine particles (PM10). Data on maximum concentrations of carbon monoxide and ozone is also available. Our panel covers the years 2002–2009.

Economic Complexity Indicator

Our main independent variable, ECI, denotes the Economic Complexity Index (hereafter ECI), an innovative index developed by Hausmann and Hidalgo (Hausmann et al. 2014). The ECI captures the productive capacity of an economy by taking into account the complexity of its products,[2] considering their diversity (i.e. the number of products the economy exports) and ubiquity (i.e. the number of economies that export a given product). Ultimately, this index quantifies the complexity of an economy in one single number, with more complex products being exported by a smaller number of economies, as they require more sophisticated productive knowledge to be produced (Hidalgo and Hausmann 2009; Hausmann et al. 2014). Following the EKC concept, we also include the square term of the ECI, $(ECI)^2$.

The visualisation tool DataViva expanded the index for the specific case of Brazil. Using information compiled by the Brazilian Secretariat of Foreign Trade (SECEX) and the Ministry of Development, Industry and Foreign Trade (MDIC), DataViva has gathered high-quality historical data on Brazilian international trade flows to

[2]More precisely, the ECI is calculated as the average complexity of products exported by a specific economy with international comparative advantage, weighted with the share of exports by the said economy.

construct the ECI for Brazilian municipalities and states. As the index is not available for Brazilian metropolitan regions, we constructed it as the average over the ECI of Brazilian municipalities constituting the respective metropolitan regions.

Control Variables

We include income, its square, and a set of control variables to our baseline specification:

$$ENV_{it} = \alpha_i + \beta_1 ECI_{it} + \beta_2 (ECI_{it})^2 + \beta_3 \frac{GDP_{it}}{P_{it}} + \beta_4 \left(\frac{GDP_{it}}{P_{it}} \right)^2 + X'\gamma + \varepsilon_{it} \quad (2)$$

As a measure of economic development, we include GDP per capita (GDP/P) in the different municipalities, states and metropolitan regions analysed. The Instituto de Pesquisa Econômica Aplicada (hereafter IPEA), Brazil's Institute of Applied Economic Research, provides data on GDP per capita for the Brazilian states. We use data from IPEA to construct this variable for municipalities and metropolitan regions. GDP per capita is denoted in thousand constant 2010 Brazilian Reais for states, and in thousand constant 2000 Brazilian Reais for municipalities and metropolitan regions.

X denotes a set of control variables that may affect the different environmental degradation indicators. As far as data is available, we include one or more measures of population density, urbanisation, education and trade openness. For the analysis on deforestation rates and forest fires, we also include a set of agricultural variables.

Following the example of Gomes and Braga (2008), Oliveira et al. (2011), Teixeira et al. (2012), Colusso et al. (2015), among many others, we include population density (in number of inhabitants per square kilometer) as an explanatory variable. Available at all disaggregation levels, we constructed this variable using IPEA data. To measure urbanisation, we include the ratio of total urban to total rural population, constructed with IBGE data. This variable is available for Brazilian states and metropolitan regions. We expect both variables to have a detrimental effect on the environment, as more densely populated and urban areas are likely to exert more pressure on the environment, having hence a positive sign.

As Managi and Jena (2008) point out, a rise in overall educational levels, but specifically in higher education, is usually accompanied by increased environmental awareness, ameliorating eventually the quality of the environment. We therefore control for education, expecting the correlation with environmental degradation to be negative. We include the average years of education for people aged 25 or older. Alternatively, we follow Castilho et al. (2012) and include the share of the economically active population (aged ten or higher) with upper-intermediate to higher education, which comprises individuals with more than eleven years of education. The first educational variable comes from IPEA and is available at the state-level, whereas the second one was constructed with IBGE data and is available for states and metropolitan regions.

Analogously to Iwata et al. (2010), Jalil and Feridun (2011), Nasir and Rehman (2011), Al-Mulali et al. (2015), we include a trade openness ratio as independent variable. Using UN Comtrade and IPEA data, we constructed this ratio as the sum

of exports and imports over GDP. The ratio is denoted in constant 2010 Brazilian Reais at the state-level, and in constant 2000 Brazilian Reais at the metropolitan region- and municipality-level. According to Antweiler et al. (2001) as well as Cole and Elliott (2003), the effect of trade on the environment can be decomposed into three effects: scale, technique, and composition effect. The scale effect relates to the increase in overall economic activity ensuing from intensified trade, being hence detrimental to the environment. In contrast, the technique effect improves the quality of the environment due to more environmentally-friendly production brought about by international trade. Production changes either because of increased (domestic) competition, forcing the least energy-efficient firms to leave the industry, or the import of cleaner technologies. The composition effect can be positive or negative and refers to the changes in the industrial structure of an economy arising from international trade. A country or region will specialise on the production of goods for which it has a comparative advantage, which can be in cleaner or more polluting industries. Overall, the net effect of trade openness on the environment is theoretically ambiguous.

As Selden and Song (1994), Grossman and Krueger (1995), Antweiler et al. (2001), and Fosten et al. (2012), among others, we include a time trend to capture technological advances and changes in environmental awareness that are not related to either income or economic complexity.

Finally, we include an additional set of agricultural variables withdrawn from IPEA for our analyses of deforestation rates and forest fires in Brazilian municipalities and states. Various authors (e.g. Margulis 2003; Brown et al. 2005; Aguiar et al. 2007; Miragaya 2008; Vera-Diaz et al. 2008) investigate the drivers of deforestation in the Amazon rainforest, identifying agriculture—most notably in terms of cocoa, coffee, sugarcane and soy production—and cattle as the main culprits.[3] We follow Colusso et al. (2015) and include total harvested and total planted area, both in hectares, as explanatory variables.[4] We expect the agricultural variables to be positively correlated with deforestation and forest fires. In other words, we expect larger areas in the Amazon rainforest to be destroyed, and more forest fires to be observed, when there is an expansion of agricultural activity in the municipalities of the Amazon basin region and in Brazilian states.

Table 8 in the Appendix provides a detailed list of all the variables used in our analysis (in regressions or, whenever necessary, for the construction of variables) and their sources. Tables 9, 10, 11 and 12 contain descriptive statistics for the variables in the four panels.

[3] Aguiar et al. (2007) state that 70% of the total deforested area in the Amazon Basin is destined for cattle production. 13 and three per cent were transformed into temporary and permanent harvests, respectively.

[4] Oliveira et al. (2011) and Teixeira et al. (2012) add harvested area for the aforementioned agricultural products (in hectares) and cattle units per square kilometre as control variables. IPEA provides data on harvested area by agricultural products, but the panels are rather incomplete and lead to a drop in the number of observations when employed.

3.2 Methodology

Our choice of estimation approach is driven by two main considerations: whether the correlation between time-invariant region-specific effects and all of the explanatory variables is zero; and whether the error term is idiosyncratic. We assume strict exogeneity, that is, all the explanatory variables to be uncorrelated with the error term.

Intuitively, the assumption of zero correlation between time-invariant region-specific effects and all the explanatory variables is unlikely to hold, as industrial policies within the different Brazilian municipalities, states and metropolitan regions are likely to be correlated with characteristics and features of these subregions. Omitting them could thus be an important source of bias. Unlike in the random effects approach, which assumes that these time-constant specific effects are randomly distributed across the subregions, fixed effects and first differences estimation allows for this correlation to be nonzero.

We compute first differences estimates and conduct a Breusch-Godfrey test for autocorrelation in order to choose between the first differences and fixed effects approach. For our analysis on deforestation, forest fires, maximal sulphur dioxide concentrations, and average ultrafine particle concentrations, first differences estimates are preferred over fixed effects estimates. The Breusch-Godfrey results indicate that the differenced error term is idiosyncratic. In other words, fixed effects estimation is non-stationary with these datasets. Consequently, results could be biased, as the error terms have a unit root and are highly persistent in the time-series dimension. For solid waste generation, and the other air pollution indicators, the error term is idiosyncratic, allowing for the use of fixed effects. Constant region characteristics are differenced out or time-demeaned, respectively.

To correct for heteroskedasticity and autocorrelation, which are data properties found in virtually all indicators after conducting Breusch-Pagan and Breusch-Godfrey tests, we use clustered standard errors at the municipal, state, and metropolitan region level.

4 Empirics

4.1 Solid Waste Generation

Table 1 reports the fixed effects estimates for our analysis on the relationship between solid waste generation and economic complexity in Brazilian municipalities in the state of São Paulo from 2003 to 2011. In our baseline regression, we follow Eq. (1) in Sect. 3.1 and regress per capita solid waste generation on the ECI and its square term. Since the two coefficients are not statistically different from zero, we exclude

Table 1 Domestic per capita solid waste generation (fixed effects estimation)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: solid waste generation p.c.						
ECI	−0.00337	−0.00363***	−0.00363***	−0.00363***	−0.00361***	−0.00360***	−0.00520*
	(0.00256)	(0.00137)	(0.00136)	(0.00138)	(0.00133)	(0.00134)	(0.00282)
$(ECI)^2$	−0.000147						0.000152
	(0.000109)						(0.000140)
GDP p.c.		0.00185***	0.00184***	0.00171***	0.00137***	0.00114**	0.00117**
		(0.000513)	(0.000506)	(0.000561)	(0.000415)	(0.000485)	(0.000482)
$(GDP\ p.c.)^2$		−1.5e−05***	−1.49e−05***	−1.39e−05**	−1.12e−05***	−9.67e−06**	−9.81e−06**
		(5.68e−06)	(5.60e−06)	(5.91e−06)	(4.09e−06)	(4.44e−06)	(4.41e−06)
Population density			5.10e−06			−2.04e−06	−2.08e−06
			(1.00e−05)			(1.10e−05)	(1.12e−05)
Trade openness				−0.000647*		−0.00151*	−0.00150*
				(0.000359)		(0.000864)	(0.000860)
Year					0.00105	0.00118	0.00118
					(0.000663)	(0.000929)	(0.000930)
Constant	0.389***	0.373***	0.370***	0.391***	−1.736	−1.964	−1.979
	(0.000696)	(0.00407)	(0.00727)	(0.00467)	(1.330)	(1.859)	(1.861)

(continued)

Table 1 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: solid waste generation p.c.						
Observations	3169	2812	2812	2253	2812	2253	2253
# of municipalities	455	448	448	360	448	360	360
R-squared	0.002	0.002	0.002	0.002	0.003	0.003	0.003
Adjusted R-squared	0.00116	0.00108	0.000747	0.000100	0.00202	0.000386	6.84e−05

Notes Standard errors, in parentheses, are clustered at the municipality-level. *Interpretation* ***p < 0.01, **p < 0.05, *p < 0.1

the square term in the subsequent specifications to allow for a linear relationship between the environmental degradation indicator and complexity.

Column (2) reports the estimation results of Eq. (2), which includes GDP per capita and its square term as additional explanatory variables. The ECI estimate is now statistically significant and negative, indicating that a rise in economic complexity leads to a reduction of the amount of solid waste generated daily per person. For concreteness, individuals generate an average of 3.63 g less waste per day if the complexity index increases by one unit. This finding shows that waste generation has a negative relation with economic complexity, which suggests that individuals generate less waste in more complex municipalities. An intuitive reasoning is that in more economic complex municipalities, there is a higher percentage of tertiary sectors which generate less waste than manufacturing sectors. Another reason could be that more complex economies have more knowledge about how to make more efficient use of resources and materials, leading to less waste.

Both GDP per capita and its square term are significantly different from zero. With the square term bearing a negative sign, the relationship between solid waste generation and income per capita is inverted U-shaped. This finding supports the existence of a waste generation EKC for the state of São Paulo.

The two significant relationships found in specification (2) are robust to the inclusion of individual controls and the complete set of variables. Population density and the time trend are unrelated to solid waste generation. In contrast, trade openness has a significant and negative impact on the dependent variable, suggesting that individuals generate less solid waste with rising trade.

Overall, our estimation results provide evidence that rising economic complexity and trade openness have a significant negative impact on the amount of solid waste generated per person per day in the municipalities of the state of São Paulo. In line with the EKC concept, our estimates further confirm the existence of an inverted U-shaped relationship between solid waste generation and economic development. The turning point, i.e. the level of per capita income at which the detrimental effect of economic development on the environment reverses, lies between 59,120 and 61,499 constant 2000 Brazilian Reais. These values lie within the income per capita range in our sample (see Table 9 in the Appendix).

4.2 Deforestation

Table 2 reports the first differences estimates for our analysis on the relationship between deforestation and economic complexity in municipalities in the Amazon basin region between 2002 and 2014. We find no evidence of a relationship between economic complexity and deforestation. Our estimates provide evidence, instead, for an inverted U-shaped relationship between deforestation rates and economic development. GDP per capita and its square term yield statistically significant estimates in all specifications. Deforestation rates soar with rising income per capita, but this

Table 2 Deforestation (first differences estimation)

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: deforestation rate					
ECI	−0.392	1.661	1.724	2.783	2.344	2.328
	(2.079)	(3.038)	(3.053)	(2.933)	(3.678)	(3.662)
$(ECI)^2$	0.0710					
	(0.0585)					
GDP p.c.		3.125***	3.135***	1.183	3.210***	3.098***
		(0.979)	(0.980)	(0.716)	(1.098)	(1.040)
$(GDP\ p.c.)^2$		−0.0235***	−0.0236***	−0.0122	−0.0240**	−0.0234***
		(0.00873)	(0.00874)	(0.00947)	(0.00933)	(0.00901)
Population density			0.0628**			
			(0.0298)			
Trade openness				−0.584		
				(0.728)		
Harvested area					−3.28e−05	
					(1.27e−04)	
Planted area						2.08e−05
						(1.07e−05)
Cattle density	–					
	–					

(continued)

Table 2 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: deforestation rate					
Constant	−4.630***	−7.006***	−7.067***	−5.182***	−7.154***	−7.243***
	(0.605)	(1.010)	(1.019)	(1.267)	(1.026)	(1.039)
Observations	2194	1448	1448	551	1408	1408
R-squared	0.000	0.006	0.006	0.003	0.006	0.006
Adjusted R-squared	−0.000899	0.00399	0.00338	−0.00463	0.00330	0.00328

	(7)	(8)	(9)	(10)	(11)
	Dependent variable: deforestation rate				
ECI	0.814	1.676	1.674	1.657	1.653
	(3.255)	(4.464)	(4.463)	(4.519)	(4.519)
$(ECI)^2$				0.0757	0.0776
				(0.287)	(0.288)
GDP p.c.	5.319***	5.804***	5.787***	5.801***	5.785***
	(1.377)	(1.561)	(1.554)	(1.562)	(1.555)
$(GDP\ p.c.)^2$	−0.0398***	−0.0428***	−0.0427***	−0.0428***	−0.0427***
	(0.0123)	(0.0132)	(0.0131)	(0.0132)	(0.0131)
Population density		0.122	0.121	0.121	0.120
		(0.248)	(0.248)	(0.250)	(0.249)
Trade openness	–				
	–				

(continued)

Table 2 (continued)

	(7)	(8)	(9)	(10)	(11)
	Dependent variable: deforestation rate				
Harvested area		−1.43e−04		−1.43e−04	
		(1.26e−04)		(1.26e−04)	
Planted area			−0.000137		−0.000137
			(1.25e−04)		(1.25e−04)
Cattle density	−0.300	−0.293	−0.294	−0.293	−0.294
	(0.239)	(0.243)	(0.243)	(0.243)	(0.243)
Constant	−8.012***	−8.008***	−8.025***	−8.017***	−8.034***
	(1.435)	(1.444)	(1.443)	(1.452)	(1.451)
Observations	888	862	862	862	862
R-squared	0.011	0.012	0.012	0.012	0.012
Adjusted R-squared	0.00702	0.00514	0.00510	0.00398	0.00394

Notes Standard errors, in parentheses, are clustered at the municipality-level. All variables are first-differenced. *Interpretation* ***p < 0.01, **p < 0.05, *p < 0.1

trend reverses when a certain income threshold is reached. The turning points for income per capita lie between 48,585 and 66,810 constant 2000 Brazilian Reais, thus well within the range (cf. Table 10).

Included individually, the coefficient on population density is statistically significant with a positive sign, confirming our expectation that deforestation is more acute in densely populated areas. Nevertheless, the estimate turns out to be insignificant when including additional control variables.

4.3 Forest Fires

Table 3 reports the first differences estimates for our analysis on the relationship between forest fires and economic complexity in Brazilian states and the federal district between 2002 and 2009. As in Sects. 4.1 and 4.2, neither the ECI nor its square term are significantly different from zero in the baseline specification. The ECI estimate turns significant in specifications (6), (10), (11) and (12), suggesting a linear and positive correlation between forest fires and economic complexity. In other words, the number of forest fires rises with economic complexity. This can be ascribed to the fact that rising economic complexity is likely to call for a more efficient use of the land. Forest fires could be an easy way to clear the land for new activities.

Further, there is robust evidence for an inverted U-shape relationship between forest fires and per capita income. The square term of GDP per capita is significant in all specifications and bears a negative sign. In line with the EKC hypothesis, this implies that the number of observed forest fires in Brazilian states first increases with rising incomes, but levels off and starts declining at a certain GDP per capita value. This is because economic development is accompanied by a growing demand for environmental quality, which will render the regulatory framework limiting forest fires more effective.

Additionally, forest fires are significantly and negatively associated with trade openness, a finding that stands firm to the inclusion of multiple variables. All things equal, the number of annually observed heat sources in Brazilian states hence decreases with intensified trade. There is also evidence that the number of forest fires decreases with more hectares planted. While the sign of this estimate seems odd at first sight, if plantation accounts for reforestation as well, this might be an indication that Brazil's current sustainable reforestation projects are yielding the desired outcomes (cf. Goldenberg and Roberts 2015).

In order to test the robustness of our findings, we run regressions (1)–(12) on a subsample which does not comprise the state of São Paulo (unpublished results). São Paulo accounts for ECI values more than ten times higher than the other Brazilian states. Excluding this state confirms our findings from the full sample analysis with respect to economic complexity and trade openness. In the subsample analysis forest fires increase linearly with GDP per capita. This finding is not surprising when the

Table 3 Forest fires (first differences estimation)

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: forest fires					
ECI	287.7	419.1	415.4	418.5	413.2	430.2*
	(247.0)	(253.3)	(248.8)	(245.5)	(251.1)	(252.2)
$(ECI)^2$	−0.752					
	(0.811)					
GDP p.c.		7929**	8640***	8228**	7475**	7800**
		(2903)	(3046)	(3046)	(2821)	(2903)
$(GDP\ p.c.)^2$		−65.04**	−80.66**	−68.93**	−61.28**	−63.05**
		(25.83)	(35.26)	(27.66)	(24.72)	(26.23)
Population density			168.9			
			(180.8)			
Urbanisation				−133.8		
				(651.1)		
Trade openness					−12,401*	
					(7174)	
Average education						−4421
						(3363)
Higher education	–					
	–					

(continued)

Table 3 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: forest fires					
Harvested area	–					
	–					
Planted area						
	–					
Cattle density	–					
	–					
Constant	−620.7	−2694***	−2927***	−2737***	−2327***	−2001**
	(377.1)	(945.2)	(1024)	(946.1)	(834.7)	(774.9)
Observations	189	189	189	177	189	189
R-squared	0.008	0.119	0.120	0.126	0.122	0.127
Adjusted R-squared	−0.00309	0.104	0.101	0.105	0.103	0.108
	(7)	(8)	(9)	(10)	(11)	(12)
	Dependent variable: forest fires					
ECI	421.5	410.5	423.2	477.1*	618.3***	614.5***
	(252.4)	(249.5)	(251.6)	(248.0)	(203.5)	(206.2)
$(ECI)^2$						0.211
						(1.270)
GDP p.c.	7834**	8291**	8289**	9471***	13,537***	13,481***

(continued)

Table 3 (continued)

	(7)	(8)	(9)	(10)	(11)	(12)
	Dependent variable: forest fires					
	(2899)	(3357)	(3337)	(3227)	(4773)	(4808)
(GDP p.c.)^2	−63.28**	−68.47**	−68.63**	−78.80**	−118.3*	−116.7*
	(26.26)	(29.51)	(29.46)	(29.96)	(57.85)	(61.90)
Population density					−54.69	−68.77
					(350.9)	(414.7)
Urbanisation					493.6	496.8
					(568.1)	(580.6)
Trade openness					−304,53**	−304,48**
					(127,224)	(127,993)
Average education					−7783	−7771
					(6757)	(6754)
Higher education	−356.4					
	(468.2)					
Harvested area		−0.00192				
		(0.00182)				
Planted area			−0.00237		−0.00454*	−0.00456*
			(0.00191)		(0.00251)	(0.00254)
Cattle density				−70.50	−885.6	−886.6
				(437.2)	(610.4)	(617.1)

(continued)

Table 3 (continued)

	(7)	(8)	(9)	(10)	(11)	(12)
	Dependent variable: forest fires					
Constant	−2281***	−2668***	−2641***	−2607**	−970.4	−959.0
	(778.1)	(953.5)	(939.4)	(1165)	(1742)	(1791)
Observations	189	189	189	135	123	123
R-squared	0.121	0.121	0.122	0.155	0.220	0.220
Adjusted R-squared	0.102	0.102	0.103	0.129	0.158	0.150

Notes Standard errors, in parentheses, are clustered at the state-level. All variables are first-differenced. *Interpretation* ***p < 0.01, **p < 0.05, *p < 0.1

turning points of the full sample regressions are taken into account. The turning points are higher than the maximum income per capita recorded in the panel of ca. 55,000 constant 2010 Brazilian Reais (cf. Table 11). The highest turning point amounts to 62,231 Brazilian Reais and lies well outside the range. Reaching an income that allows to reverse the detrimental effect of growth on the environment is hence unrealistic, leaving the states in the upward sloping part of the EKC.

4.4 Air Pollution

Our last set of regressions examines the relationship between air pollution and economic complexity in Brazilian metropolitan regions from 2002 to 2009. In total, we analyse ten different indicators of air pollution: maximum and average concentrations of sulphur dioxide, nitrogen dioxide, TSP and ultrafine particles, as well as maximum concentrations of carbon monoxide and ozone. For most of these indicators the models were poorly specified and over-parameterised because of a low number of observations. Therefore, we give more emphasis to two air pollution indicators: maximum concentration of carbon monoxide, and maximum concentration of ozone. Tables 4 and 5 show that, neither economic complexity nor income per capita have a statistically significant impact on these air pollutants. In the case of ozone, population density has a robust and statistically significant impact on maximum concentrations. These concentrations decrease in more densely populated metropolitan regions, probably due to higher industrialisation standards providing cleaner technologies and enhanced environmental awareness on the part of their inhabitants. The other control variables have no robust impact on carbon monoxide or ozone concentrations. Finally, Tables 6 and 7 show some indication of a negative impact from ECI to air pollution and a positive impact from GDP per capita to air pollution. These results should be read with cautions given the low number of observations.

5 Conclusion

This paper investigates the extent to which economic complexity affects the environment in Brazil. We hypothesize that environmental degradation rises as economies diversify their production and become more complex, but an eventual structural change towards knowledge-intensive industries creates the technology necessary to limit degradation. Using panel data regression techniques and a rich set of control variables, we analyse the relationship between economic complexity and solid waste generation, deforestation, forest fires and air pollution. We find that waste generation decreases, but forest fires increase linearly with rising complexity. Economic complexity has no robust, if any, impact on deforestation or air pollution. In line with the traditional EKC, whereby degradation first increases and subsequently decreases

Table 4 Maximum carbon monoxide concentrations (fixed effects estimation)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Dependent variable: maximum carbon dioxide concentrations									
ECI	−0.0651	0.361	0.303	0.368	0.393	0.382	0.380	0.386	0.449	0.183
	(0.152)	(0.442)	(0.306)	(0.437)	(0.359)	(0.246)	(0.291)	(0.238)	(0.272)	(0.197)
$(ECI)^2$	0.456									0.302
	(0.292)									(0.340)
GDP p.c.		−6.223	−1.059	−1.886	−1.028	0.187	−0.559	0.378	0.747	−0.156
		(9.626)	(0.716)	(1.051)	(0.809)	(0.745)	(0.692)	(0.865)	(1.175)	(12.99)
$(GDP\ p.c.)^2$		10.20								1.332
		(23.66)								(31.91)
Population density			−2.175						2.099	1.444
			(1.404)						(2.731)	(1.655)
Urbanisation				0.113					−0.0683	0.0932
				(0.384)					(0.471)	(0.798)
Trade openness					−0.190**			−0.0365	−0.0172	−0.0546
					(0.0586)			(0.159)	(0.151)	(0.148)
Year						−0.0738**		−0.0973	−0.136	−0.107
						(0.0227)		(0.0799)	(0.0909)	(0.0956)
							−0.0327*	0.0156	0.0130	0.0143
Higher education							(0.0131)	(0.0277)	(0.0319)	(0.0307)

(continued)

Table 4 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Dependent variable: maximum carbon dioxide concentrations									
Constant	8.671***	14.67***	25.59**	12.74***	10.93***	156.4**	11.65***	202.2	266.5	212.5
	(0.230)	(3.014)	(9.564)	(1.564)	(1.728)	(44.87)	(1.590)	(157.9)	(173.2)	(186.0)
Observations	54	46	46	46	46	46	46	46	46	46
# of metropolitan regions	7	6	6	6	6	6	6	6	6	6
R-squared	0.103	0.136	0.172	0.133	0.169	0.219	0.198	0.223	0.231	0.253
Adjusted R-squared	0.068	0.0744	0.113	0.0714	0.11	0.163	0.14	0.125	0.0899	0.0662

Notes Standard errors, in parentheses, are clustered at the metropolitan region-level. We use the natural logarithm of all variables, except for the ECI, its square term, and the share of total economically active population which has attended higher education. *Interpretation* ***p < 0.01, **p < 0.05, *p < 0.1

Table 5 Maximum ozone concentrations (fixed effects estimation)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Dependent variable: maximum ozone concentrations								
ECI	0.137	0.379	0.28	0.336	0.384	0.381	0.377	0.084	−0.226
	(0.157)	(0.463)	(0.270)	(0.415)	(0.450)	(0.416)	(0.456)	(0.339)	(0.351)
$(ECI)^2$	0.285								0.303*
	(0.168)								(0.146)
GDP p.c.		12.98	1.092	0.206	0.144	0.579	0.143	−0.268	−9.402
		(21.66)	(1.119)	(1.400)	(1.548)	(0.933)	(0.970)	(2.209)	(22.78)
$(GDP\ p.c.)^2$		−30.50							20.41
		(53.64)							(58.10)
Population density			−3.398**					−8.768**	−10.39***
			(1.226)					(3.009)	(2.487)
Urbanisation				−0.789				−0.248	−0.216
				(1.086)				(0.784)	(0.511)
Trade openness					−0.0632			−0.0286	−0.0475
					(0.0901)			(0.150)	(0.102)
Year						−0.0257		0.0580	0.0862
						(0.0257)		(0.0873)	(0.112)
Higher education							−0.00688	0.0490	0.0599
							(0.0168)	(0.0562)	(0.0803)

(continued)

Table 5 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Dependent variable: maximum ozone concentrations								
Constant	5.042***	0.618	25.05**	7.620	4.751	55.34	5.164	−54.21	−96.71
	(0.185)	(5.845)	(9.602)	(6.190)	(3.363)	(52.82)	(2.726)	(166.5)	(233.3)
Observations	54	46	46	46	46	46	46	46	46
# of metropolitan regions	7	6	6	6	6	6	6	6	6
R-squared	0.063	0.070	0.122	0.080	0.047	0.052	0.046	0.223	0.249
Adjusted R-squared	0.0262	0.00389	0.0593	0.0141	−0.0211	−0.0154	−0.0221	0.0793	0.0613

Notes Standard errors, in parentheses, are clustered at the metropolitan region-level. We use the natural logarithm of all variables, except for the ECI, its square term, and the share of total economically active population which has attended higher education. *Interpretation* ***p < 0.01, **p < 0.05, *p < 0.1

Table 6 Average total suspended particle concentrations (fixed effects estimation)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Dependent variable: average TSP concentrations									
ECI	−0.149**	−0.112*	0.00745	−0.147*	−0.0196	0.0481	−0.0163	0.00259	−0.0983	−0.140
	(0.0543)	(0.0506)	(0.0435)	(0.0489)	(0.110)	(0.0745)	(0.0507)	(0.0772)	(0.0828)	(0.0851)
$(ECI)^2$	−0.00885									0.0999
	(0.0575)									(0.0462)
GDP p.c.		0.319	3.726**	6.377**	3.882	2.521	5.752***	4.845**	4.063**	4.292**
		(4.012)	(1.002)	(1.268)	(2.812)	(3.646)	(0.320)	(0.857)	(1.139)	(1.243)
$(GDP\ p.c.)^2$		−3.893	−8.842**	−16.77**	−10.32	−5.394	−13.21***	−11.39**	−12.04**	−12.43**
		(9.110)	(2.241)	(2.921)	(5.464)	(7.962)	(0.719)	(2.579)	(3.010)	(3.069)
Population density			−3.852***					−3.644*	−6.651*	−7.051*
			(0.707)					(1.444)	(2.487)	(2.382)
Urbanisation				0.648**				0.106	0.520	0.539
				(0.151)				(0.245)	(0.382)	(0.379)
Trade openness					−0.190				−0.107	−0.122
					(0.218)				(0.126)	(0.118)
Year						−0.0567			0.118	0.120
						(0.0340)			(0.115)	(0.109)
							−0.0235		−0.0209	−0.0184
Higher education							(0.0154)		(0.0328)	(0.0313)

(continued)

Table 6 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Dependent variable: average TSP concentrations									
Constant	4.343***	7.094**	28.12***	1.051	3.642	116.7	3.022***	27.87*	−186.2	−187.5
	(0.0448)	(2.188)	(3.997)	(0.949)	(2.929)	(66.24)	(0.214)	(10.58)	(210.4)	(199.8)
Observations	42	34	34	28	34	34	28	28	28	28
# of metropolitan regions	6	5	5	4	5	5	4	4	4	4
R-squared	0.026	0.136	0.313	0.405	0.210	0.204	0.502	0.682	0.747	0.763
Adjusted R-squared	−0.0244	0.0492	0.219	0.302	0.100	0.0946	0.415	0.610	0.641	0.645

Notes Standard errors, in parentheses, are clustered at the metropolitan region-level. We use the natural logarithm of all variables, except for the ECI, its square term, and the share of total economically active population which has attended higher education. *Interpretation*: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 7 Average ultrafine particle concentrations (first differences estimation)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: average PM10 concentrations							
ECI	−0.0540	−0.0587	−0.0734	−0.0122	−0.0745*	−0.0775	−0.0164	0.0251
	(0.0448)	(0.0314)	(0.0422)	(0.0364)	(0.0366)	(0.0393)	(0.0395)	(0.0376)
$(ECI)^2$	−0.0124							−0.0396
	(0.0495)							(0.0397)
GDP p.c.		7.525	1.026**	1.492**	1.205***	1.222***	1.715*	7.427
		(5.725)	(0.258)	(0.417)	(0.212)	(0.201)	(0.837)	(7.125)
$(GDP\ p.c.)^2$		−14.57						−13.01
		(12.84)						(15.32)
Population density			−1.222				0.584	1.202
			(1.439)				(1.498)	(2.351)
Urbanisation				−0.493**			−0.543	−0.553
				(0.171)			(0.297)	(0.280)
Trade openness					−0.0196		0.0380	0.0423
					(0.0424)		(0.0769)	(0.0769)
Year						7.48e−05	0.00837	0.00790
						(0.0191)	(0.0327)	(0.0318)
Higher education								

(continued)

Table 7 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: average PM10 concentrations							
Constant	−0.0206	−0.0510*	−0.0279	−0.0587**	−0.0456	−0.0492	−0.0912	−0.103
	(0.0183)	(0.0213)	(0.0267)	(0.0198)	(0.0241)	(0.0427)	(0.0867)	(0.0842)
Observations	39	32	32	32	32	32	32	32
R-squared	0.009	0.121	0.115	0.225	0.107	0.106	0.231	0.245
Adjusted R-squared	−0.0457	0.0272	0.0199	0.142	0.0110	0.00983	0.0459	−0.0177

Notes Standard errors, in parentheses, are clustered at the metropolitan region-level. All variables are first-differenced. We use the natural logarithm of all variables, except for the ECI, its square term, and the share of total economically active population which has attended higher education. *Interpretation* ***p < 0.01, **p < 0.05, *p < 0.1

with income, we find a non-linear relationship between economic development and waste generation and deforestation.

Being the first study to investigate the environment-complexity nexus for Brazil, it leaves scope for improvement and extension. The quality and quantity of Brazilian data as well as the access to it should be enhanced and facilitated. Moreover, our study can possibly be extended by time series analyses on individual municipalities or states. Notwithstanding these considerations, our study sheds first light on the compelling relevance of economic complexity as a potential additional driver of environmental degradation. To that extent, our paper is also novel since such a relationship has not been analysed in other academic papers. By looking at economic complexity we pay specific attention to the structure of the economy. Nonetheless, the impact of economic complexity and technological progress on environmental quality cannot easily be separated from environmental policies. As Jaffe et al. (2003) argue, well-designed environmental policies can contribute to technological innovation and dissemination and can help maintain (or create) a high standard of living. There is a strong need for Brazil to develop and conciliate specific national and local industrial and environmental policies to increase the economic complexity of its industries and create growth in a sustainable way by protecting the environment.

Appendix

Data Sources

Table 8 contains the sources of all the data employed in our study. This includes both data of variables included in the regressions, and data of variables used to construct or transform variables that could not be found in the necessary disaggregation level. The variables are listed in alphabetical order.

Descriptive Statistics

Tables 9, 10, 11 and 12 provide descriptive statistics for our five panels. Since we find robust evidence for inverted U-shaped relationships between income per capita and solid waste generation, deforestation and forest fires in Sect. 4, the statistics on income per capita are needed to determine whether the turning points of the EKCs lie within the range.

Table 8 Data sources

Variable	Unit	Disaggregation level	Source
Air pollution indicators (average concentrations)	Microgram per cubic meter	Metropolitan region	IBGE
Air pollution indicators (maximal concentrations)	Microgram per cubic meter	Metropolitan region	IBGE
Area	Square kilometre	State, metropolitan region, municipality	IPEA, PRODES (INPE)
Average years of education	Units	State	IPEA
Cattle	Units	State, municipality	IPEA
Cattle density	Units per square kilometer	State, municipality	Constructed with IPEA Data
Deflator	Annual percentage	United States of America	World Bank
Deforestation rates	Square kilometers	Municipality	PRODES (INPE)
Domestic solid waste Generation	Tons per day	Municipality (state of São Paulo)	CETESB
Domestic solid waste generation per capita	Kilograms per day per person	Municipality (state of São Paulo)	Constructed with IPEA and CETESB data
ECI	Index	State, municipality	SECEX/MCID
ECI	Index	Metropolitan region	Constructed with SECEX/MCID data
Exchange rate	USD-BRL	Brazil	IMF
Export volume	Current USD	State, municipality	UN Comtrade
Export volume	Current USD	Metropolitan region	Constructed with UN Comtrade data

(continued)

Table 8 (continued)

Variable	Unit	Disaggregation level	Source
Export volume	Constant 2010 BRL	State	Constructed with UN Comtrade, IMF and World Bank data
Export volume	Constant 2000 BRL	Metropolitan region, municipality	Constructed with UN Comtrade, IMF and World Bank data
Forest fires	Number of heat sources	State	IBGE
GDP	Constant 2010 BRL	State	IPEA
GDP	Constant 2000 BRL	Metropolitan region, municipality	IPEA
GDP per capita	Constant 2010 BRL	State	IPEA
GDP per capita	Constant 2000 BRL	Metropolitan region, municipality	Constructed with IPEA data
Import volume	Current USD	State, municipality	UN Comtrade
Import volume	Current USD	Metropolitan region	Constructed with UN Comtrade data
Import volume	Constant 2010 BRL	State	Constructed with UN Comtrade, IMF and World Bank data
Import volume	Constant 2000 BRL	Metropolitan region, municipality	Constructed with UN Comtrade, IMF and World Bank data
Population density	Inhabitants per square kilometer	State, metropolitan region, municipality	Constructed with IPEA (and PRODES) data
Rural population	1000 inhabitants	State, metropolitan region	IBGE
Share of individuals with low/intermediary/high education	Percentage	State, metropolitan region	Constructed with IBGE data

(continued)

Table 8 (continued)

Variable	Unit	Disaggregation level	Source
Trade openness ratio		State, metropolitan region, municipality	Constructed with IPEA, UN Comtrade, IMF and World Bank data
Total harvested area	Hectares	State, municipality	IPEA
Total planted area	Hectares	State, municipality	IPEA
Urban population	1,000 inhabitants	State, metropolitan region	IBGE
Urban-to-rural-population ratio		State, metropolitan region	Constructed with IBGE data

Abbreviations CETESB (Companhia Ambiental do Estado de São Paulo); IBGE (Instituto Brasileiro de Geografia e Estatística); IMF (International Monetary Fund); INPE (Instituto Nacional de Pesquisas Espaciais); IPEA (Instituto de Pesquisa Econômica Aplicada); SECEX/MDIC (Secretaria de Comércio Exterior/Ministério da Indústria, Comércio Exterior e Serviços); UN Comtrade (United Nations Commodity Trade Statistics Database)

Table 9 Descriptive statistics

Variables	N	Mean	SD	Min.	Max.
Waste generation p.c.	5805	0.350	0.135	0.0182	4.320
ECI	3169	0.381	1.582	−4.652	19.41
$(ECI)^2$	3169	2.647	16.36	0	376.8
Trade openness	2253	0.483	1.319	5.02e−05	29.49
GDP p.c.	5160	8.153	7.342	1.867	115.6
$(GDP\ p.c.)^2$	5160	120.4	451.1	3.487	13,368
Population density	5805	299.2	1190	3.714	12,956

Panel: solid waste generation

Table 10 Descriptive statistics

Variables	N	Mean	SD	Min.	Max.
Deforestation rate	9880	17.85	59.40	0	1408
ECI	2622	−0.125	0.805	−8.223	9.972
$(ECI)^2$	2622	0.663	5.535	0	99.44
GDP p.c.	6832	4.255	5.308	0.743	84.49
$(GDP\ p.c.)^2$	6832	46.27	252.3	0.552	7139
Population density	9874	23.08	124.9	0.0736	2732
Trade openness	763	0.533	1.269	0.000307	18.04
Harvested area	6765	15,762	52,826	8	847,884
Planted area	6765	15,997	53,433	8	875,851
Cattle density	4533	33.20	35.74	0.000564	247.8

Panel: deforestation

Table 11 Descriptive statistics

Variables	N	Mean	SD	Min.	Max.
Forest fires	216	7632	12,746	36	75,548
ECI	216	0.650	29.51	−29.26	153.6
$(ECI)^2$	216	867.1	4091	7.54e−06	23,591
GDP p.c.	216	14.49	9.172	4.953	55.15
$(GDP\ p.c.)^2$	216	293.6	501.8	24.54	3041
Population density	216	64.76	97.82	1.548	449.3
Urbanisation	204	5.674	6.322	1.355	30.16
Trade openness	216	0.0631	0.0793	0.00122	0.471
Average education	216	6.247	1.119	3.982	9.643
Higher education	216	20.61	5.803	8.070	39.24
Harvested area	216	2.256e+06	2.740e+06	12,726	9.998e+06
Planted area	216	2.297e+06	2.769e+06	13,687	1.007e+07
Cattle density	162	29.06	18.64	0.570	69.96

Panel: forest fires

Table 12 Descriptive statistics

Variables	N	Mean	SD	Min.	Max.
Sulphur dioxide (avg. concentration)	54	9.037	4.829	0	25
Sulphur dioxide (max. concentration)	59	148.8	229.4	14	1395
Nitrogen dioxide (avg. concentration)	47	34.13	17.84	7	83
Nitrogen dioxide (max. concentration)	52	261.1	142.0	82	716
TSP (avg. concentration)	42	88.36	70.83	36	328
TSP (max. concentration)	43	380.7	287.3	89	1379
PM10 (avg. concentration)	47	34.34	13.69	16	72
PM10 (max. concentration)	54	167.5	71.13	59	420
Carbon monoxide (max. concentration)	54	8571	3515	3557	21,641
Ozone (max. concentration)	54	228.7	149.7	97	1081
ECI	72	0.292	0.700	−0.621	2.104
$(ECI)^2$	72	0.568	1.223	1.12e−06	4.428
GDP p.c.	64	11.28	4.784	5.386	24.36
$(GDP\ p.c.)^2$	64	149.9	142.2	29.01	593.3
Population density	64	953.3	856.2	38.73	2489
Urbanisation	56	56.36	45.09	9.419	161.0
Trade openness	72	0.399	0.411	0.0192	2.468
Higher education	56	47.97	4.758	39.51	58.43

Panel: air pollution

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Consideration of Environmental and Socio-economic Aspects of a Territory for Sustainable Production and Consumption in a Biorefinery Context

Tatiana Bratec, Pauline Marty and Nadège Troussier

Abstract The question of sustainable production and consumption is increasingly being raised in our modern society. The depletion of natural resources, the deterioration of environmental quality as well as the degradation of ecosystems and human health lead to a reconsideration of public production and consumption patterns. More attention is paid nowadays to the production and consumption of biomass-based products. Biomass represents a sustainable alternative to oil products, allowing us to obtain a wide range of different commodities and to guarantee environmental, social and economic benefits. However, in order to ensure really sustainable production and consumption, it is not enough to produce goods from biomass instead of oil. It is necessary to ensure sustainable management, starting with the choice of the sustainable biorefinery location, passing through the value and supply chains, which must guarantee minimum waste and environmental emissions, and finishing with sustainable consumption of goods. This article discusses the choice of an optimal sustainable biorefinery location, while taking into account the environmental and socio-economic characteristics of a territory. Several zones of one French region were considered for this investigation. Each zone was studied in terms of its ecological (access to water resources, …) and socio-economic (unemployment rate, …) aspects. The results of our study demonstrate which aspects are the most important when choosing the optimal sustainable location, and which of the studied zones is most suitable for the biorefinery sustainable anchoring.

Keywords Environment · Territory · Biorefinery · Sustainable development

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1 Introduction

The fossil fuel era had a great influence on human development, contributing considerably to global technological, economic and social progress. Fossil fuels are still the main resources for the world energy supply and account for more than 80% of worldwide primary energy consumption (Escobar et al. 2009). However, since these reserves are being steadily depleted and as fossil sources are subjected to certain economic (e.g. increasing market prices, …) and environmental (e.g. air quality, global climate change, …) concerns, the search for and development of alternative sources has been launched by the global community. Among these sources, particular attention is given nowadays to biomass, seen as the only natural possibility for replacing solid, liquid and gaseous fossil fuels in large quantities (Klass 1998).

Biomass is non-fossil organic material that has stored sunlight in the form of chemical energy. It could be produced from agriculture, forestry, municipal waste and residues. At present, global demand for biomass is constantly increasing, driven by market development as well as regulatory policies implemented in many countries. Apart from its contribution to the energy supply, the biomass is increasingly used for the production of a variety of chemical products and construction materials (Dornburg et al. 2008). The use of biomass in the industrial production of both energy and non-energy sectors is supported at national, regional and local levels (Cherubini 2010) by the development of new biorefinery facilities or by the integration of biorefinery processes into already existing industrial infrastructures. However, as Cherubini (2010) indicates, newly constructed biorefineries most probably encompass a whole range of different-sized installations, unlike, for example, those converted from former oil refineries, which are almost invariably very large plants (Cherubini 2010).

International Energy Agency Task 42 proposed the following definition of biorefinery: "*Biorefining is the sustainable processing of biomass into a spectrum of bio-based products (food, feed, chemicals and materials) and bio-energy*" (Bioenergy 2014). Biorefineries are grouped into two main categories: energy-driven and material driven biorefinery systems. In the first case, the biomass is used for the production of secondary energy carriers, while in the second case, the biorefineries generate bio-based products and process residues that could be then processed or utilized for the energy production (Cherubini et al. 2009). According to 2017-year data of the Cologne-based nova-Institute, 224 biorefineries of different types ("sugar-/starch based", "oil-/fat-based—biodiesel" and "oil-/fat-based—oleo chemistry", "wood-based", "lignocellulose other than wood" and "bio-waste-based") are operating across Europe, and several dozen more are currently under construction. The type of these refineries is dependent on the locally available biomass (Green Chemicals Blog 2017). Indeed, to guarantee sustainable, well-operating biorefineries it is very important to provide a well-organized management strategy since poor management and inappropriate direction of biorefineries could contribute to deterioration in environmental quality and endanger social and economic development. In addition, the consideration of possible environmental and socio-economic aspects should be considered not only at the operational stage, but long before the facility

starts operating and even before its construction. This could help in the selection of an appropriate site ensuring that the biorefinery is both sustainable and embedded at the territorial scale, thus minimizing environmental impact and guaranteeing the best economic and social profits.

The problem addressed in this paper can be described as follows: a consortium of industrial actors defined a new bio-based process to create biomolecules they believe would have an interesting market potential. The process is actually at the sixth level of *Technology Readiness Level* and the next development phase implies the study of its industrial production, from a lab- to a biorefinery-scale. The goal of the project is to study the construction of a new biorefinery facility or to integrate the defined industrial process to an already-existing infrastructure. In addition to the technology used, the candidate feedstock is also a given, other aspects of the biorefining value chain are not identified. We therefore have the possibility of providing different scenarios for the value chain stages (considering different feedstock production and storage sites, transport modes and distances, …). The main goal of this work is to select the optimal location for the new biorefinery/or identify where the industrial process could be integrated into existing infrastructures. The final choice of the biorefinery location will depend on the performance of the territory (three potential territories are under study) in terms of a combination of its environmental, social and economic parameters.

2 Optimal Sustainable Biorefinery Location: A Short Literature Review

The question of optimal biorefinery location is not absolutely novel and it has already been discussed by a significant number of studies (Marvin et al. 2012; Santibañez-Aguilar et al. 2014; Harvey and Pettersson 2014; Serrano-Hernandez et al. 2016; López-Díaz et al. 2017; Ng and Maravelias 2017, etc.). Despite an increasing interest into this issue, there is at present no generally accepted methodology allowing easy identification of the most important criteria to be considered. Nevertheless, we propose to find out more about possible criteria discussed by the authors.

For example, Serrano-Hernandez et al. (2016) indicate that the location of biorefineries is a critical factor since many tactical and operational decisions depend on it. The authors specify that the choice of the optimal location requires the analysis of several factors, from many points of view, namely economic, social, technological, commercial and environmental. However, within the case study presented, only the environmental impacts of biorefinery location are discussed, based on the model's calculations. The authors highlight that for the best biorefinery location the environmental impacts should be minimized: the distances between the facility and tactical sites (e.g. crop and stockage places) should be as short as possible.

Santibañez-Aguilar et al. (2014), identify among important criteria for biorefinery location: the selection of raw materials (including their availability and seasonality),

treatment routes, harvesting sites, processing and markets. Through the application of the model to a case study of a multi-product biorefinery in Mexico, the authors show how the variation of several parameters at different stages of a biorefinery supply chain can influence the results on environmental, social and economic issues considered simultaneously. The authors consider various biomass feedstocks at different harvesting sites, multiple potential geographical locations for processing plants, various production technologies and storage facilities, as well as different transport modes between the supply chain components and market options. Nine types of bioresource (wood chips, sugar cane, corn grain, sunflower, etc.) are involved in the study producing two final products (bioethanol and biodiesel). Six different possible sites are considered for raw material production and processing. Four different processing technologies are considered. Finally, five possible locations are included for the sale of the products. The measurement of environmental impacts is performed using the life-assessment technique (Eco-indicator 99), while the social effects are studied by quantifying the number of jobs generated. The results show that the selection of year-round feedstock could bring cost-effective solutions. From the economic point of view, it is better to use wood chips for the ethanol production, while from the environmental and social points of view, sugar cane and sorghum present more benefits.

According to López-Díaz et al. (2017), the key parameters that must be taken into account for the optimal biorefinery location are the type of biomass to be cultivated, available land, water resources, energy, infrastructure and socio-economic aspects. The authors indicate that the location of cultivation areas is directly connected with the location of end-use biorefineries. The biomass availability depends significantly on geographical location and seasonal variability. However, the construction and operation of a biorefinery could expand the cultivation areas necessary for the raw material production. The authors propose considering different potential processing location sites and feedstock selection, as well as potential markets. Nevertheless, water is used within almost all biorefinery chain stages (cultivation and harvesting sites, pretreatment and processing), this study gives priority to the impact of interactions of biorefinery systems on water resources. A material flow analysis formulation is used for the modeling of the surrounding watershed interacting with the biorefinery system, through water use and wastewater discharge.

Harvey and Pettersson (2014) have proposed more detailed criteria that may influence the choice of the biorefinery location. The authors suggest taking into account the following parameters: proximity of raw materials and envisaged market, presence of heat sources, existing experience and know-how available in the territory. The proximity of raw materials enables shorter transport distances and, therefore, reduces associated environmental effects and economic costs. Closeness to the market/consumer could also reduce impacts. The opportunity for heat integration is one of the most significant driving forces for biorefinery location, ameliorating its overall efficiency. The heat integration of a biorefinery with an already existing industrial process or a district heating system could avoid excess heat use, and therefore, reduce the heating costs. The re-use or co-use of existing process units or infrastructures reduces investment costs. Moreover, it leads to reduced technical risks since the expe-

rience and know-how are already present within the industry. However, if the effects of some parameters (e.g. transportation distance or degree of heat integration) are rather easy to evaluate, the effects of others (e.g. existing experience and know-how) are more difficult to quantify.

Harvey and Pettersson have also shown that a co-location of biorefineries with different types of industries could be very advantageous. For example, pulp and paper industries are specifically interesting in terms of biorefinery co-location for several reasons, namely closeness to biomass resources, long-term experience, well-developed infrastructures for handling large biomass volumes, etc. The co-location with the petrochemical and oil refinery industries could also present many positive aspects. For example, these industries could use intermediate biorefinery products as feedstocks for their production processes. They also provide possibilities for heat integration. Besides, petrochemical/oil refinery industries have experience and know-how concerning final products and their possible markets. However, if these industries are far from the biomass resources, and lack knowledge/experience in biomass handling, this could be regarded as disadvantages to this type of co-location. The authors highlight, in addition, that all types of industrial processes could consider the integration with a biorefinery for heat integration purposes, without any material flow exchanges or use of existing process units.

In conclusion, it is noted by the authors that the appropriate location for the different parts of the biomass conversion chain, in relation to each other and to existing industries, is very important for the biorefinery performance. However, the entire chain "raw material—final products" need not necessarily be located on the same site; intermediate products could be produced and transported to other places for further upgrading.

Thus, the literature review shows that several parameters, such as raw materials (biomass), transport, energy and market, are commonly identified within the aforementioned studies aimed at identifying the optimal biorefinery location. Other parameters are only mentioned in one or two studies, despite this fact their importance cannot be questioned and we cannot ignore them, each of them has its unique sense within the specific case study. However, it should be stressed that all the papers described are based on real case studies, i.e. already existing biorefineries, while our investigation deals with a potential biorefinery. Thus, a broader selection of parameters could be necessary.

3 Towards Sustainable Biorefinery Location Based on Social, Economic and Environmental Aspects: A Case Study of a Potential Biorefinery Facility

As mentioned before, the construction of a new biorefinery or the integration of the chemical process to an already existing industrial infrastructure is considered. The new biorefinery, producing various bio products from the sunflower plant, will be

built/integrated in France. Two scenarios are considered for the annual production capacity: 1 t (minimum) and 100 t (maximum).

First, in order to identify study territories, three French regions should be chosen for the potential biorefinery installation/integration. Thus, we analyzed the 13 French regions in terms of their bioeconomy strategy (led by local public and private actors), biomass potential, scientific and technical capital, presence of different industrial complexes as well as already-present biorefineries and transport infrastructure. According to the analysis, the regions were classified into three groups: (1) Regions of high development, (2) Regions of medium development and (3) Regions of poor development. The regions of the first group are characterized by an excellent bioeconomy strategy, they have significant technical and scientific potential and a well-developed industrial sector as well as transport infrastructure. In the regions of the second group, the bioeconomy strategy is less developed, technical and scientific sectors are quite well developed, but the industries in the biomass sector are rare. The regions of the third group have a poorly developed bioeconomy strategy, limited biomass potential as well as scientific, technical and industrial sectors. To study regions at different development levels, we decided to select one region from each group. In addition, we avoided selecting neighboring regions in order to differentiate the geophysical parameters of studied territories.

Within this paper, only one region of the three selected will be discussed—The Grand Est region (a region of high development), located in the east of the country. The region is one of the European leaders in terms of bioeconomy strategy with well-developed economic, innovation and internationalization plans. Various universities, research and technology centers, innovative platforms, industrial complexes working in the field of bioeconomy/biorefinery as well as renewable sources are located here. The region possesses the Bazancourt Pomacle biorefinery, an archetypal territorial biorefinery and an example of industrial ecology, representing a network of connections between different biorefinery territorial actors (Bioeconomy in European regions 2017). The regional monitoring and observatory of ID Champagne-Ardennes have produced regional biorefinery maps (https://id-champagne-ardenne.fr/en/bioeconomy-potential-grand-est-region-maps), showing its bioeconomy potential. The maps are based on different themes: abundant feedstock, industrial partners in biomass production and processing (agro-industry, wine, wood, chemical industries, textile and plastics processing), research and development centers and experimental platforms. Three sites representing three case studies have been chosen within this region to evaluate which one of them could be the most appropriate biorefinery location in terms of its environmental, social and economic performances (Fig. 1).

Site selection is based on the already existing biomass production and processing industries in the chemical sector, as well as research and development centers and experimental platforms in the region (see regional biorefinery maps). Site 1 is located in the industrial zone of the Bazancourt Pomacle biorefinery. Thus, the integration of the chemical process into an already existing industrial facility is considered. There are numerous research and development centers, as well as several experimental platforms located here. Site 2 is located far from any existing industries, development and research centers and experimental platforms as well as main trans-

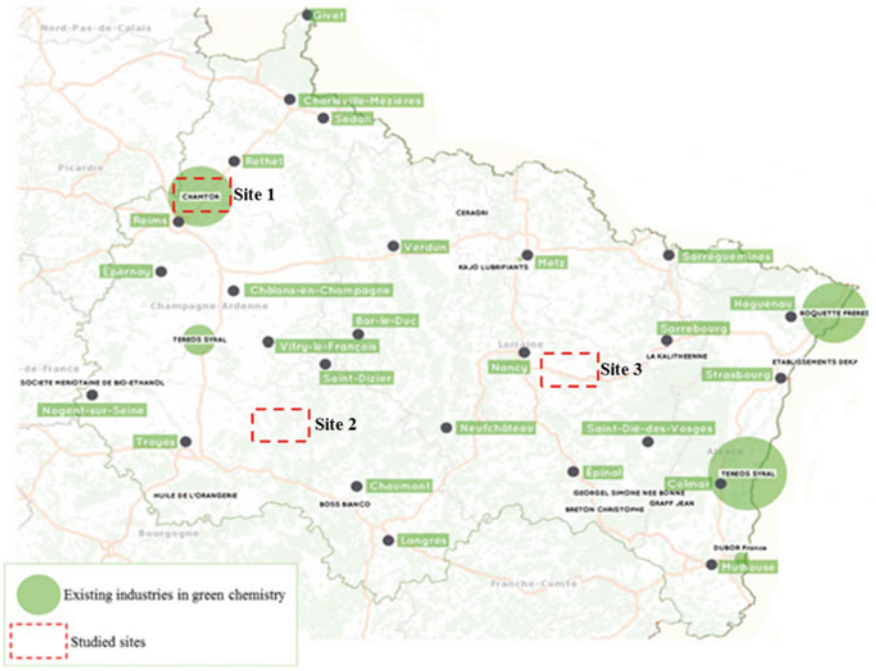

Fig. 1 Schematic location of studied sites (adapted from ID Champagne-Ardennes biorefinery maps)

port communications and big cities. The study will consider the construction of a new biorefinery facility there. Site 3 is situated near Nancy, where road communication is well-developed. Several development and research centers and experimental platforms are located near the site. However, site 3 does not include any existing industrial structures. Therefore, the construction of a new biorefinery will also be considered.

The first preliminary analysis of socio-economic and environmental aspects of these sites is presented below.

3.1 Social and Economic Impacts and Territorial Embeddedness

Despite the fact that socio-economic aspects, along with environmental ones, are part of a sustainable development strategy, they have currently received very little attention in biorefinery studies (Raman et al. 2015). Furthermore, when studied, those aspects are reduced to quantitative parameters (e.g. the number of jobs created (López-Díaz et al. 2017)) or to static parameters (existing know-how (Harvey and

Pettersson 2014), in spite of the local know-how elicited by the implementation of the biorefinery). Rakotavao et al. (2017) presents a fairly full literature review of socio-economic issues of existing biorefineries. In addition, the authors provide their own picture of the socio-economic assessment of rural-agricultural biorefineries in order to measure their territorial embeddedness. The case study presented is focused on two starch biorefineries located at different sites in France. Based on the interviews conducted with various biorefinery stakeholders, namely managers, biomass producers, agricultural cooperatives as well as local authorities and others, the authors provide the framework to assess the socio-economic impacts and territorial embeddedness of biorefineries. Thus, the study of Rakotavao et al. (2017) represents a starting point for our investigation, by adapting the social- economic parameters of the existing biorefinery complexes to the potential biorefinery facility. The analysis of other parameters presented by the authors, influencing territorial embeddedness, was also carried out in order to identify which of them could be important to consider for the potential biorefinery.

In existing literature, the economic impacts usually focus on the economic benefits of the biorefinery (profitability, return on investment, net present value, …). Indicating that this is not sufficient to measure the real economic fallout of the biorefinery on a territory, the authors propose the following economic parameters: the ability to mobilize local resources, including raw materials as well as human resources and skills, and the ability to promote the local economy, including operations with local subcontractors, contribution to regional production and impact on agricultural employment.

In our opinion, almost all of these parameters could be considered for our case study. The *ability to mobilize local raw materials* allows the industrial facility to be integrated locally, with local suppliers. Based on the biomass potential data of the Grand Est region, 17,070 ha was used for sunflower cultivation in 2016 (Statistiques des oléagineux et plantes riches en protéines 2015–2016) and it did not change significantly in other years. According to our evaluations, for the minimal annual industrial production envisaged, only 0.66 ha of sunflower are necessary, while the maximum production requires 65.57 ha. It means that the region is capable of providing the necessary quantity of initial feedstock in both production cases and this could contribute to the local economy. However, several concerns could be raised. For example, it is necessary to know if the cultivated sunflower feedstock of the region is already assigned to specific industries/purposes/activities or not. If all raw materials are supposed to be distributed to defined actors, additional sunflower production is needed, that would necessitate the evaluation of consequences on direct and indirect land uses. If the additional quantities of sunflower cannot be cultivated, the raw materials would have to be imported from other regions or neighboring countries which will not benefit the local economy and would affect environmental impacts since additional transportation is necessary. The *ability to mobilize local human resources and local skills* is also of importance. There are various educational institutions in the region, able to prepare qualified specialists/engineers/technicians and, therefore, to provide the labor force necessary for the biorefinery facility. However, this parameter would not have the same importance for site 1 and sites 2–3. Since site 1 is to be

integrated to the existing industrial facility that has already employees working there, probably less (or even zero) new human resources would be necessary. For sites 2–3, however, all the human resources must be recruited. Therefore, more expense would be necessary for sites 2–3 to assure the working activity. However that represents more social profits for the local recruitment rate. The parameter *operation with local subcontractors* measures the ability of the biorefinery to interact with regional economic operators. The fact of having local subcontractors could promote the activity of local micro and small enterprises. It is necessary to assure this activity at as many biorefinery value chain stages as possible. In depth study is necessary to confirm this, but, for all the studied sites, operation with local subcontractors seems to be feasible at each biorefinery value chain stage. *The contribution to regional production* defines the capacity of the biorefinery to create value for the local territory. The market of final products is still not identified; therefore, it is difficult to make an analysis of our case study on this issue. However, it could be implemented in the case of potential biorefinery facility when the market objectives are known. *The impact on agricultural employment*, corresponding to the proportion of local farmers involved in the biorefinery supply, is the only economic parameter that seems to be difficult to integrate to the inexistent biorefinery facility. Currently it is impossible to predict how many famers will be involved in the biorefinery activity, and furthermore this parameter depends also on the agricultural techniques (more or less labor-intense) used by the farmers.

The social dimension includes the following parameters: social equity of farmers (form of collaboration with local producers, contract sustainability, contract flexibility, price policy, adaptation to specifications and assistance of farmers) and social acceptance (participation to social development, ability to contain and reduce nuisances).

The form of collaboration with local producers includes two main types: "integrated sector" when the biorefinery concludes a supply contract with an agricultural cooperative to deliver the biomass feedstock, and "independent model" where the biorefinery obtains the feedstock from the market, by selecting the most attractive price. In our case study, site 1 implies the implementation of the process in an existing biorefinery in which an agricultural cooperative is a business partner. In that case, the form of collaboration with local producers will be an integrated one, where a contract is provided. In fact, the existence of a contract will ensure stability in the supply (volume and quality) for several years as well as in the revenue of local producers—an important point of the cooperative model. Furthermore, the biorefinery can ensure the necessary biomass feedstock's quality through the assistance of farmers, either by control and adaptation throughout the production phase, or by encouragement to switch to seeds or production techniques adapted to the required quality. For sites 2–3, the independent model is considered, which will imply that cheaper non-local feedstock might be chosen over local feedstock, and thus reduce the biorefinery's contribution to the local economy, as well as the ability of local producers to cope with price variability. This choice will then affect the distances that need to be considered in environmental impacts. *The form of contract sustainability* measures the duration of contracts between the biorefinery and local farmers and

storage agencies. In our case, site 1 will be studied with a pluriennial contract that goes together with the supply contract aforementioned. The 'independent model' for feedstock supply does not involve a contract for local producers. Site 2, close to the Nancy area, includes existing storage facilities with which a contract can be implemented—annual or pluriennial, whereas for site 3, no existing storage facility is included, meaning that the economic cost of finding a storage facility as to be taken into account, as well as the distance it may imply.

Among other parameters that could influence territorial embeddedness and be important to consider for a potential biorefinery, we can find spatial, temporal, institutional, organizational and cultural ones. Institutional factors will not influence our case study, because all the sites are located in a region where public authorities are committed to bioeconomy development through an ambitious and already implemented bioeconomy strategy. Nevertheless, regarding the organizational and cultural factors, site 1 will benefit from an existing partnership between economic actors in agriculture, biochemistry and research within the Pomacle-Bazancourt biorefinery that will facilitate the implementation of the value chains at each stage. The spatial dimension (including ground area, impact on agricultural land and accessibility to major transport routes) refers to the physical implantation of the biorefinery. For example, it is important to know the area occupied by the potential installation to estimate its impact on the territory. In our case, if a new biorefinery were constructed in the region (sites 2 and 3), it would occupy between 200 and 400 m^2 of land surface. In site 1, where the biorefinery will be integrated into an already existent infrastructure, this parameter could be ignored.

Territorial embeddedness of the biorefinery is a combination of all those factors and impacts, and, in that regard, cannot be studied only through quantitative data. Our study aims at combining quantitative and qualitative data, the latter obtained by a comprehensive study of local stakeholders for each site through interviews.

3.2 Environmental Considerations for the Territory

Even though biorefineries have lower environmental impact compared to petrochemical complexes, they could be associated with different ecological concerns, namely due to land and water use (Demirbas 2010). Currently, life cycle assessment (LCA) is one of the most commonly used methods to assess the environmental impacts of biorefineries (Caldeira-Pires et al. 2013; Caffrey et al. 2014; Ahlgren et al. 2015; Tonini et al. 2016). An LCA study is also considered for our case study at each stage of the biorefinery value chain, but at the second phase of territorial environmental evaluation. Within the first-phase evaluation, we propose to carry out the environmental analysis of three studied territories, based primarily on their natural characteristics.

Industrial activity has an obvious impact on environmental quality, by transforming natural bio-systems, degrading soils, reducing natural resources, contributing to the deforestation process and so on. Since some regions and localities could be

more susceptible to these anthropogenic interventions than others, we decided to begin with the analysis of the studied territories' natural space availability.[1] Site 1 is located in a zone of intense industrial activity, the natural space availability here is very low—less than 15%. However, construction of a new biorefinery is not planned here, so the impact on the natural space volume will not be changed. The natural space availability at site 2 varies from 15% to more than 80%, with the dominant natural space part of around 50%. This site is not currently experiencing intensive industrial disturbance. However, if the new industrial complex is constructed here, the territory would be subjected to a serious environmental transformation. As for site 3, the natural space availability is in the range of <15–50%. Therefore, this area is not characterized by a high natural space availability. In the case of a biorefinery facility construction it would undergo several transformations, but these would be less important than for site 2. None of the sites studied is located at the zone of existing/projected natural parks or biosphere reserves.

The activity of the biorefinery facility could impact the water quality at all stages of its value chain. Nevertheless, there are two main phases, involving large water volume use risking water pollution: the agricultural production site, including pretreatment site, as well as the industrial process site (Roundtable on Environmental Health Sciences 2014). To evaluate the possible water pollution of the three studied sites, we analyzed the regional hydrographic network[2] of the Grand-Est region. Sites 1 and 2 are located within a contrasting hydrographic network with many basin heads. Both sites are in the Seine-Normandy basin, where the hydrographic network is organized mainly around the Marne, the Aube and the Aisne rivers. The sites are rather close to several rivers that could be polluted during biorefinery operating. In contrast to site 1 where no new construction is envisaged, the process of biorefinery construction at site 2 could lead to more significant impact on local water resources. Site 3 is located in the Meuse basin, that is also crossed by many rivers. Thus, the construction of a biorefinery facility here and its operation could lead to water pollution.

Numerous past and present industrial and agricultural activities of the Grand-Est region led and still lead to soil pollution that is more or less obvious in different zones. At site 1, soil pollution as a result of industrial activity has been identified, however some specific treatment technologies have been implemented here; at this site the underground water quality is already under surveillance. At site 2, no polluted or potentially polluted soils are identified. Site 3 is located in a zone of polluted soils. In addition, it is situated near to a mine salt basin zone. As for air quality, all three sites are located in zones identified as not being sensitive to air pollution. However, it should be noted that this evaluation is limited, since the air quality sensitivity is based only on known NO_2 and PM_{10} emission levels.

[1]Based on the regional natural space map (http://draaf.grand-est.agriculture.gouv.fr/IMG/png/CarteGrandEstCom-OSCOM2014_EspNat_New1_cle85fdcb.png).

[2]The hydrographic network map of the Grand-Est region (https://www.actualitix.com/carte-grand-est.html).

4 Conclusion

This paper describes how the consideration of socio-economic and environmental aspects of a territory could influence a choice of the location of a new biorefinery facility. Three potential sites in the Grand-Est region in France are considered in our case study in order to find out which of them is the most appropriate for the biorefinery installation in terms of socio-economic and environmental performances.

Socio-economic aspects are the main factors of the territorial embeddedness of the new biorefinery. They rely on a combination of static and dynamic impacts that take place throughout the biorefinery value chain. From an economic standpoint the value-added by the process is important, but also the biorefinery's whole contribution to the local economy: agricultural employment, local contractors' markets, and the overall contribution to enhancement of local skills. Regarding the agricultural sector, the biorefinery's contribution may be very large, but depends on collaboration with this sector and whether it takes place over a long or short time period. From this point of view, site 1, where the new biorefinery will be established in an existing partnership between biochemistry and agricultural sectors, will be the case study with the most intense territorial embeddedness.

The first phase of environmental evaluation, based on the natural context of the studied territories, shows that it is really important to consider such characteristics in order to identify the currently existing environmental problems. Past or present activity could have caused serious environmental degradation that would make it impossible to envisage any future projects. According to the preliminary results obtained from our analysis, there seems to be less environmental impact on the natural space availability and the water quality at site 1 than sites 2 and 3. This is due to the fact that for site 1 the integration of the defined chemical process into the existing industrial infrastructure is envisaged, while for sites 2–3 construction of a new biorefinery facility would be necessary. The analysis of the actual situation on soil pollution suggests that site 2 would have less environmental impact during the operating stage. According to the geological context of site 3, the possibility of constructing a new facility here seems to be rather low. However, we must insist on the fact that our preliminary analyses have numerous limits and more detailed study on the environmental impacts of the planned activity is necessary.

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The Role of the Ecological Fiscal Transfers for Water Conservation Policies

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Abstract The purpose of this chapter is to fill the lacuna found in the literature with regard to describing the role of EFTs for water conservation policies. The literature tells us that ecological fiscal transfers (EFTs) are analysed so to pursue biodiversity conservation policies and solid waste management (SWM). For biodiversity conservation policies, EFTs have two purposes: (1) to incentivize municipalities to create local protected areas (PA); and (2) to compensate municipalities for corresponding land-use restrictions. In the case of SWM, the main idea is that, even considering the fees paid by the households, it is still costly to maintain waste services in the municipal territories. In this context, EFTs are appealing policy instrument to help local governments create landfills or composting plants. However, in Brazil EFTs are functioning as a policy instrument which also includes a wide range of policy domains, such as water conservation, indigenous land, fire-control, and so on. Six states adopted EFTs specifically for water conservation policies: Goiás, Paraná, Pernambuco, Piauí, Rio de Janeiro, and Tocantins. Descriptive analyses, focusing on legislative differences are conducted for each of these states.

Keywords Ecological fiscal transfers · Water conservation policies · Brazil

1 Introduction

Ecological fiscal transfers (EFTs) redistributes revenues from upper to lower levels of government using ecological indicators (Ring and Barton 2015). Brazil was the first country to adopt ecological indicators in fiscal transfers (Ring 2008; Paulo and Camões 2018), followed by Portugal (Droste et al. 2017) and France

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(Schröter-Schlaack et al. 2014). Poland has already introduced the discussion on EFT implementation introduced in the policy arena (Schröter-Schlaack et al. 2014), and other countries have theoretically simulated such a scheme: Germany (Ring 2002), Switzerland (Köllner et al. 2002), and Indonesia (Mumbunan et al. 2012).

Brazil follows a mix of policy instruments to achieve targets in environmental policies (May et al. 2012). EFTs are a policy tool, among others, that contribute to achieve environmental and social goals at local level. Its operation in Brazil is based in a tax collected from the state government which is transferred to municipalities. There are several policies targets introduced in EFTs schemes across Brazilian states, but the literature theoretically and empirically explores two: protected areas (PA) and solid waste management (SWM).

The potential of EFTs goes beyond those related to PA and SWM. Indigenous land, fire control, environmental education, and water conservation are examples of policies in which EFTs tools may contribute to sustainable local development. In the case of water conservation policies, there is a literature gap on the role of EFTs mechanisms regarding the incentive and compensation to local governments in such fiscal transfers. It is an exciting research agenda because it can inspire other developing countries to adopt similar policies so to achieve goals related to water policies. It is strongly related to the 2030 Agenda for Sustainable Development, particularly concerning the importance in ensuring availability and sustainable management of water and sanitation for all.

The paper is structured in three more sections. The second section addresses the EFTs policy tool in Brazil, detailing the mechanism of fiscal transfers, the criteria that is usually adopted, and the potential of EFTs across states. The third section addresses the role of the ecological fiscal transfers for water conservation policies, mainly concerning the incentive and compensation. The last section presents the conclusion, by showing suggestions for future research and policy recommendations.

2 Ecological Fiscal Transfers in Brazil

Ecological fiscal transfers in Brazil are a mechanism for redistributing a tax collected from the state government, the ICMS (*Imposto sobre Operações Relativas à Circulação de Mercadorias e sobre Prestações de Serviços de Transporte Interestadual e Intermunicipal e de Comunicação*), to local governments. They are known using different names: *ICMS Ecológico, ICMS Verde*, and *ICMS Socioambiental*. To be precise, three-quarters of the revenue collected from ICMS remains with the state government and only one is redistributed to local governments. Three-quarters of this one-quarter is transferred according to fiscal value-added criterion, while remaining quarter may be transferred according to the state-policy objectives. The states are free to decide upon the criteria used in these transfers. EFTs may compose the amount destined to state-policy objectives (see Fig. 1).

EFTs in Brazil are not earmarked, that is, the local governments can use the money they receive as they deem fit. The first state to adopt EFTs in Brazil was Paraná in

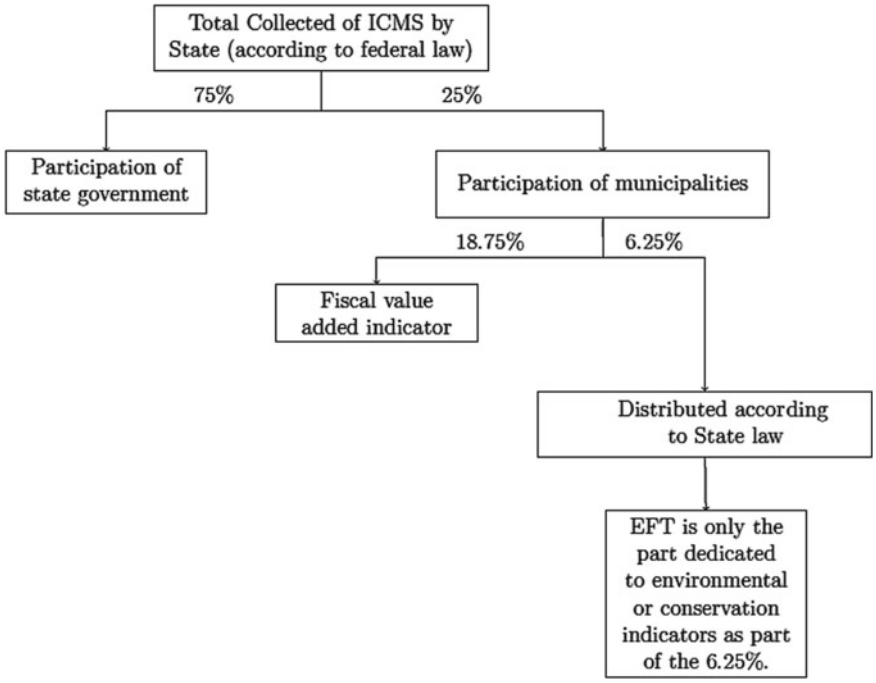

Fig. 1 Ecological fiscal transfers in Brazil. *Source* de Paulo and Camões (2017)

the early 1990s. To date, there are sixteen out of twenty-six states that have adopted ecological indicators to redistribute the ICMS. The criteria vary according to each state, including those related to water conservation policies. However, there are two main areas which are usually adopted across Brazilian states: protected areas and solid waste management (see Table 1).

EFTs schemes adopted in Brazil have one criterion in common: protected areas. The comprehensive literature on EFTs highlights their objective for the protected area as a mechanism to compensate local governments for land-use restrictions and to serve as an incentive mechanism for local governments to create a more protected area (Droste et al. 2017; Sauquet et al. 2014). Sauquet et al. (2014) summarize EFTs objectives for protected areas in two ways: first, for "*[…] rewarding municipalities for hosting state and federal PAs*"; second, for "*encouraging municipalities to create new PAs*." The incentive component of EFTs originates from the creation of new protected area by local governments, while the compensation component comes from the protected areas imposed by federal government and state government that lead to a loss in the economic exploitation of the land by the municipal government. Also, the municipality is compensated in creating a new protected area due to the benefits of the land-restrictions which go beyond its borders. Usually, there are quantitative and qualitative measurements to evaluate a protected area by the state government. The state government may use the area of the protected area, its category (meaning

Table 1 EFT criteria adopted across Brazilian states

States	Protected areas	Solid waste management
Paraná	x	
São Paulo	x	
Mato Grosso do Sul	x	x
Minas Gerais	x	x
Amapá	x	
Rondônia	x	
Rio Grande do Sul	x	
Pernambuco	x	x
Mato Grosso	x	x
Tocantins	x	x
Acre	x	
Ceará	x	x
Rio de Janeiro	x	x
Piauí	x	x
Goiás	x	x
Paraíba	x	x
Pará	x	

Source Paulo (2017)

the degree of land-use restrictions of PA), as well as its quality of management (Paulo and Camões 2018).

In the case of solid waste management, nine out of twenty-six states having adopted EFTs, have waste-related indicators in their schemes. These indicators vary across states, but the landfill and composting plants appear more frequently (see Table 2).

As a developing country, most of the Brazilian states face problems with solid waste management, mainly where the collection and disposal are concerned. Although the federal government implemented a command and control instrument which imposes the deactivation of dumps at the local level—the National Policy on Solid Waste-, most municipalities still persist in maintaining inadequate waste disposal in their territory (Castagnari 2005). Changing such an institutional arrangement at the local level is an enduring task for politicians, and deactivating dumps at the local level and implement landfills and composting plants, have proved challenging. Firstly, mayors face financial stress and do not have enough money to cover all expenses for their electorate, despite a fee paid by each household. Also, implementing a landfill in their territories create conflicts among residents, a movement so called as NIMBY (Not in My Back Yard). Another difficulty is that officials have to choose from between policies that align with the expectation of their electorate in order to increase political benefits. Then there is the problematic situation in which

Table 2 Solid waste criteria in EFTs schemes

States	Waste-related indicators
Goiás	Collection, transportation and final destination for solid waste; landfill; incineration of waste; recycling; and composting plant. All of these criteria include also treatment for hospital and civil construction waste
Mato Grosso do Sul	Selective collection; municipal plan for solid waste management; treatment and disposal of solid waste
Pernambuco	Landfill; composting plants
Piauí	Collection and transportation of solid waste; public cleaning services; special waste; hazardous waste; and social and economic inclusion of collectors of recyclable
Ceará	Collection and transportation of solid waste; Landfill
Rio de Janeiro	Landfill
Tocantins	Collection, transportation, and final destination for solid waste
Minas Gerais	Landfill; composting plants; and recycling
Mato Grosso	Collection, transportation and final destination for solid waste

Source Compiled by authors from The Nature Conservancy TNC (2017)

most of the local government disposes their waste far away from areas with a higher populational density or, at times, in other municipalities. Collective action among mayors may minimize costs to implement landfill and composting plants due to economies of scale. Also, EFTs are a remedy to minimize the costs for such actions and they function as a financial incentive for politicians if the money they receive exceeds the costs in implementing and operating a landfill, a composting plant, or another waste management system.

Empirical works on EFTs present the potential of the policy instrument across Brazilian states. Concerning protected areas, Droste et al. (2017) find in all Brazilian states that "*there are clear indications for local responses to the implementation of EFT: after an ICMS-E introduction additional municipal PA are designated*". The conclusion of Grieg-Gran (2001) in Minas Gerais was that "*the ICMS ecológico has the potential to create incentives for conservation but the effect appears to be highly variable*". Sauquet et al. (2014) studied the interaction effect among local governments in terms of EFT´s incentive to create new protected areas. They found that the creation of local PA "*reveals strategic substitutability in municipalities´ conservation decisions*"; that is, "*the creation of [PA] by a municipality decreases the incentive of neighboring municipalities to create [PA].*"

Empirical works on EFTs concerning solid waste management are relatively scarce. In the state of Pernambuco, Silva Jr et al. (2012) conclude that the "*ICMS Socioambiental*" did not contribute to the improvement of the solid waste management across local governments. de Paulo (2013) notes a similar pattern in Pernambuco. The author concludes that only twelve out of one hundred eighty-four municipalities have tried to increase landfills.

3 Ecological Fiscal Transfers for Water Conservation Policies

As presented in the last section, EFTs are traditionally applied to biodiversity conservation policies and solid waste management. However, the state government can use EFTs for other policies, such as water conservation programmes. Six out of twenty-six states EFTs having adopted such a programme, implemented criteria related to water conservation policies in Brazil (see Table 3).

Water policies vary little across states. They share some common strategies related to water policies: water conservation, quality, protection of water sources and river, and protection of public water supply. In the state of Goiás, the EFTs scheme for water policies comprises five percent of the total amount dedicated to such policy instrument (see again Fig. 1). The criteria in the scheme are based on programmes related to water conservation and protection of public water supply at the local level, that is, the policy instrument works as an incentive for municipalities to implement these policies in their territories. In the state of Paraná, water policies comprise 2.5% of the EFTs to be redistributed to municipalities. This policy instrument encourages local governments to preserve basins of superficial springs that serve the urban centers of neighboring cities, as well as the underground springs that also help the

Table 3 Water conservation policies criteria in EFTs schemes

States	Water-related Indicators	Legislation
Goiás	Water conservation, protection of public water supply (water quality)	Supplementary law n.º 90, 22 December 2011
Paraná	Protection of water sources	Constitution of the state of Paraná, 5 December 1989, Law n.º 9.491, 21 December 1990, Supplementary law n.º 59, 1 October 1991, Supplementary law n.º 67, 8 January 1993, Decree n.º 2.791, 27 December 1996, Decree n.º 3.446, 14 August 1997, Decree n.º 1.529, 2 October 2007
Pernambuco	River protection and water sources	Law n.º 15929/2016
Piauí	Protection of water sources, water quality	Law n.º 5.813, 3 December 2008, Decree n.º 14.348, 13 December 2010
Rio de Janeiro	Water quality	Law n.º 5.100 4 October 2007, Decree n.º 41.844, 4 May 2009
Tocantins	Water conservation	Law n.º 1.323, 4 de April 2002, Decree n.º 1.666, 26 December 2002, Regulation COEMA n.º 2, 4 November 2003

Source Compiled by the authors from the state legislations

urban centers of neighboring municipalities. In Piauí, the EFTs scheme is based on stamps, which vary from "A" to "B", "A" meaning the best standard of environmental protection at the local level, and "B" the minimum standard of environmental protection of municipalities to receive money from EFTs. Such schema dedicate five percent, among other criteria, for water conservation policies at the local level. It comprises protection of water sources, such as the protection of areas where water sources are recharged, replantation or conservation of riparian forest and headwaters, adequate disposal of sanitary sewage, and monitoring the quality of the public water distributed and served. In Rio de Janeiro, the EFTs scheme comprises 30% of the total dedicated to EFTs and has two main criteria: the watershed drainage area and water supply springs. In Tocantins, the EFTs scheme for water policies comprises only 3.5% (among other criteria: basic sanitation, and solid waste management) includes the quality of the public water distributed and served. In Pernambuco, EFTs for water conservation is not regulated by the state government so far. However, the inclusion of conservation of water source and rivers is predicted for near future.

The role of ecological fiscal transfers for water conservation policies in these schemes is to secure the availability and sustainable management of water and sanitation at the local level by providing financial incentive and compensation to local governments. Incentive because some municipalities in developing countries face financial stress and lack of technology to provide such type of public good. Mayors face dilemmas when making policy choices for their electorate. Compensation because municipal governments will be more willing in contribute to providing a collective good (water conservation) in which its benefits extend beyond their borders. They are compensated for the benefits that other municipalities may enjoy, such as the case of EFT in Paraná that compensate local governments that preserve basins of superficial springs which, in turn, serve the urban centers of neighboring cities. This role of EFTs is strongly supports goal 6 of the 2030 Agenda for Sustainable Development.

4 Conclusion

EFTs in Brazil redistribute the ICMS from the state government to local governments using ecological indicators. This mechanism can be quite different from other tax systems, such as in more centrally governments. It can change the incentive and compensation dimensions of EFTs to be implemented. However, both cases may apply such policy tool to achieve targets in water policies.

As a policy recommendation, we suggest participation of the political actors involved in the policy process. EFTs are a redistributive policy tools which affect the budget of local governments. This effect may be strong for developing countries; therefore, this strategy can minimize conflicts and resistances.

For future research, we recommend testing the effects of EFTs for water conservation policies empirically, mainly to test whether with the introduction of EFTs the water policies increased at the local level (concerning quality and quantity).

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Green Infrastructure and Social Welfare. Lessons for Sustainable Urban Development in the Metropolitan Zone of Leon, Mexico

Jairo Agustín Reyes Plata, Mónica Elías Orozco and Iliana Zuri Jiménez Villaseñor

Abstract Making cities and human settlements inclusive, safe, resilient and sustainable is a goal of sustainable development (Sustainable Development Goal 11, SDG 11). To achieve sustainable cities, urban planning of natural spaces must contribute to deal with the socioenvironmental challenges brought by urbanization. However, planning strategies for green infrastructure are frequently skewed toward ecological aspects. Such a unidimensional perspective in the development of planning tools may have a poor contribution to social welfare. Therefore, there is a need for integrating the social aspects to achieve effective planning, and to recognize the social contributions of green infrastructure. The objective of this study is to diagnose the functions and dysfunctions of green infrastructure, as well as its contributions to the social welfare in the Metropolitan Zone of Leon, Mexico. The area of study is characterized by an accelerated urban growth in one of the most dynamic industrial regions in the country. The methodology includes an assessment of green infrastructure components of its distribution. An evaluation of welfare-related social context was also conducted. Main results showed that (i) green infrastructure can be a strategic approach for the land sustainability, (ii) the metropolitan area of Leon showed the existence of key green infrastructure components and reveled a fragmented network of natural spaces and (iii) people perceived social and environmental functions and dysfunctions from green infrastructure components. This study has concluded that an effective planning approach to green infrastructure should integrate functions and dysfunctions related to social context. This approach may contribute to create more sustainable cities with benefits for all people.

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1 Introduction

Cities are the center of sustainability crisis: economic, ecological, political and cultural. They encompass problems associated with climate change, deficient supply of basic services, social inequality and the lack of essential public goods. UN-Habitat estimates that in 2015 cities concentrated 7.3 billion people and that this figure may reach 9.7 billion in 2050 (2018). Population growth will have massive consequences for sustainable development.

In this context the UN-Habitat advocates for a new type of city, one sustainable city, one people-centered city, with equal access to quality public services, and where tangible and intangible aspects of prosperity are integrated. A key concept in this approach is "prosperity", defined as "a social construct that materializes in the realm of human actions. It builds deliberately and conscientiously on the objective conditions prevailing in a city at any time, wherever located and however large or small. This is a broader, wide-ranging notion that has to do with a well-balanced, harmonious development in an environment of fairness and justice" (UN-Habitat (United Nations Human Settlements Programme) 2013, p xii).

In accordance with this definition a major action to achieve prosperity is that cities invigorate urban planning and design approaches and tools for social welfare. It may imply to pursue, among other objectives to ensure the provision of infrastructure for supporting quality of life, equity and environmental sustainability (UN-Habitat (United Nations Human Settlements Programme) 2013). Despite the solutions may be different depending on local conditions, some key interventions include the provision of public goods and infrastructure for all inhabitants (UN-Habitat (United Nations Human Settlements Programme) 2018).

Green Infrastructure approach has been recently introduced in urban planning as a novel approach for the land conservation and land management. This approach implies the creation of a network of open spaces in multiple scales, with different qualities and functions, according to the natural attributes of land (Calderon-Contreras and Quiroz-Rosas 2017; Vásquez et al. 2016). Planning strategies for green infrastructure are frequently skewed toward ecological aspects. Such a fragmented and unidimensional perspective in the development of urban planning may have a poor contribution to social welfare. There is a need of integrating the social aspects to achieve effective planning, and to recognize the social contributions of green infrastructure. Therefore, the present study builds upon a diagnosis on the functions and dysfunctions of green infrastructure components for the social welfare in one of the most dynamic industrial regions in Central Mexico. The analysis focuses on the inhabitants' perception about the benefits and problems of different open natural spaces in the Metropolitan Zone of Leon, Mexico. Additionally, lessons for sustainable urban planning are discussed.

2 Green Infrastructure as a Strategic Approach for the Urban Sustainability

According to the 2030 Agenda, making cities and human settlements inclusive, safe, resilient and sustainable is a goal of sustainable development (Sustainable Development Goal 11, SDG 11) To achieve this objective, effective urban planning can contribute to tackle with the socioenvironmental issues brought by urbanization (e.g. accelerated expansion of urban areas, aquifer depletions, increasing urban footprint, loss of native species or heat island phenomena).

The New Urban Agenda (UN-Habitat (United Nations Human Settlements Programme) 2017) integrates a set of commitments and principles related to the SDG 11. The Commitment 37 promotes the creations of safe, inclusive, accessible, green public spaces. It includes streets, sidewalks, bikeways, squares, gardens, parks and other natural spaces that provide multiples functions for social interaction, public health and social welfare; the Commitment 65 centers on the need of facilitating sustainable planning of natural resources in cities and human settlements in a way that it improves and protects urban ecosystems and environmental services, the reduction of greenhouse emissions and the management of natural disasters. Interestingly, Commitment 100 highlights the need for supporting well designed networks of streets and safe, ecological public spaces for all, free of delinquency and violence. Green infrastructure can be a strategic approach for the design of public space networks of ecological value and contributes to sustainable development of cities.

The meaning of green infrastructure has different interpretations. This study refers to Green Infrastructure (GI) as an interconnected network of natural spaces that provides environmental benefits. In this sense, Bendict and McMahon (2006) defines GI as "an interconnected network of natural areas and other open spaces that conserves natural ecosystems values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife". To the authors, green infrastructure constitutes a natural life-support framework for environmental, social and economic systems. From this perspective, green infrastructure components are key spaces in urban or rural settings that contributes to land sustainability.

The European Agency on Environment points out that green infrastructure is an efficient well-proved tool of urban planning that provides ecological, social and environmental benefits by nature (Gorm 2015). Natural and semi-natural spaces and other natural elements work together to provide ecological and social services. Ecological services include aspects, such as, the reduction of air pollution, flood mitigations and the improvement of environmental health (Austin 2017; Calaza 2016; Castro Castro 2018). Social services refer to the provision of a sense of history, sense of a place and leisure and recreation activities, among other benefits (Selman 2012). Seen from this perspective, green infrastructure serves as a multifunctional network of natural and semi-natural spaces and elements that provide benefits for the support and the improvement of the quality of life and the social welfare in multiple scales of a given territory.

Green infrastructure quality integrates a wide spectrum of open spaces: natural areas, woodlands, waterways, greenways, private and public lands, parks and other open spaces. A green infrastructure network connects all these spaces in a system of hubs, sites and links (Bendict and McMahon 2006) Hubs anchor green infrastructure network and may integrate strategic lands, ecosystems and landscapes for the biodiversity conservation. Sites are smaller than hubs but also provide important ecological and social functions. Links are key components to interconnect hubs and sites and create a system. It can be realized that components of a green infrastructure network are not all green and that can vary in size and ownerships. Despite the ecological and social potential of green infrastructure to provide environmental services and to contribute to urban sustainability, it depends on the ecosystem quality e integrity.

Urban sustainability is often reduced to the search for balance between the natural and built environments. However, the concept goes beyond the conservation of nature and its availability to meet the current and future material needs of the population. Urban sustainability implies to make the city livable, regardless of its size (Lezama and Domínguez 2006), meaning the quality of a place to meet the people's needs and aspirations in the individual and collective spheres (Castro 1999 cited by Moreno 2008). Thus, the adaptation of the surrounding environment has a purpose: to improve the quality of life. Pérez Maldonado (1999 cited by Moreno 2008) argues that the quality of urban life, which is an aspect of social welfare, involves the feeling of biological and psychosocial comfort of those who inhabit and live in the city, according to the degree of satisfaction in the use of services and the perception of the urban space as healthy, safe and visually pleasing. The presence of natural open spaces is therefore a conditioning factor of urban livability, resulting in the improvement of the inhabitant's quality of life and social welfare (Álcala 2007).

People perceptions about open natural spaces strive the conservation and planning of a green infrastructure network. Land can possess a network of parks, gardens, water bodies or natural areas broad enough to be recognized by inhabitants. Some people may appreciate that open spaces meet key functions for environment conservation and environment enhancement (e.g. provision of shade, contribution to clean air, biodiversity refugee, increase places attractiveness). In opposite, to many people open space simply refer not developed land without specific functions or dysfunctional spaces, where environmental problems and delinquency emerge (Busquets and Cortina 2009). This condition can affect the provision of ecological benefits of green infrastructure and be an obstacle for the enjoyment of social benefits.

3 Methodology

3.1 Area of Study

The area of study is the Metropolitan Zone of Leon in the State of Guanajuato. It belongs to the region known as Bajío Mexicano, an urban industrial belt for the automotive sector that has been favored by its strategic location in Central Mexico. The Metropolitan Zone is part of an agglomeration of 1.9 million inhabitants, equivalent to 35% of the State's population (INEGI 2015; Iplaneg 2018a, b). It includes four local administrative areas or "municipios": (1) Silao de la Victoria, (2) León de los Aldama, (3) San Francisco del Rincón y (4) Purísima de Bustos.

The Metropolitan Zone in Mexico is part of a public policy in urban matter to deal with regional issues that require local Governments' coordination.

Geographically speaking, the metropolitan area is characterized by the presence of steep slopes and hills to the north, large expanses of plains and some hills towards the center, a portion that comprises the urban area and of greater growth of the main city (Leon City) and by extensive plains towards the south, where different agricultural activities are performed. Landscape features oak forests, xerophytic shrubs and introduced plants.

Areas of special management along the study area include six natural areas (e.g. Sierra de Lobos, Cerro del Palote, Cerro del Cubilete and Presa de Silva), water bodies (e.g. Palote dam and San José dam) and perennial rivers (e.g. Guanajuato River, Silao River and León River).

3.2 Evaluation of the Distribution of Green Infrastructure Components in the Metropolitan Area of Leon

Conceptual references on green infrastructure were examined. Furthermore, a review on ecological and urban planning was carried out by gathering information from the current model of land management in Guanajuato, particularly in the Metropolitan Zone of Leon. Official plans and programs at local and State levels were reviewed in order to identify specific actions, plans or projects to create a network of open spaces. Additionally, geographical information on the natural, green and public spaces were consulted from the National Geography System of Mexico (INEGI 2018).

A key aspect was the evaluation of green infrastructure attributes. It includes the attributes related to scope, scale, settings and geographical features. This helped to establish different categories of evaluation.

Additionally, interviews were held with governance personnel (Director and Charmain of State Government) on urban and ecological planning and with members of a Local Council on Landscape and Urban Image to ask for information on (i) the existing initiatives about green infrastructure and (ii) the current principles and model

of land management. The Council is integrated by public authorities, businessmen, academics and other members of the civil society.

3.3 Evaluation and Diagnosis of the People's Perception About Social Benefits of Green Infrastructure

We conducted a diagnosis protocol in order to gather information on the people's perception about green infrastructure components and its benefits (environmental, social and economic). Two aspects of green infrastructure were included by authors: (i) perception of functions (benefits) and (ii) perception of dysfunctions (problems). With these two aspects the aim was to answer these questions: What is the current public perception about the benefits and problems associated to different green infrastructure components? What are the green infrastructure components with positive perception and why? What are the green infrastructure components with negative perception and why?

We conducted a survey by using Zoho platform (Zoho Corporation Pvt. Ltd. 2018), from 8th to 17th of October 2018. A sample was selected by using a Simple Random Sampling ($p = 0.05$). According to this method a representative sample was 384 inhabitants. This work collected the data from 377 inhabitants in the study area. All participants must have met three conditions: (i) $\geq$18 years old, (ii) permanent residents in some of the four 'municipios' and (iii) $\geq$6 months old residency at the same 'municipio'.

A semi-structured questionnaire was designed for the survey. It includes open and closed questions about five categories of green infrastructure components: (i) natural area, (ii) water body, (iii) park, (iv) greenways and (v) rivers. People were asked about benefits and problems of components in the three dimensions of sustainability: environmental, social and economic (Table 1).

4 Results

4.1 Local Authorities and the Council Members Showed Inconsistent Understanding on Green Infrastructure Approach

Local Authorities and members of Local Council in Landscape and Urban Image of Leon participated in a meeting that was designed to investigate the perception on green infrastructure approach and about initiatives to create a system of natural open spaces.

Based on a self-developed questionnaire, meeting participants were asked: (i) What does green infrastructure mean for you? And Do you believe it is important

Table 1 Sustainability aspects related to natural spaces

Sustainability dimension	Benefits	Problems
Environmental	Improve environmental quality and mitigate global warning	Sources of pollution and a risk for human health
Economic	Increase property value	Decrease property value
	Contributes to attractiveness places and sightseeing activities	Abandoned places without any activity
Social	Contributes to social inclusion and harmony	Trigger conflicts among neighbors
	Fosters physical activity and public health	Trigger unsafe conditions and vandalism
	Release stress and generate positive emotions	

Adapted from Austin (2017), Bendict and McMahon (2006), Calaza (2016), Castro Castro (2018) and Selman (2012)

and why? (ii) What specific plans or projects on green infrastructure are you collaborating at? (iii) What do you believe challenges green infrastructure planning at the Metropolitan Area of Leon?

Regarding the conceptual perception on green infrastructure, interviewees perceived green infrastructure as a network, a set of elements, a planning tool or a policy. Public spaces, natural spaces and green spaces were mentioned as key components of a green infrastructure network. Despite there is no an agreement on what green infrastructure is, it was associated with the provision of services that contribute for the enhancement of quality of life and the development of city. Interestingly, green infrastructure is perceived beneficial for urban settings. To many participants, the perception on benefits was implicit. Meaning that authorities and the Council members have a general concept but less understanding of the characteristics of green infrastructure and its specific benefits.

The collaboration in plan or projects about a green infrastructure system or its components is not common. Participants only mentioned that they respect trees or nature elements in the projects. Although, some participants mentioned to be collaborating on research about some components of green infrastructure (e.g. parks).

Based on the results of interviews and questionnaires, two aspects were mentioned to strive green infrastructure planning: (i) coordination among local authorities and (ii) a misunderstanding of green infrastructure approach. Interestingly, some interviewees reported there is a need for stimulating a discussion on the green infrastructure approach among the authorities and with the public.

4.2 *Metropolitan Area of Leon Showed the Existence of Key Green Infrastructure Components and Reveled a Fragmented Network of Natural Spaces*

Ecological and urban plans at local and state levels were analyzed in order to identify the existence green infrastructure components. We used national data of Mexico about open and natural spaces in the Metropolitan Area of Leon (INEGI 2018). Five components (natural areas, rivers, water bodies, parks and greenways) were classified into categories and subcategories based on the following attributes: (i) type of green infrastructure component (hub, site and link), (ii) subtype based on the scope (regional, metropolitan and local), (iii) component, (iv) land settings and (v) geographical features (Table 2). Nine categories and 4459 subcategories were obtained. Categories express the sort of green infrastructure component (e.g. RH: Regional Hub, LL: Local link) and subcategories refer to characteristics of green infrastructure component (e.g. 'municipio' + land settings + geographical feature = Leon + natural area + sierra/plateau). A summary with the results can be consulted in the Table 3.

Table 2 Attributes for the green infrastructure categories

Green infrastructure			Land settings	Geographical feature
Type	Subtype	Component		
Hub	Regional	Natural area	Urban	Plateau
Site	Metropolitan	Water body		Plain
		Park	Rural	Hills
Link	Local	Green corridors		Mountain
		Rivers		

Table 3 Categories and subcategories of green infrastructure

Type	Subtype	Category	Total of categories
Hub	Regional	RH	2
	Metropolitan	MH	1
	Local	LH	2
Site	Regional	RS	21
	Metropolitan	MS	2
	Local	LS	1998
Link	Regional	RL	6
	Metropolitan	ML	19
	Local	LL	2408
		Total	4459

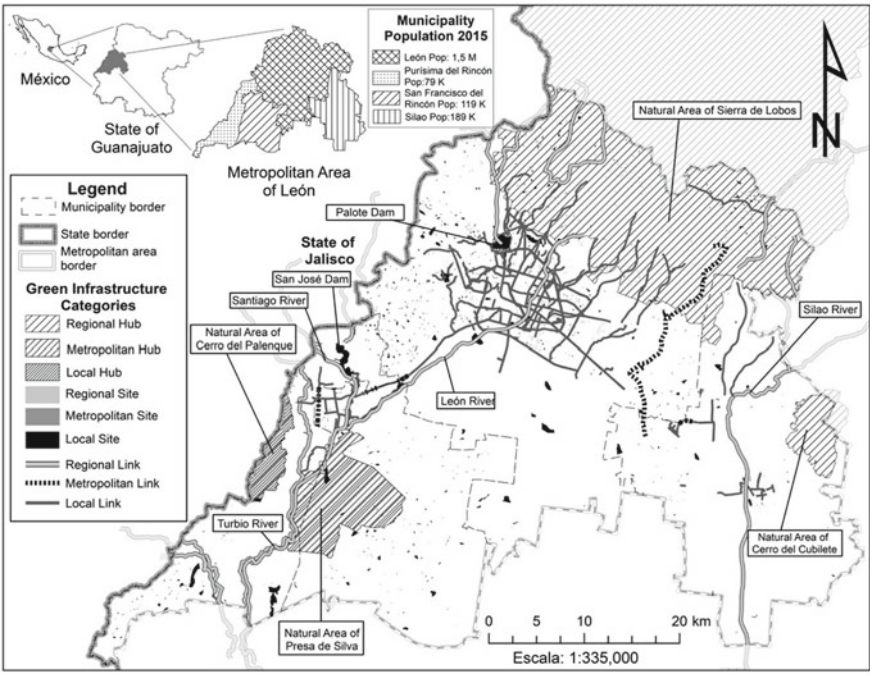

Fig. 1 Distribution of green infrastructure components

Regarding the categories, different components of a green infrastructure network (hubs, sites and links) were identified at regional, metropolitan and local scales. First, hubs are key components for the conservations of ecological biodiversity. Some examples include the natural areas (e.g. Sierra de Lobos, Cerro del Palenque and Presa de Silva), where there are different elevations of regional importance (Fig. 1). Sites are local parks in the urban settings the most and concentrate on the 'municipio' of Leon. Similar to parks, links are mainly at the local scale. These are green corridors the most. Meaning that connections have a local scope within the 'municipio'.

Interestingly, there are 6 regional links. One of them (Leon River-Turbio River) has connections with a regional hub and metropolitan hub and connections to another links (green corridors or water streams). This reveled that some links can contribute to create a green infrastructure network.

4.3 Sociodemographic Characteristics of Participants in the Survey

372 inhabitants participated in the survey about green infrastructure (Table 4). 52.69% (196 ppl.) were females. The majority of people belongs to the ≥18–29 years

Table 4 Demographic characteristics of survey about green infrastructure

Variable	Category	N	%	Variable	Category	N	%
Gender	Male	176	47.31	Residency years	≥6 months-1 year	10	2.69
					1–5 years	31	8.33
	Female	196	52.69		6–19 years	67	18.01
Age	≥18–29 years old	188	50.54		≥20 years	264	70.9
	30–39 years old	64	17.2	Occupation	Students	90	24.19
	40–59 years old	103	27.69		Professionals	199	53.49
	≥60 years old	15	4.03		Factory worker	7	1.88
Current residency	León	318	85.48		Merchant	15	4.03
	San Francisco del Rincón	12	3.23		Businessman	27	7.26
	Purísima del Rincón	6	2.96		Housewives	22	5.91
	Silao	11	1.61		Other	12	3.23

old group. Many participants (64.25%) reported to be residents for more than 20 years in the Metropolitan Area of Leon. More than half of the people interviewed are inhabitants of Leon (85.48%). Finally, many participants engage on different professional fields.

4.4 People Perceived Social and Environmental Benefits from Green Infrastructure Components

People perceived different benefits from green infrastructure components (Table 5). Benefits were referred to the environmental and social dimensions of sustainability (e.g. enhancement of quality of life or contributions to social inclusion).

Parks obtained most positive rates. Green corridors and natural areas followed. The highest positive rate (84%) was for the component of green corridors. People believed that they contribute to enhance environmental quality, specifically air quality. Parks were associated with social values and health benefits (87 and 82% respectively). It can be expected that the green is the key element that provides these benefits. Additionally, this means that green corridors and parks are key open spaces to perceive benefits from green infrastructure.

Table 5 Benefits perception of green infrastructure

Value	Green Infrastructure component									
	Natural areas		Water bodies		Parks		Greenways		Rivers	
	N	%	N	%	N	%	N	%	N	%
Improve environmental quality and mitigate global warning	239	65	210	60	271	74	294	84	149	41
Increase property value	139	38	88	25	249	6	174	49	28	8
Contributes to attractiveness places and sightseeing activities	271	74	101	29	285	77	54	15	18	5
Contributes to social inclusion and harmony	210	58	116	33	320	87	102	29	35	10
Fosters physical activity and public health	184	50	115	33	302	82	178	51	46	13
Release stress and generate positive emotions	188	52	110	31	272	74	178	51	58	16
None	6	2	62	18	1	0.27	13	4	140	39
Other benefits	9	2	23	7	5	1	15	4.26	37	10.2

In contrast, rivers were rated the lowest of all items. Finally, economic benefits were associated to parks.

4.5 People Perceived Environmental Issues from Key Green Infrastructure Components

People perceived environmental issues of green infrastructure components, particularly rivers (Table 6). For many people rivers were a source of pollution and a risk for health (60%) and abandoned places without any activity (40%). These aspects are related to environmental and economic dimensions of sustainability. Rivers are key components to connect a green infrastructure network in the Metropolitan Area of Leon, although people perceived them negatively. Meaning that rivers are an obstacle for having a positive perception of green infrastructure as a unit.

In opposite, parks were rated the lowest of all items, which confirms that parks meet positive rates the most.

5 Discussion

We have conducted a diagnosis on the functions and dysfunctions of green infrastructure components for the social welfare with the aim to contribute to an effective planning approach of natural open spaces. The results are based on a homogenized framework on green infrastructure concept, the evaluation of green infrastructure components in the Metropolitan Area of Leon and the perception of public, local Authorities and members of local Council. This framework was used to evaluate (i) the distribution of green infrastructure components in the Metropolitan Area of Leon, and (ii) the people's perception about social, economic and environmental benefits and problems of green infrastructure.

The common framework was an important starting point because the green infrastructure approach was recently introduced in land planning. This was the basis for evaluating the existing distribution of green infrastructure in the study area and of the different social perceptions on its components.

In the present work, we have identified that people attached different benefits (functions) and problems (disfunctions) to green infrastructure. People did not perceive all different natural spaces as social, economic or environmental beneficial. Meaning that each component of a green infrastructure network may meet different functions within a network and have different contributions to urban sustainability. Therefore, having a network that integrate a variety of components is desirable to keep ecological values of land. This perspective is important but only if it takes into consideration the environmental dimension of sustainability, disregarding the social dimension to achieve an effective urban land planning.

Table 6 Perception on problems about green infrastructure

Problems	Green Infrastructure component									
	Natural areas		Water bodies		Parks		Greenways		Rivers	
	N	%	N	%	N	%	N	%	N	%
Sources of pollution and a risk for health	16	5	65	29	15	4	30	9	199	60
Decrease property value	4	1	5	2	3	0.87	4	1	28	8
Abandoned places without any activity	32	9	64	29	17	5	76	22	133	40
Trigger conflicts among neighbors	14	4	20	9	14	4	15	4	34	10
Trigger unsafe conditions and vandalism	39	11	62	28	24	7	89	26	117	35
Do not generate problems	244	70	91	41	259	75	176	51	56	17
Other problems	20	6	10	4	21	6	32	9	25	8

The physical settings have been traditionally considered key aspects for the quality of life and social welfare. For instance, Gelh (2013) holds that social benefits of open spaces rely on aspects related to proximity and connectivity. However, proximity does not ensure itself equitable access or translate into positive effects if people cannot freely experience the place due to social factors in the environment such as crime or heavy vehicular traffic (Jennings et al. 2016). The sociodemographic characteristics of the population, as well as their needs, merits and choices, can aslo determine the opportunities for enjoying benefits from green infrastructure components (Hay 1995).

In consequence, ongoing projects and plans must contribute to tackle with the problems that trigger negative perception of green infrastructure. Open spaces with green elements and activities met positive rates. In contrast, people evaluated negatively rivers. Connectivity is key to stablish a green infrastructure network; therefore, a negative perception of people about rivers may be an obstacle to integrate efficiently a green infrastructure network that provide benefits for all inhabitants. People reported that rivers were abandoned and without activities. Local authorities have fostered some initiatives and projects to create linear parks along rivers, however it has not succeeded. Gelh (2013) mentioned that uncomprehensive design and planning approaches trigger social conflicts on the use and attractiveness of places.

A land planning based on a green infrastructure approach can be a way to guarantee the transfer and acquisition in optimal conditions, under minimum standards, of the services and benefits for the whole population. In this sense, some sectors may have their own means of achieving a pleasant, dignified and valuable life, but others may not, unless the public administration guarantees it (Svara and Brunet 2005).

Van Assche and Verschraegen define planning as "the coordination of policy and practice affecting spatial organizations" (2008, p. 263). From these authors perspective, planning enables envisioning and working on several problems at the same time and creating new qualities and assets. The creation of new assets is the provision of public goods and their benefits. In this sense, green infrastructure planning can result in a sustainable Metropolitan Area of Leon with economic growth, environmental assets, abundance of public goods (e.g. infrastructure, physical assets and amenities and other "commons"), social services and low poverty and inequalities (UN-Habitat (United Nations Human Settlements Programme) 2013).

In order to achieve this objective, local Authorities and local Council have the opportunity of articulating different open natural spaces with the aim to create an efficient network, where all components have ecological and social functions at different scales of the Metropolitan Zone. A key starting point is to emphasize the need of disseminating the green infrastructure approach among authorities. A lack of understanding of green infrastructure concept has translated into a fragmented vision of urban planning, where natural spaces are not strategic for quality of life and for the sustainability of the Metropolitan Zone. A paradigm shift towards comprehensive schemes may help authorities to efficiently integrate economic, social and environmental dimensions in the design and planning of a sustainable green infrastructure network.

6 Conclusion Remarks

This study has described a brief conceptual framework on how to understand the conceptual aspects of green infrastructure and its links to sustainable urban planning. Sustainability involves a paradigm shift toward new schemes that transcends the traditional unidimensional approach of natural spaces planning.

In order to tackle with a fragmented vision of green infrastructure in the Metropolitan Zone of Leon, this study has held that an effective planning approach should integrate functions and dysfunctions related to social perception. The United Nations-Habitat Program defines urban planning and design as the strategic areas for supporting urban growth and improving sustainability, efficiency and equity in urban development at all levels and scales (UN-Habitat (United Nations Human Settlements Programme) 2018). According to this definition, policies for urban planning and design should provide a set of prospective approaches, methodologies and tools for the decision-making process within local and national governments. The objective of these policies is to establish a comprehensive model of a long-term urban development in order to contribute to social inclusion, particularly for vulnerable and disadvantaged groups, and to gender equity.

This study has identified key lessons that can contribute to effective urban planning for land conservation and land management. First, the case of the Metropolitan Zone of Leon illustrates that the clarity of conceptual perception is fundamental for effective urban planning. An explicit incorporation of green infrastructure principles and objectives is pivotal to create a green infrastructure network that provides multiple benefits for all inhabitants. Urban planning needs to transform its forms of approaching to land conservations and management in order contribute to urban sustainability.

Another lesson is that people do not perceive all different natural spaces as economic, social and environmental beneficial. Natural spaces can show dysfunctionalities. This aspect strives the strategic role of green infrastructure to achieve efficient urban planning. Key natural space to be invigorated are the water streams (rivers) in the Metropolitan Zone of Leon. To aim this objective, it may need to answer questions as following: (i) what are the obstacles to socially aware metropolitan benefits of rivers and why? (ii) what are the specific contributions of rivers to the peoples' quality of life? and (iii) How can rivers be integrated in the urban structure as public spaces that contribute to urban sustainability in the Metropolitan Zone of Leon?

It is important to say that the survey sample used in this study was not statistically representative and that many of the participants belonged to the same locality. Therefore, additional research will be desirable to aware on the different groups and local perceptions of each green infrastructure component and its specific contributions to the sustainability in the Metropolitan Area of Leon.

Finally, we argue that addressing the integration of social dimension in urban planning is a key aspect to foster the quality of life and social welfare. This approach may contribute to create more sustainable cities with benefits for all people.

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Appendix

See Table 7.

Table 7 Conceptual perception on green infrastructure

Participant	Approach	Key GI components	Services	Contributions	Specific plans/projects	Challenges
1	NM	Green space	Environmental, social and economic	Help to human development	NM	To achieve agreement among the different authorities
2	Network	Natural spaces/green elements	NM	Support life and conservation	Research on GI	Environmental education
3	There is not such approach	NM	NM	Social welfare	Respect trees during project execution	To encourage developers to respect trees
4	Tool	NM	NM	Provide services to urban settings	NM	To create collaboration between public and academic sectors
5	Network	Green spaces	NM	Provide Environmental services	NM	NM
6	NM	NM	NM	Enhance quality of life	Research on economic value of parks	NM
7	Set of land elements	NM	NM	Enhance quality of life	Greenways design	To teach society about green infrastructure
8	Network	Public spaces	Green/natural elements	NM	NM	To create a network of green spaces
9	Public policy	NM	NM	Help to community development	Installation of solar panels	To encourage clean technologies
10	Network	NM	Ecosystem services	Benefits people and city's economy	Teaching on this new approach	To encourage research on this subject

*NM: No mentioned

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Exploring the Locus of Social Sustainability Implementation: A South Asian Perspective on Planning for Sustainable Development

Usama Awan, Andrzej Kraslawski, Janne Huiskonen and Nazia Suleman

Abstract Social sustainability is one of the keys to sustainable development. The social sustainability agenda is not easy to be achieved without implementing pro-buyer and pro- institutional policies. A sustainable development not only calls for environmental and economic sustainability but also for social sustainability that is the basis of sustainable development. Moreover, commonplace unsustainable consumption practices increasingly manifest in manufacturing firms in developing countries, making sustainable development management failures highly visible and institutions relevant. We employee Multiple-criteria decision-making (MCDM) approach to identify the critical factors that hinder the implementation of social sustainability performance. There exists a scarcity of investigations on appropriate planning regarding a global partnership for achieving SDGs in the area of sustainable development. This paper provides an empirical analysis of the many practices that implementing sustainable development goals (SDGs), SDG3, SDG5 and SDG17 pose, and contributes to sustainable development. To promote and meet the UNSD goals, it proposes adopting buyer requirements, improving institutional related policies are the most promising approaches to support and implementation of social sustainability. The aspects of social sustainability at manufacturing firms can be achieved primarily by buyer collaboration and better institutional policies. social sustainability has become a marketing tool and is becoming more important for all the companies,

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across all industries. We believe this paper is of interest to practitioners and academicians who deals with social sustainability initiatives at manufacturing firms.

Keywords Social sustainability initiatives · Implementation · Supply chain management · Barriers · Multiple-criteria decision-making

1 Introduction

There is a growing trend towards developing a more sustainable way of managing social sustainability performance among the manufacturing firms. United Nations SDGs transformation calls for a broad partnership and requires a magnitude of the cooperation. The UNSDGs that set targets for 2030 seeks to promote sustainable development includes global goals, such as good health and well being, gender equality and partnership for the goals (United Nations 2015). Social sustainability is one pillar that links to two other pillars of sustainable development (SD) that is, economic and environmental. To promote and meet the UNSD goals, it proposes adopting buyer involvement, skill, and development for meaningful collaboration. The sustainable development goals (SDGs) are a self-reliant dedication to accomplish, exactly what we began and also combat a few of the more demanding challenges experiencing the world today (ICSU 2015).

There is a growing interest towards developing a more sustainable way of managing social sustainability performance among the manufacturing firms. Supply chain management practices have a detrimental impact on the environment, human health and economic sustainability. There is a growing recognition of social sustainability issues among buyers and suppliers. Buyer-supplier relationship has become a strategic means of achieving social performance for medium to large-sized firms. Relational governance among supply chain partners impact on adaptive capabilities for improvement in social sustainability (Awan 2019). Many manufacturing companies are sourcing their suppliers from developing countries for low cost advantage (Mani et al. 2016a). The manufacturing firms are striving to satisfy sustainability requirements (SRs) in their products (Biju et al. 2017). The results show that both product and process innovations decreased waste generation, raw materials, energy and water consumptions (Severo et al. 2017). Therefore, it is important for manufacturing industries to deal with various barriers associated with their customers, employees, and management, to achieve social sustainability performance in a supply chain scenario. It is also a timely study, some recent accidents in Pakistan, Ali Enterpriser factory, supplier for German-based low-cost retailer KiK collapsed, killing 254 workers. Thus, risk base production facilities may have an impact on firm sustainability and it may have some adverse effect on society. In order to achieve sustainability targets, manufacturing firms need to identify challenging initiatives and implementation of environmentally friendly practices into their supply chain (Mani et al. 2016b).

There is an inappropriate understanding of social sustainability issues leading to ineffective solutions; the consequences of these failures are serious for worker occupational health and safety. In order to sustain employee occupational health and safety issues in the long run, the manufacturing firm needs to make effectively incorporate sustainability issues into their supply chain management (Tseng and Hung 2014). Since the last few years, interest in social sustainability issues in the supply chain has attracted attention from the manufacturing firms, aspire to engage in socially sustainable practices (Andersen and Skjoett-Larsen 2009; Mani et al. 2016a). Social sustainability is an emerging research area which encompasses human health, safety, social capital, social equity and comfort and required researcher attention (Popovic and Kraslawski 2015). The social sustainability performance perspective points out the potential importance of the buyer-supplier commitment to supply chain relationship (Awan 2019). Still, the challenge in the developing countries is to categorize a good number of persistent barriers impeding the implementation of social sustainability practices (Mani et al. 2016b). The ever-increasing awareness on social issues in the supplier-manufacturing firm in developing countries means that there is a need to understand barriers that hinder for the implementation of social practices.

Thus, it is imperative important to understand and identify the barriers which affect the implementation of social sustainability practices. Social sustainability issues in inherently connected with United Nations Sustainable Development Goals (UNSDGs), for example, SDG3 (good health and well-being), SDG5 (gender equality), SDG8 (decent work and economic growth and SDG10 (reduce inequalities). This gives manufacturing firms a distinct perspective in the context of SD goals. However, there are several practical challenges for implementations. There exists a scarcity of investigations on appropriate planning regarding a global partnership for achieving SDGs in the area of sustainable development. This paper provides an empirical analysis of the many practices that implementing sustainable development goals (SDGs), SDG3, SDG5 and SDG17 pose, and contributes to sustainable development. To address this research gap, we build on the analytical hierarchy process (AHP), such that we model the factors that are most challenging in the implementation of social sustainability practices. The objective of the present study is (1) to prioritize barriers hindering the effective implementation of social sustainability practices. This study attempts to answer the research questions, what are the existing barriers to implement social sustainability practices in manufacturing firms in emerging country perspective? In answering these questions, we particularly contribute to the field by identifying how social sustainability initiatives can be promoted in the manufacturing firms. This study proposes a structural model for evaluating the barriers associated with the implementation of social sustainability initiatives in a supply chain. The proposed model can use as the roadmap to their implementation of social sustainability initiatives. The findings of this study offer contribution to social sustainability. This paper contributes to the increasing body of research on how different barriers influences to implement social sustainability practices by (1) taking a perspective on the developing country perspective, and (2) our findings add

to understanding to implement social sustainability practices that may potentially help the firm evolve as socially responsible over the time.

2 Literature Review Social Sustainability

Social sustainability underpins by a wide range of activities and practices related to social issues. The primary concern with devising such ways and practices to concern with developing process and products and incorporate efficient ways to incorporate broader employee and community perspective. The concept of sustainability appeared in (Elkington and Burke 1987). The concept of Social sustainability first appeared in agenda 21 in Rio conference on social aspects. Since then social sustainability in the supply chain has emerged a study area and brought the concept to global prominence. It is regarded as integral to sustainability in order to achieve sustainable development in both developing and industrialized countries (Hutchins and Sutherland 2008). Hutchins and Sutherland (2008) argued that a firm supply chain that is socially sustainable, must establish policy and laws within firms and with its employees, devise policies about employee health and safety, working conditions, wages, child labour, labour hours, betterment for local community and society. Social sustainability practices are therefore characterized by health and safety, equity, wages, discrimination, equal opportunity, employability, safety and quality of life both employee and society (Andersen and Skjoett-Larsen 2009; Klassen and Vereecke 2012; Husgafvel et al. 2015). Social sustainability is a system of coordinated social interaction practices for the management of the social impact on people and society with the key internal and external stakeholders. This all happens for creating, developing and delivering the best social and ethical code of conduct (Awan et al. 2018)

Other studies (Hutchins and Sutherland 2008; Mani et al. 2015) discussed different dimensions and came to conclude that social sustainability measures are important for reaching sustainable development goals. Furthermore, social sustainability is a key factor for the development of industry, it covers broad employee and societal issues and emphasizes the expectations and needs that the local community has for wellbeing. Implementations of social sustainability practices are considered to be one of the most challenging and therefore it needs to employ procedural and contextual social sustainability (Suopajärvi et al. 2016). In the current global environment, buyer involvement can contribute to the improvement of occupational and health practices. The social sustainability aim is, to have value for the survival of current business system (customers, partners, and society) and its growth for the future generation in an equitable and prudent manner (Awan et al. 2018).

3 Identification of Barriers

Technical barriers are critical to achieving the sustainability objectives. Social sustainability issues in the supply chain are still in its developing state with many challenges and issues. Lack of awareness and knowledge among the employees about social practices in the supply chain is a major barrier for manufacturing companies (Schaltegger 2011). In many developing countries non-availability trained human resource and resistance to adopting new practices may hinder the sustainable growth (Merli et al. 2015). The major injuries and accidents at the workplace result from faulty machinery, equipment, or facilities. Effectiveness and efficiency of facilities, equipment, and machines contribute to the reduction of accidents and injuries at the workplace (Amponsah-Tawiah et al. 2015). Achieving desired results in the implementation of social issues lying with the availability of the resources and it is a barrier that hinders implementation efforts. Technical barriers might include a focus on both the knowledge of equipment and machines contributes to improving safety at the workplace. Lack of involvement of operational staff into decision making can act as a challenging barrier for re-design the whole or part of the system. It is the obvious successful implementation of any quality management program is dependent on managerial decision making (Baumgartner 2009; Ehrgott et al. 2011). This highlights the need for more flexible employee work behaviour and more resilient approach towards practices and policies including repeated and improvable process and ability to retransformation of resources is a key towards attaining sustainable performance. Shoetown achieved world-class best practice in sustainable management The management at Shoetown utilise a skillful mix of eastern and western business theories embedded in the Chinese business context (Huang et al. 2014).

According to Mamic (2005), lack of participation and promotion from government and social communities on social issues affect the implementation of social initiative programs. Moreover, challenges arise due to the lack of action plans and strategies and uncertainty from institutions (Dube et al. 2016). The researcher has suggested that a strategic tie-up between supportive policies and guidance from institutional actors can have a positive influence on social initiative actions (Lim and Phillips 2008). It is argued that in order to the successful implementation of these issues, firms need to understand the priority barriers that hinders in the effective implementation of strategies and actions plans form institutions.

The mutual understanding of buyer and supplier is crucial to enhance the competence of socially responsibility issues in the supply chain. Prior researchers have reported that a lack of shared understanding and exchange of information on best practices is an important barrier (Gualandris et al. 2015). There is also resistance to the implementation and understanding how to improve the productions and process system and find a right balance between prod, However, interaction frequency, in particular, might not always be beneficial action and safety within operational level influence achieving sustainable performance (Schaarschmidt and Hoeber 2017).

4 Solution Methodology

AHP has been recognized as an important tool in sustainability decision making for identifying and competing decisions objective. The use of AHP in the decision-making process can be found in various research studies and have previously been applied in sustainability decision making. AHP has been used for complex decision making and it organizes factors into categories and sub-categories (Saaty 2008). Analytical Hierarchy Process (AHP) has been recognized and applied in a wide of variety of practical decision-making. Based on the literature review, AHP has been used in evaluation, ranking and prediction of decision making (Luthra et al. 2015). AHP was developed and was originated from the Wharton School of Business by (Saaty 1987). AHP is an appropriate decision-making tool for decomposing the relationship into objective, categories and sub-categories and alternatives. The use of AHP in the present study allows for developing a hierarchy of goals and their criteria, sub-criteria, and evaluation of alternatives. AHP not only help to assess the determining the linkages between the selected barriers and corresponding to evaluate alternatives but also helps to formulate policies and strategies to manage social sustainability initiatives. AHP has been widely used in different research fields due to its usefulness in decision-making process, such as supply chain logistics, healthcare, engineering, new product development and information technology management and many others (Singh 2013; Luthra et al. 2011, 2015) In this study, a computational method was used to determine the priority factor in decision making. This study uses the AHP to evaluate and determine the barriers to the social sustainability decision making.

To begin with, the sub-categories of the hierarchical model is shown in Fig. 1.

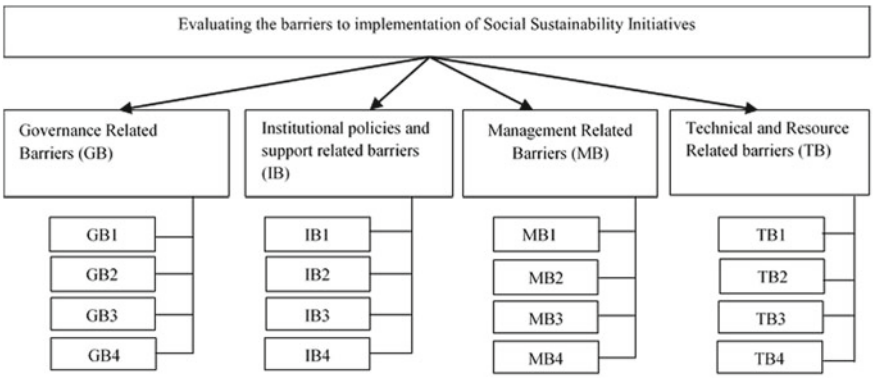

Fig. 1 Hierarchial decision model

5 Research Methods

In order to identify the barriers to the implementation of social sustainability by manufacturing firms, a literature review was conducted. Further, a list of selected key barriers was sent to experts to select the likely key barriers in the Pakistan context. Base on their recommendation, additional barriers items were categories. The list of barriers was also evaluated by experts to ensure to have their insight, belongs to diverse titles from the manufacturing industries, representing, and sports goods and Leather wares manufacturing firms. After consulting with the experts, a questionnaire was constructed to reflect the key barriers for social initiatives are shown in (Table 1). The finalized 16 social initiative barriers were analyzed using AHP. Significance consistency ratio value set at <10% for all compare wise comparison matrices. The identified barriers were further grouped into four major categories (see Table 1). The final barriers were then categorized into 4 dimensions base on their nature, governance-related Barriers (GB), Institutional policies and support related barriers (IB), Technical and Resource-Related barriers (TB), Management Related Barriers (MB).

Pakistan manufacturing goods industry is vibrant and considered for this study. The sports and surgical manufacturing industries are situated in Sialkot North Pakistan; these firms internationally well know which act as a major source of revenue and backbone of Pakistan economy. The identified barriers were then sent to select 87 manufacturing firms. The respondents were also requested to compare carefully the categories and sub-categories of each hierarchy level by assigning a relative measure in pairwise comparison with respect to the nine-point scale of intensity (See Table 2). With the use of this table, the comparison matrix for specific categories and relative weights are calculated by assigning numerical values in (Table 3. Random Index (RI) consistency index values). The duration of the survey was six weeks, at the end of this period, 34 responses were received from targeted firms. The incomplete questionnaires were not considered, and 6 responses were abandoned.

The result was satisfactory as the response rate was 39.08% and acceptable for the analysis Malhotra and Grover (1998). The respondents were also asked to compare carefully the categories and sub-categories of each hierarchy level by assigning a relative measure in pairwise comparison with respect to the nine-point scale of intensity (See Table 2). With the use of this table, the comparison matrix for specific categories and relative weights are calculated by assigning numerical values in (Table 3. Random Index (RI) consistency index values).

6 Results and Analysis

The results of the pairwise comparison matrix is provided in Table 4 of the four categories to the implementation of social sustainability barriers. From the computational performed, the results of the pairwise comparison of sub-categories are

Table 1 Identification of barriers to social sustainability initiatives

Barrier dimensions	Key barrier sub-dimensions	Authors
Governance-related barriers (GB)	Lack of shared understanding and exchange of information (GB1)	Mamic (2005), Boyd et al. (2007), Beske et al. (2008), Gualandris et al. (2015)
	Lack of monitoring from the buyer on use of equipment (GB2)	Beske et al. (2008), Bledow et al. (2009), Ciliberti et al. 2009)
	Lack of encouragement from International buyers (GB3)	Ehrgott et al. (2011), Klassen and Vereecke (2012), Terpend and Krause (2015)
	Lack of buyer-driven social initiative and support (GB4)	Ehrgott et al. (2011), Terpend and Krause (2015)
Institutional policies and support related barriers (IB)	Lack of support and encouragement programs (IB1)	Hutchins and Sutherland (2008), Schaltegger (2011), Locke et al. (2013)
	Lack of regulations on occupational health and safety (IB2)	van Donk et al. (2010)
	Lack of participation and promotion from (IB3)	Locke et al. (2013)
	Lack of supportive policies and uncertainty from institutions (IB4)	Hutchins and Sutherland (2008)
Management related Barriers (MB)	Lack of adaptions to new occupational health and safety policies (MB1)	Mani et al. (2015), Huq et al. (2016), Kuppig et al. (2016)
	Lack of managerial capabilities for implementation (MB2)	Carter and Rogers (2008), Ciliberti et al. (2009), Power et al. (2014)
	Lack of involvement of operational staff in planning decisions (MB3)	Baumgartner (2009)
	Lack of flexibility and resilience skills (MB4)	Bhamra et al. (2011)

(continued)

illustrated (Tables 5, 6, 7 and 8). In the present study, the results of AHP modeling reveals that governance Related Barriers (GB) is a leading barrier followed by Technical and Resource-Related barriers (TB). Management Related Barriers (MB) and Institutional policies and support related barriers (IB) occupy third and fourth most important barriers, which is not an as much serious concern.

After the pairwise comparison, local weights of a total of 16 barriers (from Tables 5, 6, 7 and 8) with global weights with respect to the highest relative importance at the hierarchical level are presented in Table 8. Lack of shared understanding and exchange of information (0.284994), with regard to global weight results, is

Table 1 (continued)

Barrier dimensions	Key barrier sub-dimensions	Authors
Technical and resource-related barriers (TB)	Lack of knowledge of resource management (TB1)	Amponsah-Tawiah et al. (2015), Sartor et al. (2016)
	Lack of acceptance to adopt new practices (TB2)	Merli et al. (2015), Sartor et al. (2016)
	Lack of use of protecting equipment and practices (TB3)	van Donk et al. (2010), Amponsah-Tawiah et al. (2015)
	Lack of technical resources for maintenance equipment (TB4)	Kuppig et al. (2016)

Table 2 Saaty's pair-wise comparison nine point scale for AHP preference

Importance weight value	Importance weight value	Definition
1	1st factor is equally important than the 2nd factor	Equally important and preferred
3	1st factor is weakly more important than the 2nd factor	The first factor is slightly more important/preferred than the second is
5	1st factor is strongly more important than the 2nd factor	The first factor is strong more preferred that the second factor
7	1st factor is very strongly more important than the 2nd factor	The first factor is very strong more preferred that the second factor
9	1st factor has an absolute mare important than the 2nd factor	The first factor is extremely very strong more preferred that the second factor
2,4,6,8	Intermediate values reflect alternatives, as compared with the first	

Saaty (1987)

Table 3 Random index (RI) consistency index values

Size of matrix	1	2	3	4	5	6	7	8	9	10
Random consistency index (RCI)	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

Table 4 Pairwise comparison matrix of the four categories

Barriers categories	GB	IB	MB	TB	Weights	Ranking
Governance related barriers (GB)	1	7	5	3	0.563179	1
Institutional policies and support related barriers (IB)	1/7	1	1/4	1/5	0.054227	4
Management related barriers (MB)	1/5	4	1	1/2	0.145552	3
Technical and resource related barriers (TB)	1/3	5	2	1	0.237043	2
Sum	1.6762	17.0000	8.2500	4.7000		

Note $\lambda_{max} = 4.180764$ for n = 4, CI = 0.060255, CR = 0.066949

Table 5 Pairwise comparison matrix for buyer governance related barriers (GB)

Barriers categories	BB1	BB2	BB3	BB4	Weights	Ranking
GB1	1	6	4	2	0.506046	1
GB2	1/6	1	1/2	1/5	0.069776	4
GB3	1/4	2	1	1/3	0.135440	3
GB4	1/2	5	2	1	0.288737	2
Sum	1.9167	14.0000	8.5000	3.5333		

Note $\lambda_{max} = 4.118243$ for n = 4, CI = 0.039414, CR = 0.043793

Table 6 Pairwise comparison matrix for technical and resource-related barriers (TB)

Barriers categories	TB1	TB2	TB3	TB4	Weights	Ranking
TB1	1	1/2	1/3	3	0.162301	3
TB2	2	1	1/2	5	0.287893	2
TB3	3	2	1	7	0.489437	1
TB4	1/3	1/5	1/7	1	0.060369	4
Sum	6.3333	3.7000	1.9762	16.0000		

Note $\lambda_{max} = 4.0262331$ for n = 4, CI = 0.008744, CR = 0.009716

Table 7 Pairwise comparison matrix for management related barriers (MB)

Barriers categories	MB1	MB2	MB3	MB4	Weights	Ranking
MB1	1	1/4	6	3	0.252320	2
MB2	4	1	8	5	0.589774	1
MB3	1/6	1/8	1	1/2	0.055281	4
MB4	1/3	1/5	2	1	0.102625	3
SUM	5.5000	1.5750	17.0000	9.5000		

Note $\lambda_{max} = 4.231368$ for n = 4, CI = 0.077122, CR = 0.0856918

Table 8 Global Rankings for categories and sub-categories

Barriers categories	*RW	*R	Barriers sub-categories	*RW	*R	GW	*R
Governance-related barriers (GB)	0.563179	1	Lack of shared understanding and exchange of information (GB1)	0.506046	1	0.284994	1
			Lack of monitoring from buyers on use of equipment (GB2)	0.069776	4	0.039296	7
			Lack of encouragement from international buyers (GB3)	0.135440	3	0.076277	5
			Lack of buyer-driven social initiative and support (GB4)	0.288737	2	0.162611	2
Institutional policies and support related barriers (IB)	0.054227	4	Lack of support and encouragement programs (IB1)	0.486906	1	0.026403	10
			Lack of regulations on occupational health and safety (IB2)	0.059091	4	0.0.204	16
			Lack of participation and promotion from (IB3)	0.148996	3	0.008079	14
			Lack of supportive policies and uncertainty from institutions (IB4)	0.305006	2	0.016539	11
Management related barriers (MB)	0.145552	3	Lack of adaptions to occupational health and safety policies (MB1)	0.252320	2	0.036726	9
			Lack of managerial capabilities for implementation (MB2)	0.589774	1	0.085843	4
			Lack of involvement of operational staff in planning decisions (MB3)	0.055821	4	0.008046	15
			Lack of flexibility and resilience skills (MB4)	0.102625	3	0.014937	12

(continued)

Table 8 (continued)

Barriers categories	*RW	*R	Barriers sub-categories	*RW	*R	GW	*R
Technical and resource-related barriers (TB)	0.237043	2	Lack of knowledge on resource management (TB1)	0.162301	3	0.038472	8
			Lack of acceptance to adopt new practices (TB2)	0.287893	2	0.068423	6
			Lack of use of protecting equipment and practices (TB3)	0.489437	1	0.116018	3
			Lack of technical resources for maintenance equipment (TB4)	0.060369	4	0.014310	13

Relative weights = *RW; Ranking = *R; Global Weights = GW

the most prioritized barrier among the 16 barriers to the implementation of social sustainability practices. The second and third most important barrier is "Lack of buyer-driven social initiative and support" (0.162611). This means the absence of this barrier firm can make more progress towards better implementation of social practices.

This shows that firm is giving leas importance to "Institutional policies and support" and in global weigh category it holds the lowest ranked position 16, 14, 10 and 11 respectively. Due to lack of buyer-driven social initiatives and support firm is not motivated towards implementation of social practices.

The Third barrier "Lack of use of protecting equipment and practices" (0.116018) followed by lack of managerial capabilities for implementation (0.085843), "Lack of encouragement from International buyers" (0.076277) and "Lack of acceptance to adopt new practices" (0.068243). These barriers are important and necessary to overcome and hinder the successful implementation of the case firm. The understanding of these priority barriers will help the managers to understand them, so they can implement social sustainability initiatives program in their firm. This shows that lack of management capabilities of the firm is a most important barrier for the firm and management and managers of the firm are not able to provide a great deal of the support in the implementation of social initiatives in the supply chain. It requires the firm to make essential changes and adopt new practices. This shows that building capabilities are a key strategy for transforming social sustainable behaviour across the supply chain (Ciliberti et al. 2009). For example, if a firm is lack of management capabilities, then it will be a permanent failure on which no social initiative can be implemented.

7 Conclusions

The UNSDGs that set targets for 2030 seeks to promote sustainable development includes global goals, such as good health and well being, gender equality and partnership for sustainable development. The objective of the study was to prioritize the most significant barriers that hinder the successful implementation of social sustainability practices in the manufacturing firms. We identified two important factors. First, we found that governance related barriers effect on sustainable performance, as it values activities related to exchange of information, monitoring suppliers, support from buyers and buyer-driven knowledge driven practices. Hence, support from the buyer can be necessary to ensure exposure to diverse practices on social initiatives and can help of integrating these inputs an adjusting to new market demands. Second, Institution policies and support is the least important barrier, implies that it requires focused attention from government bodies, policymakers need to prioritize the elimination of these barriers to promote social sustainability. There are various barriers encountered in implementing social sustainability practices for the manufacturing firms in Pakistan. The top three critical barriers encountered in practice are highlighted as 'Lack of shared understanding and exchange of information', 'Lack of

buyer-driven social initiative and support', 'Lack of use of protecting equipment and practices'. The multi-criteria decision-making process in the paper has evidenced this. In this context, there is an urgent need for proactive support from the buyers. On the other side, institution policies and support is the least important barrier, implies that it require focused attention from government bodies, policymakers need to prioritize the elimination of these barriers to promote social sustainability. A path to enhanced social sustainability will be built by expanding the scope of buyer-supplier relationship and institutional environment. A socially sustainable future will emerge if suppliers' firms build a strong relationship with their multiple buyers and institutions has to better understand the needs of the firms, to pursue an sequel growth of natural and social environment for the future generations.

As a result, researchers suggest that the locus of implementation of social sustainability initiatives is often situated in buyer-driven knowledge practices on social issues and encouragement programs from institutions.

There is growing interest in social sustainability in buyer-supplier relationships. The findings of this study offer contribution to social sustainability. This paper contributes to the increasing body of research on how different barriers influences to implement social sustainability practices by (1) taking a perspective on developing country perspective, and (2) our findings add to understanding to implement social sustainability practices that may potentially help the firm evolve as socially responsible over the time. The findings of this study may provide guidelines to other developing countries like China, India or Brazil to analyze the barriers to social sustainability implementation. This means that international firms sourcing from the developing countries need to support social issues and help suppliers instill sustainability specifically within their manufacturing operations. With respect to policy implications, we suggest that policy incentives on international certification related to health, safety and labour issues are necessary for them to thrive and grow their international business successfully. Besides that, a study has contributed to the social sustainability literature, it has some limitations which provides a baseline for future research on the implementation of social sustainability practices. Future research should incorporate the evaluation of barriers to the implementation of social sustainability practices in the service sector and it may be useful for cross-industry and cross-company comparisons. Thus, in future research studies, academic researchers should include other barriers categories within the domain of social capabilities and technical resources.

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Brief Analysis of the Scientific Articles Produced About "Social Innovation", During the Last Ten Years

Sandra Aparecida Santos, Norma Brambilla, Ubiratã Tortato and Carlos Olavo Quandt

Abstract The objective of this work is to perform a Systematic Review of the Literature about the number of scientific articles published in the last ten years related to social aspect of sustainability: the Social Innovation. To do so, we performed researches in the databases "Scopus" and "Web of Science", in which were inserted filters to select productions on the subject in question. After the research was made, the abstracts were read, 169 studies were carried out in the first base, and 85 in the second, based on the research protocol of Tranfield et al. (Br J Manag 14(3):207–222, 2003). In order to select the works to be analyzed, the articles were read to verify in which of them the theme "Social Innovation" was more recurrent and had greater visibility as a theoretical foundation. After this analysis, it was decided to study the articles in which the theme "Social Innovation" had more scope. Regarding the selected studies, the general characteristics of the articles about the topic were identified and, also, at which point there was convergence and/or divergence between them. In addition, it was also carried out an analysis of the articles, in order to identify how Social Innovation was scientifically studied in the last decade.

Keywords Social innovation · Systematic review of literature · Scopus · Web of Science

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1 Introduction

The understanding of the "innovation" concept goes through many variables, until the present days. One of them concerns to the competitiveness of the market. This notion has given rise to a broader conceptualization of the expression, which is related to the collective imagination, that is, the innovation that generates changes in the collective and it has been treated as "social innovation".

In this particular context, André and Abreu (2006) understand that, in recent years, the term has become more relevant, with proportional growth to its appearance in various fields. Proof of this, according to the authors, is that "in the literature about social innovation are, in fact, especially recurrent the third sector initiatives aimed at combating social exclusion" (André and Abreu 2006, p. 123).

In this way, Juliani (2014) states that, considering the expansion of the expression in discussions and publications in various contexts, not only universities have established research centers about the subject, but also private foundations and institutions began to develop actions that focused on social innovation.

"Innovation" means, according to Michaelis Dictionary, "making innovations, innovate, produce or make something new, renew, restore".[1] In fact, innovation is seen as a synonym of novelty in many different means of communication. "The popularization of the term took away its initial meaning established by Joseph Schumpeter—and until today it is used as a basic concept in most academic studies on the subject—that innovation is linked to the generation of economic value", according to Bignetti (2011, p. 4). According to the author, it is unquestionable that the rise of a global economy forces the companies to innovate constantly, and academic research on the subject intended to precisely analyze the phenomenon and understand how companies remain competitive.

The commitment of companies to sustainability has often been discussed in theory and practice. For Engert et al. (2016), the commitment to corporate sustainability requires a strategic approach to ensure that business sustainability becomes an integral part of business strategy and processes.

In the business environment, ecological and social issues are factors that promote changes, the companies increase their interest in corporate sustainability (Moon 2007; Baumgartner 2014; Barnett et al. 2015). Considering the Triple Bottom Line as a broader concept of sustainable development, it relies on the integration of social, environmental and economic issues (Elkington 2011). The three pillars theory gives a broad view of each pillar and their challenges, as well as proposes a reflection on the importance of sustainability.

To face these challenges and achieve the three pillars theory, executives must examine current performance and future goals, and that will require drastic changes. The human development and the consumption that are explored by the capitalism have caused a great concern and reflection for the society and for the organizations (Elkington 2011).

[1] https://michaelis.uol.com.br/moderno-portugues/busca/portugues-brasileiro/inovar/.

How to face and work with Sustainability to ensure that today's actions will not limit the range of economic, social and environmental options available to future generations. From this perspective, the reflection challenges to look for an understanding of the relationship and conflict between capitalism and sustainability.

Even tough, it is important to have in mind that the social economy progresses in parallel to the global one, so many social problems are unresolved, such as social inequalities, sustainability factors and epidemics that do not stop growing. Therefore, efforts have been made so that there is support for the neediest communities. For André and Abreu (2006), social innovation is a new and socially recognized response in which the goal is to generate social changes, from three attributes:

> (i) satisfaction of human needs not satisfied by the market; (ii) promotion of social inclusion; and (iii) training of agents or subject actors, potentially or actually, to processes of exclusion/social marginalization, triggering, in this way, a change, more or less intense, of the power relations (André and Abreu 2006, p. 124).

Given the increased attention that has fallen on "social innovation" in recent times—which can be seen by reading the works of various authors, such as those who will be cited in this article—it was chosen, in this research, to analyze the scientific production that involves the issue studied.

In other words, from the selection of scientific articles based on criteria previously established, it was identified a certain amount of production covering the subject in the last decade. After it, the cut and the analysis of the selected corpus was proceeded in order to check the amount of production in the time lapse and how the mentioned research behaved. Considering what was presented until now, the objective of this article is to make a Systematic Review of Literature (SRL) about the number of scientific articles published in the last ten years, according to Scopus and Web the Science databases.

2 Research Method

Based on the particular needs of this research, due to its objectives, it was decided to conduct a systematic review of literature, summarizing the results of studies related to a particular problem, analyzing possible contributions (Malhotra 2005). Furthermore, Tranfield et al. (2003) comprehend that in the studies which relate to the administration area, the literature review is the main tool to approach the diversity of knowledge because, according to Ridley (2008), it gives opportunity to the conclusions of the reviewer to be found, mainly due to his/her structured and transparent process.

In this context, the fact that the systematic review is the scientific method from which it is possible to search for and analyze documents of some specific area, it is transformed into a "specific method of location of existing studies, selection and assessment of contributions, analysis and synthesis of information, description of

evidences in order to allow clear and reliable conclusions about the studied subject" (Denyer and Tranfield 2009, p. 671).

Considering the theoretical notes about the research methodology, now it is necessary to show, in a practical way, what were the steps followed to find the results.

First, it was chosen two databases (Scopus and Web of Science) in which the scientific articles about "Social Innovation" in the last ten years (2008–2018) could be collected. Based on it, the research was made—from the insertion of specific filters—to select a number of scientific articles that would fit the requirements of this research, such as: approach a specific issue, at a predetermined period of time. Thus, the result was 169 scientific articles in the Web of Science database and 85 in Scopus.

By the fact that the items selected in the first place resulted in more than 250 productions, it was chosen to analyze a smaller amount of the entire corpus. The choice was made according to the importance given to the subject "social innovation" due to all the summaries of the selected articles, the importance that the subject received, and it was also counted how many times the phrase was cited in each summary. Therefore, those which the subject was put in more evidence—a total of 24 items, from both databases—were the selected ones.

Simultaneously, besides the cut of the most significant productions, it was analyzed the amount of articles produced annually, in order to understand in which period the issue discussed here had greater academic emphasis.

3 Presentation and Discussion of Results

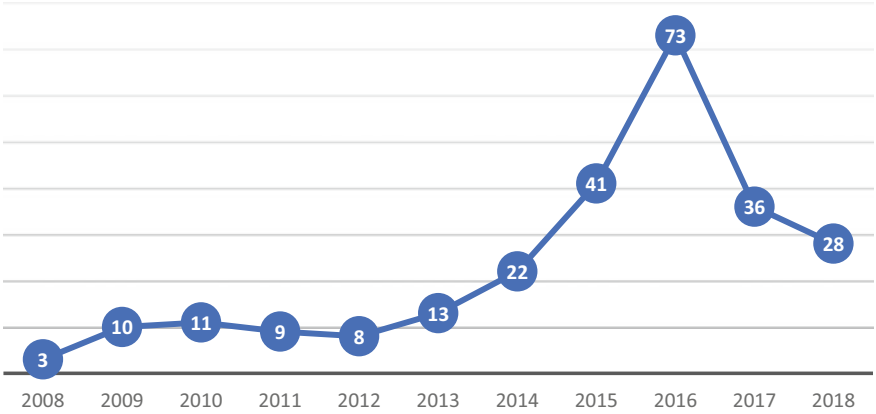
The procedures that were followed to obtain the results, which will be explored here, have been described in the previous section. Nevertheless, it will be made a more detailed interpretation about them.

First, this research will be about 169 scientific articles resulting from the search in Web of Science database. The graphic below shows how this amount of productions were divided according to the researched period.

By analyzing Graphic 1, it can be observed that the year 2016 was the one with the largest number of scientific productions involving the theme "social innovation" in the searched period. Although later (in 2017 and in the 1st semester of 2018) there has been a reduction on the amount of articles, it was gradual. Between the years of 2008 and 2014, it was verified that academic papers written about the subject were not very significant, different from the followed years.

It is possible to say that the number of productions of the first five years researched (2008–2012) do not even reach a quarter of the productions made in the last five years (2013–2018).

Possibly, the highest number of scientific articles published about the subject "Social Innovation" was from 2013 to 2018, perhaps the reason was some global crises, which had happened in the previous years, such as the Great Recession of the United States (2008–2009) and the Debt Crisis in Europe (2009–2010). Thus,



Graphic 1 Scientific articles produced in the last decade about "Social Innovation", according to Web of Science database. *Source* Own production (from survey data—2018)

basic rights that were previously supplied by the State are now no longer supplied—because of the financial crisis. In this way, the civil society had to get organized in order to create alternatives to fulfill the basic needs of human beings.

Therefore, it is likely that the term "social innovation", first built in practice, has become object of academic analysis, given the fact that it gathers in real social practice, reflected in many different contexts.

Moreover, it should be noted that even with apparently higher growth in the academic field in the last five years, the issue cannot be further considered, even minimally, dominated by researchers. It is explained: as it will be seen, although being recently searched more often, the subject "Social Innovation" requires further deepening, because most of the scientific papers related to it are about the absence of a specific concept about it.

By observing the data collected among the analysis of the corpus of this research, it was possible to reach some conclusions: there was no significant production during the years 2008 to 2012; the year 2016 was the peak of publication of scientific articles on the subject; the years between 2014 and 2018, even with regarding the quantity, demonstrated consistency in production.

Finally, it is possible to move on to the analysis of the content of the selected articles. From now on, so that the term "Social Innovation" does not get extremely repetitive, it will be referenced by "SI". The analyzed written productions, in short, are about: (a) the need to clarify, more closely, the concept of SI, due to its lack of contextualized search; (b) the discourse of SI policy in the European Union; (c) interaction with social entrepreneurship to generate greater SI in the emerging economies; (d) how the HR management finds limited contributions to understand organizational determinants of social enterprises and contribute to the SI; (e) what are the factors that support the success of the SI; (f) the need to expand the debate between SI and sustainability for large scale changes; (g) the power of words in

SI—social marketing; (h) the contribution of microfinance to SI and the consequent reduction of poverty; (i) the study of OKM case—the only one about SI in Canada; (j) the usefulness of the concept of SI to analyze climate adaptation in institutional environments with complex contexts of vulnerability.

It is also subject: (k) the core processes that support the development of SI; (l) the materialization factors of SI as well as its consolidation process and propagation; (m) the analysis of the relationship between SI and its promotion in the patrimony of health; (n) the analysis of case studies to build a structure which describes SI factors, as well as SI that create social value and competitive advantage; (o) the importance of SI processes and the engagement of the interested people in the development of healthy lifestyles and of existing and emerging sustainable practices; (p) the importance of community engagement by social innovators; and (q) the strategies and dynamics to enhance social innovation.

In general, what can be analyzed from the interpretation of the data collected in this study was, above all, the fact that the concept of social innovation is not fully clear yet, particularly in the academic area. From this, derives the large amount of scientific articles produced about the need to expand the subject. Nevertheless, it was also found interesting scientific movements regarding the composition of SI subsidiaries definitions.

It should be emphasized, one more time, so this article becomes clear that the analyses made here relate to the universality of the corpus. That is, it is not intended to compare the articles selected by the two databases, but create one from them.

Thus, the 24 scientific articles produced in the last ten years (2008–2018), on the theme "Social Innovation", analyzed in this study, were chosen according to procedures already described in the previous section, and, in general, the brief analysis proposed in this survey was done.

4 Final Considerations

The results presented in the previous section make a possible reflection—even tough it is not depth—about the theme of social innovation among academic productions. The first topic to be discussed regarding this research is the fact that this issue is relatively recent in the category analyzed here. In other words, the term "Innovation", as already explained, was commonly related to the business world. However, it has been increasingly more often linked to the notion of "social".

The second topic to be analyzed—which is not only related to the first one, since it is literally a result of it—is about the productions analyzed, effectively. That is because it was observed that the number of scientific papers produced over the past decade on the issue gained greater emphasis in 2013 to the present days, that is, in the last five years. In addition, it was found that the most common issues related to social innovation include its lack of specific concepts, as well as some adjacent themes.

The study field of social innovation has occupied a prominent place in educational institutions, mainly due to the social, economic and civil scenario that gains strength with the crises that countless countries have undergone over the past few years. Thus, there is incapacity—especially from the governments—to cover the basic needs of their citizens, so that it resulted in social mobilization through emerging practices that aim to fulfill the expectations that are no longer supported by the ones who previously did it.

Thus, for being recent, it cannot be said that there is current scientific literature that deeply discussed the issue. For this reason, the concept is still quite flexible and shows ambiguities. The opening resulted from the gaps related to "social innovation" can be a further study of many other researches, like this one.

So, after checking 254 academic productions, in which of the articles the studied expression was more sought—through the analysis of the summaries of each one of them—a few points became clear. Because of the short time, this study analyzed just some of them.

First, it was tangible the low number of studies that propose to clarify the notion of "social innovation". This is especially necessary because, in recent years, the term has taken a different way of the one related to it (which was the one related to business). As a result, today the term still suffers from understandings that border the ambiguity, which could end up distorting the context of future research.

Second, it was noted that, due to the updated concept has not been understood by the academy yet, the works which analyze case studies or practical applications of the IS assumptions are produced in low amounts.

This article did not have the intention to exhaust the subject, but only carry out a data collection in order to review the literature that dealt on "social innovation" in the past decade, from two databases. The analysis carried out here is not deep, which allows further studies on the issues raised in this paper.

Being "Social Innovation" a reality that has been established worldwide in the recent years and that, apparently, soon will no longer be part of the most diverse realities, it is important to mention that the importance of its study and understanding in the academic context, as a social phenomenon, could be properly understood.

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Green Practices in the Fashion Supply Chain: A Literature Review

Pedro Seolin dos Santos and Lucila M. S. Campos

Abstract The intensive use of chemicals, the high exploration of natural resources, and greater dependence on external partners are factors that contribute to increase environmental impacts in the fashion supply chain. To reduce negative impacts within the supply network, an alternative is to promote green practices. This study aims to identify these green practices from a supply chain perspective that are commonly adopted by fashion companies. Our research identified and analysed barriers and opportunities to implement green practices in the fashion supply chain from 28 articles found in the literature. Those practices most commonly approached were related to the internal environmental management system (EMS), and the retail market was the supply chain (SC) link with the largest participation in the identified practices. Research also demonstrated that the main barriers to implementing green practices are lack of market knowledge, commitment to suppliers, lack of employee training, and high operational costs. Despite these challenges, opportunities are present in reducing cost, enhancing corporate image, and augmenting partners' technological offerings.

Keywords Green practices · Supply chain · Fashion industry

1 Introduction

The word *fashion* is an intersectoral concept, certainly applicable to the clothing industry but easily extended to companies operating in other clothing-related sectors, such as footwear, accessories, and jewelry segments (Brun and Castelli 2008). According to the McKinsey Global Fashion Index—MGFI (2018), activities related to sustainability will stop being just brand advertising and will become an integral

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part of the planning system throughout the fashion industry's value chain over the next years. It is expected that more companies will embrace sustainability planning: recycling of fabrics, using new sustainability technologies, and partnering with other supply chain stakeholders (MGFI 2018).

These improvements are important given that the fashion industry is one of the most exposed to public perceptions. Further, the industry has undergone recent environmental scandals, such as the use of BT cotton by fashion retail companies such as Hennes & Mauritz AB (H&M), the application and disposal of toxic dyes, and the generation of poisonous textile waste and excessive by-products (including packaging) (Caniato et al. 2012).

Another factor also resulting from the use of fiber is the amount of natural resources used for its cultivation and extraction. Cotton and wool production requires large amounts of water and pesticides, while synthetic fibers are extracted from non-renewable resources and require extensive energy use (Caniato et al. 2012).

In addition, because the clothing sector represents 4% of worldwide exports, the high amount of pollutant emissions is also something to be considered (MGFI 2018). Companies in the fashion industry depend on external partners to produce their products from distant locations; the various production activities (e.g., milling, dyeing, weaving, finishing, sewing) are subcontracted to different companies scattered throughout the world (De Brito et al. 2008). Hence, reducing the environmental impacts will require brands and retailers to re-examine the processes within their supply chains and to take more responsibility about production processes and product life cycles (Nagurney and Yu 2012).

Green practices are activities that can help to conserve natural resources, decrease waste, and sustain quality in operations. The literature demonstrates activities that may potentially improve the industry with the design of new business strategies, stakeholder management approaches, and operations planning using reverse logistics (Zhu et al. 2012), ecodesign (Zhu et al. 2008), and green purchasing (Seuring and Muller 2008). These activities are examples of green practices that can be used throughout the fashion supply chain. Thus, the objective of this study is to identify from the literature the green practices currently adopted by fashion companies within their supply chain, to clarify the opportunities and barriers of existing green practices, and to examine the role played by each supply chain link.

2 Literature Review

2.1 Green Practices in the Supply Chain

Increased pollution in urban areas, the scarcity of natural resources, and climate change are factors that have contributed to galvanize concerns about the environmental impacts of manufacturing activities (Allwood et al. 2008). In this context, green practices emerge as an operational approach in order to mitigate the negative

ecological impact of the products while conserving financial objectives (Garza-Reys 2015; Zhu et al. 2007).

Usually, manufacturing companies implement green practices in the context of Green Supply Chain Management (GSCM or GrSCM) (Zhu et al. 2008). GSCM is responsible for organizing and systematizing green practices throughout the supply chain (SC) and for redesigning them to incorporate activities into the flow of operations (Seuring and Muller 2008).

Among other practices, GSCM may include an internal environmental management system (EMS), green purchasing, customer cooperation, ecodesign, and investment recovery (Zhu et al. 2008). In addition, finance and incentive policies have been analyzed because they provide a link between environmental performance and organizational reward systems (Zhu et al. 2012).

Moreover, investment recovery practices started to include other activities within its scope. Reverse logistics is responsible for including reuse and recycling throughout the product life cycle; the practice is adopted because of increased public pressure on environmental protection and reduced resource availability among the supply chain links (Zhu et al. 2012).

Another important practice is ecodesign, which can be useful when starting a new product or process to reduce consumption of energy, materials, and costs throughout the supply chain. Furthermore, companies should give more attention to customer participation in environmental management initiatives such as product return and recycling policies (Zhu et al. 2012).

However, identifying green practices in the supply chain (SC) requires specific considerations, since these practices are carried out by companies that belong to multiple SCs, operating under different strategies and SC links geographically dispersed (Sellitto 2018). Thus, green initiatives in the supply chain can improve the consumption of natural resources, packaging, energy, water, soil, storage, and transport of goods (Srivastava 2007).

In addition, some studies (Tomasin et al. 2013; Zhu et al. 2007; Garza-Reys 2015) have pointed out that some elements generate drivers and barriers for the implementation of green practices. Barriers represent factors that make it difficult to implement green practices and identify how a sustainable supply chain seeks to prevent such difficulties. On the other hand, drivers are the factors that facilitate the implementation of green practices in the supply chain and how SC links ensure to apply those activities in their operations.

The most commonly identified barriers include the lack of market, lack of employee training, lack of balancing alternatives between social and environmental aspects involved, suppliers' commitment, the high costs associated with new technologies and operationalization (tax burden, diversification of modes), and incomplete or ambiguous legislation (flexibilization of agreements between countries) (Tomasin et al. 2013; Allwood et al. 2008; De Brito et al. 2008).

Drivers for implementing green practices in the supply chain can be divided into external and internal contexts. From the internal perspective, the factors contributing to the integration of green practices include the desire to reduce costs, improve processes and quality, improve logistics, reduce losses and dematerialization

(Tomasin et al. 2013; Zhu et al. 2007). From the external point of view, factors that encourage adoption of green practices in the supply chain include a significant need for adequacy of laws and regulations, customer demands, brand image, and technological offerings from partners (Tomasin et al. 2013).

In short, to achieve a full realization of economic benefits and to establish a meaningful diminution of negative environmental impacts, it is important that companies strive to improve their adoption of green practices. Actions such as performance measurement systems, continual improvement practices, and benchmarking may provide an overview of how companies and their supply chains are progressing ecologically (Zhu et al. 2008).

2.2 Sustainability in the Fashion Supply Chain

A vital feature of the fashion supply chain is its complexity in manufacturing and distributing products which differ in their structure and nature. In other words, the process of delivering a T-shirt and a shoe is completely different in terms of the materials involved, the manufacturing process, and packaging and delivery requirements (Brun and Castelli 2008).

In addition, the fashion supply chain is particularly sensitive to sustainability due to its high environmental impact during production process (e.g., use of chemicals and pesticides in the production of raw materials and disposal of toxic dyes in effluents during manufacturing process) (Turker and Altuntas 2014).

Indeed, sustainability in the fashion supply chain must go far beyond non-integrated business management or supply chains. It must involve the whole supply network, given the wide range of intra-sectors working in production of a fashion item (Allwood et al. 2008). Such concern can be based on the pressures imposed by international and local regulations, nongovernmental organizations (NGOs), clients, and competitors (Turker and Altuntas 2014).

Due to the complex and dynamic nature of the supply chain in the fashion industry, literature resources have created (Allwood et al. 2006; EURATEX 2004) a sector map that prioritizes business networking and existing structures and technology in the activities of raw material extraction, yarn, fabric and finished fabric, retail and final customers; the map is depicted in Fig. 1.

In the extraction and yarning of raw material stages, the most predominant and cultivated fabrics are cotton and polyester. About one-third of the world's exports of cotton from the US is used in the fashion industry. Polyester fabric is a synthetic fiber whose manufacture requires oil and releases pollutant emissions such as organic compounds and gases (e.g., hydrogen chloride) (Nagurney and Yu 2012).

At the fabric and finished fabric stages, there is a high concern with integration and sharing of information due to costs incurred by small and medium-sized (SME and SMEE) companies in the sector. Smaller companies end up suffering disparities compared to larger players because they lack the most up-to-date skills to forecast

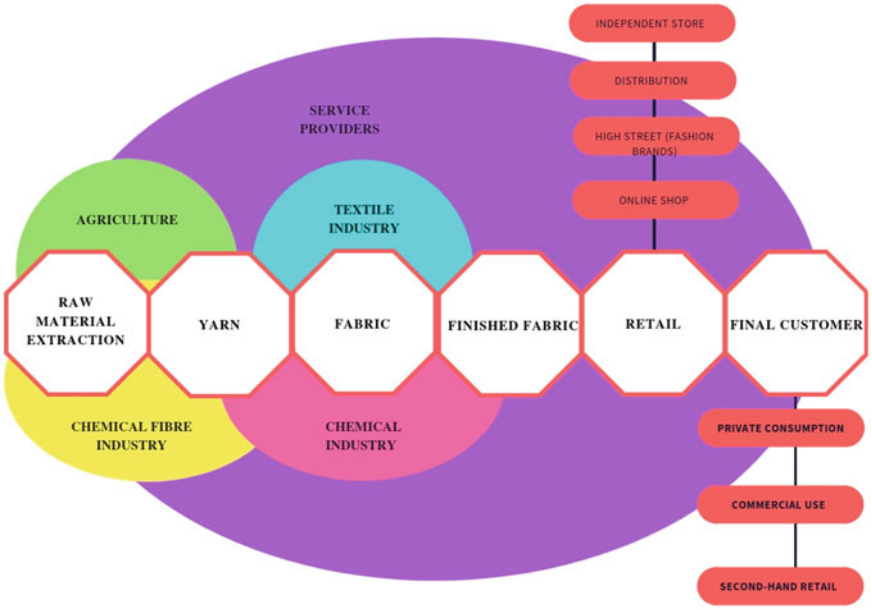

Fig. 1 Fashion supply chain: sector map (Adapted from Allwood et al. 2006 and EURATEX 2004)

demand in the industry's complex and dynamic context (De Brito et al. 2008, Allwood et al. 2008).

Usually considered the focal point of analysis in the clothing industry, retailers are looking for solutions that can reduce the negative environmental impact and governmental pressures to provide management solutions such as transportation, flexibility, and optimization of production (Tomasin et al. 2013). Therefore, retailers basis their decision-making to shape a sustainable approach to supply chain management (SCM) in order to attend to expectations from government and customers (De Brito et al. 2008).

From the point of view of the final customer, although there is demand for sustainable items, the consumer still expects the producer to assume responsibility, but does not seem open to change his not-sustainable behavior. Among the main characteristics of fashion items, two worthy of mention are: (1) young people demand; and (2) the use of energy associated with laundry (mainly cotton products) (De Brito et al. 2008).

3 Research Method

The survey procedures were delimited based on the criteria of location, selection and validation of the material, analysis and synthesis of content, and presentation of the results, as demonstrated in Fig. 2.

3.1 Location, Selection, and Validation

The ISI Web of Science, Scopus, and Elsevier databases were used for data location, and EndNote® software was used to import selected publications. The criteria for searches were: (1) publication years were restricted to 2008–2018; (2) articles were considered based only on title, abstract, and keywords; (3) conference articles, books or chapters of books, or technical articles were excluded from consideration; (4) only articles written in English were included. The material was collected in May 2018 and included publications up to that time.

The criteria for inclusion and exclusion of studies were defined based on: (1) green practices must have been addressed in the context of the clothing, footwear,

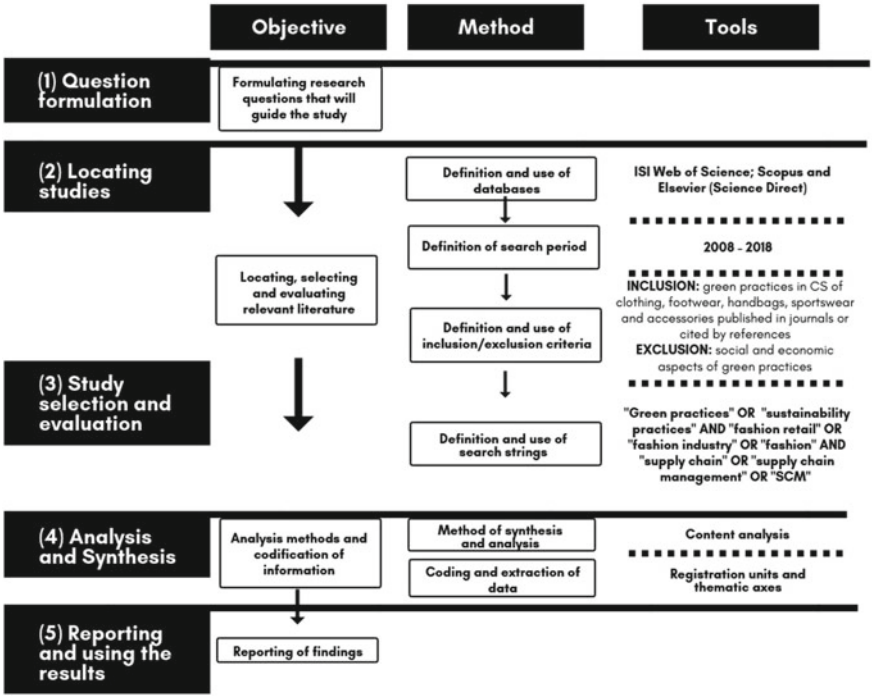

Fig. 2 Survey stages diagram (based on Garza-Reys 2015; Franco, 2008)

handbags, sportswear, and accessories segments (belt, gloves, caps, and hats); (2) sustainable practices concerning social and economic aspects were not considered.

After completing the search of the 8 keywords in 3 databases, 188 publications were selected. Among these, repeated articles were removed and the titles, abstracts, and keywords were read in order to identify association with the established research theme. In this stage, conference articles, technical articles, and journal articles dealing with sustainability in a context other than the environment in the fashion industry were excluded.

As such, 25 articles aligned to the research were obtained. Finally, 3 additional relevant articles were selected from the sample, totaling 28 studies to proceed with the synthesis and analysis.

3.2 Analysis and Synthesis

For the synthesis and analysis of findings, a content analysis adapted from Bardin (2010) was chosen for the method. This approach works the coding and extraction of content from the division of the material into (1) registration units and (2) thematic axes; it was developed with the help of Excel® software for data processing.

In this study, six thematic axes were developed: (a) green practices (environmental management; green purchasing; reverse logistics; investment recovery; ecodesign; cooperation with customers); (b) links of SC (raw material extraction; yarn; fabric; finished fabric; retail; final consumer); (c) case description (main features of the practice).

The descriptions of the registration units and thematic axes were based on Euratex (2004)' Allwood et al. (2006), Zhu et al. (2007, 2008, 2012), De Brito et al. (2008), Seuring and Muller (2008), and Tomasin et al. (2013). Green practices and SC links were organized in (a) table with case studies, type of practices and SC links involved; (b) figure of green practices frequency by SC link; (c) discussion of the results from drivers and barriers to their implementation and the relationship between SC links.

The supply chain links that will compose this study (see Fig. 1) will be delimited according to Seuring and Muller (2008) in: (a) focal company—retail link; (b) tier 1 suppliers: maintains direct contact with the company—fabric and finished fabric; (c) tier 2 suppliers: raw material extraction and yarn; (d) tier 1 customers: individual or professional use; (e) tier 2 customers: second-hand retail.

4 Results and Discussion

In Table 1, the different green practices and their main characteristics found in the studies analyzed are grouped. Note the greater incidence of practices related to corporate social and environmental responsibility (environmental management system), in the establishment of suppliers compliance attributes (green purchasing), new ways

Table 1 Characteristics of green practices identified in the fashion supply chain

Green practices	Links of SC	Case description	Adapted from
EMS	Fabric; finished fabric, and retail	Computational scheme of routes for transport of goods related to production, distribution centers, and final customer to find the best solution according to demand, total cost, and total emission	Nagurney and Yu (2012)
	Raw material extraction, yarn, fabric, finished fabric, retail, and final customer	Integration of different SCM to ensure brand reputation and product quality (high quality manufacturing, outsourced training, combined tradition of finishing with technology)	Brun et al. (2008), Brun and Castelli (2008), Machion et al. (2016)
	Fabric, finished fabric, and retail	Alternative modes of prioritization for production flow (maritime model, rail, crossdocking)	Li et al. (2014); Turker and Altuntas (2014)
	Retail	Reduction of energy waste in stores	Li et al. (2014), Turker and Altuntas (2014)
	Fabric, finished fabric, and retail	Water management strategy to reduce waste in the production process	Li et al. (2014), Turker and Altuntas (2014)
	Retail and final customer	Company's strategy for dissemination of environmental improvements developed in the field of recycling and energy consumption	De Giau et al. (2016), Oh and Jeong (2014)

(continued)

Table 1 (continued)

Green practices	Links of SC	Case description	Adapted from
	Retail	Performance indicators: green processes and green distribution, cooperation with partners and adaptation, complexity and communication management, barriers, ecodesign, green products, green purchasing, green manufacturing, operational indicators, reverse logistics	Sellitto (2018)
	Retail	Integration of CSR aspects (government, clients, and NGOs) in supply chain relations and communication to stakeholders	Pedersen and Gwozdz (2014), Khurana and Ricchetti (2016), Lueg et al. (2015), Machion et al. (2016), Pather (2015), Garcia-Torres et al. (2017), Pedersen et al. (2017), Pedersen et al. (2018), Battaglia et al. (2014)
	Fabric, finished fabric, and retail	Integration of innovation activities with collaborative practices in the design and manufacture of sustainable garments	Machion et al. (2016)
	Retail	Performance indicators of environmental, social, and economic aspects in SCM	Allwood et al. (2008), Caniato et al. (2012)
	Retail	Measurement of sustainable practices and responsibilities of stakeholders in fashion supply chain	De Brito et al. (2008)

(continued)

Table 1 (continued)

Green practices	Links of SC	Case description	Adapted from
	Fabric, finished fabric, and retail	Barriers to implementation of SSCM or sustainable practices in SC	Diabat et al. (2014), Caniato et al. (2012)
Green purchasing	Raw material extraction, yarn, and retail	Establishment of compliance and sustainability attributes to focal company suppliers (code of conduct, ISO 9000, ISO 14001, clean production, organic fibers, and technical treatises)	Turker and Altuntas (2014), Hansen and Schaltegger (2013)
	Fabric, finished fabric, and retail	Suppliers based on environmental metrics	Li et al. (2014)
	Fabric, finished fabric, and retail	Practices for manufacturing, distributing, and selling sustainable finished fabrics through SSCM	Tomasin et al. (2013)
Reverse logistics	Retail and final customer	Incentive to dispose of unused (non-brand) clothing at retailer's stores for reuse and disposal	Li et al. (2014)
	Retail and final customer	Circular economy model proposal of manufacturers and third parties to collect and recover clothing items	Oh and Jeong (2014)
Ecodesign	Fabric, finished fabric, retail, and final customer	Proposal of second-hand fabrics suppliers; fashion libraries; zero waste policies and sustainable certification (or standards) of raw material extraction	Todeschini et al. (2017), Henninger (2015), Hansen and Schaltegger (2013)

(continued)

Table 1 (continued)

Green practices	Links of SC	Case description	Adapted from
	Fabric, finished fabric, retail, and final customer	3D prototype for the development of clothing products, encompassing digital tools for adaptation and prolonging the shelf life of fabrics	Papahristou and Bilalis (2017)
Cooperation with customers	Retail and final customer	Instruct customer to reuse, recycle, and purchase products	Li et al. (2014)
Investment recovery	Retail and final customer	Proposal of take-back system for disposal, refurbishment, and reuse of garments	Todeschini et al. (2017), Li et al. (2014)

for capturing and using of raw material in production process (ecodesign), and inducing real sustainability through new revenue streams in the take-back process (reverse logistics).

From 28 articles analyzed, there are 22 case studies, three analyses of company reports, two bibliographic reviews, and one method applicable to SCM.

Among practices related to environmental management system (EMS), studies suggest that current solutions refer to specific situations and that few companies are already developing extended solutions throughout the production chain up to the point of sale due to the high complexity and subsequent difficulties in controlling the actions of suppliers (Pedersen and Gwozdz 2014). This misalignment between suppliers and the focal company is one of the barriers faced by the clothing industry (Li et al. 2014).

In addition, Khurana and Ricchetti (2016) point out that NGO campaigns play a key role in providing support for strategies and decisions on sustainability goals of fashion brands. As such, the focus of sustainability comprises from internal processes to the entire supply chain, including stakeholder needs (goals, accountability, demands) (De Brito et al. 2008).

As the range of products and needs by external suppliers grows, it becomes more difficult to integrate and manage the activities and quality of production within the supply chain (Turker and Altuntas 2014). This difficulty is observed in green purchasing practices, since the implementation of sustainability actions with the suppliers may incur high costs to the focal company or the non-acceptance by the producer for long-term partnerships.

On the other hand, green purchasing practices have been encouraged and applied by retailers in the conventional mass market due to the availability of new technologies, such as certification and use of organic cotton (Hansen and Schaltegger 2013). Improved processes can also be observed due to implementation of codes of conduct for retailers' partners. In this case, companies in the industry could integrate their code of conduct into a specific sector structure and develop a comprehensive set of principles on SCM (Turker and Altuntas 2014).

Not only would this step be important in promoting a consistent system for in-use compliance for suppliers (existing and potential ones) but it would also help overcome the problems caused by the fragmented nature of current in-use compliance systems (Garcia-Torres et al. 2017; Turker and Altuntas 2014). Partnerships can also generate new production arrangements, such as reverse logistics with companies that collect and reuse discarded clothing materials to return to the production chain (Oh and Jeong 2014).

Still regarding with reverse logistics, loss reduction is an opportunity that is tied to these processes but it can also be directly related to lack of employee training. Even if the focal company demands time and resources for product return practices (for reuse, recycling, remanufacturing, or proper disposal), the absence of a strong commitment from senior management to promote sustainable principles within the company affects the progression of this goal.

These limitations will also affect ecodesign. For example, a footwear company aims to implement products to fit in a sustainable brand

perspective. Although prioritizing the total use of materials and recycling of goods, there is no reuse of parts, returnable packaging, or reconditioning process. Furthermore, the quantity of remanufactured materials drive to stakeholders (NGOs) or others supply chain stages is still low (Sellitto 2018).

In this case, commitment of suppliers is a barrier because it is directly related to non-communication of aspects to packaging destination, type of raw material used, and integration between raw material producers for subsequent return, disassembly, and reuse of parts. The integration of various SC links from 3D virtual prototyping solutions and innovations in virtual reality in the fashion retail environment represents opportunities for energy, material, and cost savings across the supply chain (Zhu et al. 2012).

Others studies (Henninger 2015; Sellitto 2018; De Giau et al. 2016) show that customers in the fashion industry still have a marginal interest in sustainable aspects. Researchers observe that sustainability does not necessarily add directly to an improvement in the brand image (Lueg et al. 2015; De Brito et al. 2008). Instead, it is necessary for organizations to begin to observe the strategies adopted to reach their target audience, since the impact of actions on eco-friendly demand is totally different from the behavior of fast-fashion consumers (Allwood et al. 2008).

Regarding customer participation in environmental initiatives, some studies (Allwood et al. 2008; De Brito et al. 2008) state that although consumers are environmentally aware, their behavior does not change and they expect the producer to take responsibility on sustainability actions.

Concerning other opportunities in the consumption of natural resources, certain studies (Li et al. 2014; Turker and Altuntas 2014) show that companies already have strategies for water and energy consumption reduction (in stores, manufacturing, and transport activity). For example, partnerships exist between NGOs and companies for management of water in the production process and to prevent the disposal of chemicals in effluents (Li et al. 2014).

To assure significant changes to sustainable fashion, it is necessary to mobilize stakeholders (NGOs, clients, and suppliers) to exercise a proactive attitude in the major brands of the fashion industry (commonly retailers), which may then inspire improvements in other SC links' behavior (Turker and Altuntas 2014).

Regarding investment recovery, the findings show that searching for cost reduction combined with an upcycling method generate a promising option for new retailers in the sustainable fashion market, since brands who are focused on sustainability and innovation have a direct impact on key resources and sustainability activities (Todeschini et al. 2017). As companies begin to consider the aspects of innovation in their operations, they become more sensitive to sustainability issues, so a key factor is how many new revenues are returned to the companies as a result of their environmental policies.

Figure 3 shows the participation frequency of fashion supply chain links in the green practices. Hence, it was identified that the retail market (composed of clothing, distributors, department stores, and physical stores) plays a primary role with 21 practices identified. Next, the fabric and finished fabric reveal 10 practices each, followed by final customers (8), raw material extraction (2), and yarn (2). A greater

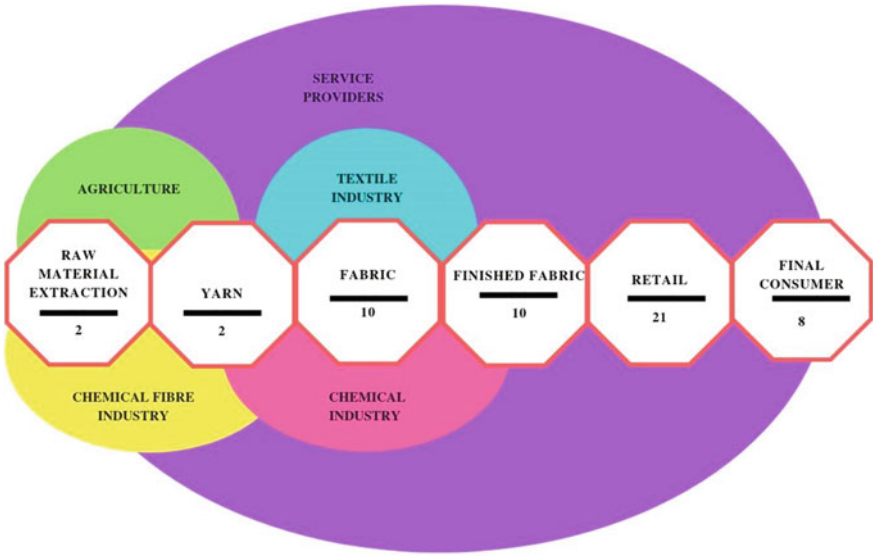

Fig. 3 Participation frequency of links from fashion supply chain on green practices (Adapted from Allwood et al. 2006 and EURATEX 2004)

distribution from the first stages of the supply chain was noticed, since they are in relationship within other supply chains from the chemical fibre industry, chemistry industry, agriculture and textile (22 practices related to raw material extraction, yarning, fabric, and finished fabric).

In the upstream stages of the supply chain, second-tier suppliers represent a large part of the environmental impact of fashion issues (Khurana and Ricchetti 2016). Those producers are suppliers of yarns or fabrics; brands can verify its quality through tests but, in most cases, they can not evaluate attributes of sustainability (e.g., the cultivation of organic cotton). Some of these issues can be managed through certificates that ensure traceability or increase transparency through supply chain (Li et al. 2014).

The literature also discusses the costs to SME and SMME producers in the fabric and finished fabric links (De Brito et al. 2008; Allwood et al. 2008). As retailers begin to transfer responsibilities to their first-tier suppliers, it also splits risk and thereby initiates a collaborative process for training its partners' employees and to direct efforts for developing new products and sustainable processes (Machion et al. 2016; Lueg et al. 2015).

Retailers may have opportunities in factors such as transportation, flexibility, and optimization of production seeking to reduce its environmental impacts (Tomasin et al. 2013). For example, it was founded that apparel companies in the internationalization process were able to maximize their profits and minimize emissions of pollutant gases throughout their supply chain by actively participating in their manufacturing, storage, and distribution activities (Nagurney and Yu 2012).

However, although the retail link is more involved in green practices, it is necessary to construct metrics to measure performance of these activities since time plays an important role on adopted strategies (Li et al. 2014; Turker and Altuntas 2014; Zhu et al. 2008). If conventional firms commit to sustainability quickly and radically, they may be asking too much of their customers, employees, and suppliers (Hansen and Schaltegger 2013).

Finally, in relation to final customers, it was observed that consumers need to be more aware and that retail companies can play an important role in this sense, as well as NGOs (Khurana and Ricchetti 2016). However, the studies focused more on barriers or modes of acceptance on the part of the client than necessarily on practices for encouraging links occurring upstream of SC engagement.

5 Conclusions

Regarding green practices in the fashion industry supply chain, studies have shown that in the last 10 years, practices related to internal environmental systems (EMS) were the most approached (12). Involved within it, the activities of integrating aspects of CSR in the SC communication were more frequently cited. The studies also demonstrated the primary barriers as the lack of knowledge about the market, commitment to suppliers, lack of training of employees and high costs of operationalization. Conversely, the main opportunities are reduction of cost, improvement of corporate image, and technological offerings of partners.

Currently, green practices have moved from an internal focus to an external level involving players from its supply chain. Thus, studies suggest that current solutions refer to specific situations and that few companies are already developing extended solutions within the whole supply chain due to the high degree of complexity and subsequent difficulties in controlling suppliers' actions.

Engagement by suppliers and customers can be pushed by focal companies and stakeholders (e.g., policymakers, media channels, NGOs) to mobilize changes and then be replicated by SME and SMEE producers. Although processes still need results measurement, the green practices analyzed demonstrate benefits in the consumption of natural resources.

In relation to supply chain links, retailers have more practices identified in the studies. The responsibilities of the focal company are to seek partnerships with suppliers, raise consumer awareness, and interact with other stakeholders. Related to communication between the focal company and the first stages of the SC (raw extraction, yarn, fabric and finished fabric), the retailers do not have direct contact with them, so a common practice is the requirement of certifications.

In the fabric and finished fabric links, responsibilities and risk sharing among them promote the development of new products and sustainable processes. Thus, customers have been encouraged to seek greater awareness on brand sustainability practices, but no consumer participation has been cited about product return and recycling policies.

After all, the future of green practices in the fashion industry depends on synergies between supply chain links driven by the focal company (retail branding) but also developed by stakeholders such as governments, NGOs, and clients. Retail companies need to measure the performance of such practices in order to recognize the benefits of seeking new activities that promote the continuous reduction of negative environmental impacts in the clothing sector.

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Environmental Performance Measurement in Hospitals: A Bibliometric Review of Literature (1987–2017)

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Abstract The publication of the Brundtland Report in 1987 has placed the term 'sustainability' as a paramount research topic in several disciplines. In the healthcare sector, hospitals have faced considerable demands: tougher legislation and ongoing pressures for cost reduction and improved quality, which have forced them to re-examine the performance of their operations and processes. Hospitals deal with a significant amount of hazardous and non-hazardous materials and generate polluting outputs. Moreover, in developing countries such as Brazil, healthcare operations involve high costs for provided services, limited productive resources and lack of public expenditure. Frameworks that directly address the measurement of environmental performance are regarded as crucial to address these demands. This study involves a bibliometric review of literature on the topic 'hospital environmental performance measurement' during the period 1987–2017, i.e., since the publication of the Brundtland Report. A certain prevalence of studies placed in high-income coun-

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tries was found. Nevertheless, a growing focus on the specific context of developing countries was also identified. The content analysis revealed that the proposal and testing of frameworks for the measurement of environmental performance in hospitals is still an unsolved issue.

Keywords Environmental performance · Measurement · Hospital · Framework

1 Introduction

Organizations in developed and developing countries have been urged to rationalize the way resources are used and how they affect sustainability (Kleindorfer et al. 2005; McNatt et al. 2015). The relationship between the healthcare sector and the environment is twofold. Environmental deterioration tends to generate health problems, which require treatment by healthcare providers whilst the waste generated by the sector, pollution and use of natural resources to provide these services should be minimized to achieve sustainability.

In the healthcare sector, hospitals have faced considerable demands: tougher legislation and ongoing pressures for cost reduction and improved quality, which have forced them to re-examine the performance of their operations. According to McGain and Naylor (2014), the measurement of the environmental impact caused by hospitals is still troublesome. Moreover, it requires an effort across borders and policy changes. Lega et al. (2013) emphasize the findings of Porter (2010), i.e., the improvement of value in healthcare is paramount. Concerns related to cost reduction are meaningless if quality is to be worsened.

Feng and Joung (2011) conducted a comprehensive review of literature, seeking an appropriate model to measure sustainability in manufacturing operations. On one hand, the authors observed a growing concern about external stakeholder perception. On the other hand, a lack of internal efforts in gathering information for decision-making or innovation was noteworthy.

Despite the current focus on frameworks related to measuring environmental performance in the healthcare sector, outcomes have been regarded as unsatisfactory (Phillips et al. 2002). The amount of waste generated from healthcare operations has gradually increased (Woolridge et al. 2005).

In developing countries, healthcare operations involve high costs of provided services, limited productive resources and lack of public expenditure. Ananth et al. (2010) argue that measuring performance is necessary to acknowledge improvement. Conceptual and methodological frameworks are regarded as necessary to forge sustainability thinking (Duić et al. 2015).

Considering this context, especially in developing countries, this study includes a bibliometric review on the topic over the past 30 years. The period includes the year of publication of the Brundtland Report (1987) up until 2017. Bibliometric

methods were adopted to identify main publications, authors and outlets, research centers/institutions and countries of origin of the researchers. A content analysis was also employed to uncover proposed environmental measurement frameworks, particularly those focused on developing countries. This paper is divided in four main sections: Introduction, Bibliometric Review Design, Data Analysis and Conclusion.

2 Bibliometric Review Design

Yataganbaba et al. (2017) indicates the effectiveness of bibliometric methods in showing a scientific roadmap on the study of a specific topic or area. The study sought to analyze the progress of the research on 'hospital environmental performance measurement' by listing most cited authors and their country of origin, main publication outlets, research centers/universities. In addition, a content analysis was used to uncover proposed frameworks for the measurement of environmental performance in hospitals. Table 1 describes the elements of the research protocol.

The terms used in the study were regarded as keywords associated with environmental performance measurement in hospitals: (1) Hospital + Environment; (2) Hospital + Environment* + Indicator; (3) Hospital + Performance; (4) Hospital + Sustain* + Environment + Framework; (5) Hospital + Indicator + Framework; (6) Indicators + Environment + Sustain*; (7) Quality + Indicators + Health + Care; (8) Health + Care + Operations + Performance; (9) Health + Care + Performance + Indicators + Environment + Sustain*; (10) Health + Care + Performance. Figure 1 describes the sequence of steps followed in the study.

Table 1 Research protocol

Research terms	10 combinations of terms
Reading	Title, Abstract, Introduction, Development, Results and Conclusion
Database	Web of Science™
Exclusion criteria	Studies related to hospital accreditation (not related to the environment); country and urban/city level environmental concerns; green infrastructure for healthcare facilities; internal environment/organizational climate; P4P studies (pay for performance); quality of care; rural level environmental concerns; strategies to improve performance in non-healthcare organizations
Inclusion criteria	Studies related to environmental performance measurement in hospitals
Language	English
Types of publication	Journals and conference proceedings papers
Period	1987–2017

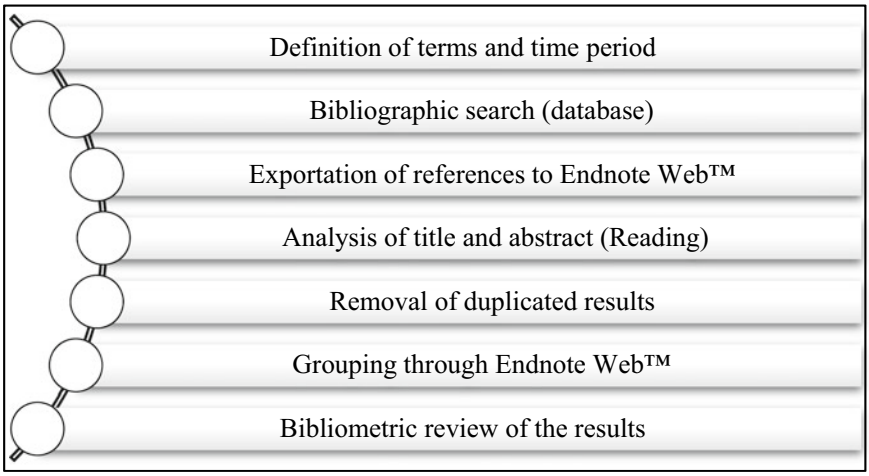

Fig. 1 Research procedure

Web of Science™ (Thomson Reuters®) was selected as the main database for data collection. It encompasses tools for citation and reference analysis, which allow bibliometric reviews. The database encompasses approximately 12,000 journals. Five collections were used: Science Citation Index Expanded (SCI-EXPANDED)—availability 1945–Present; Social Sciences Citation Index (SSCI)—availability 1956–Present; Arts & Humanities Citation Index (A&HCI)—availability 1975–Present; Conference Proceedings Citation Index—Science (CPCI-S)—availability 1991–Present; and Conference Proceedings Citation Index—Social Science & Humanities (CPCI-SSH)—availability 1991–Present. Thomson Reuters® make Endnote Web™ available in the Web of Science Platform. It was used as an analysis tool for the bibliographic references.

After examining the titles by order of relevance, 86 were regarded as related to the combination of, at least, two of the terms: 'environmental', 'performance', 'measurement' and 'hospitals'. The abstract, keywords, introduction, development, results and conclusion of these papers were read next. A total of 76 references were eliminated, since they fit the exclusion criteria. A set of 10 references was regarded as relevant to 'environmental performance measurement'. Table 2 shows the topics related to the excluded references.

Table 2 Topics of the excluded references

Topic of excluded papers	Number of papers
Hospital accreditation (not related to the environment)	1
Country and urban/city level environmental concerns (including hospital waste)	14
Green infrastructure for healthcare facilities	2
Internal environment/organizational climate	3
Pay-for-Performance studies (P4P)	3
Quality of care	45
Rural level environmental concerns	2
Strategies to improve performance in non-healthcare organizations	6
Total of results	76

3 Data Analysis

3.1 The Bibliometric Review of the Papers

The 10 remaining papers were reviewed in terms of year of publication, publication outlet, and distribution of papers/authors per country of origin, affiliation and number of citations. The content analysis aimed to uncover existing and proposed environmental performance frameworks for hospitals. Table 3 lists the authors and paper titles.

The distribution of publications between 1987 and 2017 was analyzed next: 1996 (one paper), 2011 (one paper), 2014 (one paper), 2015 (two papers), 2016 (three papers) and 2017 (two papers). The absence of studies from 1987 up until 1996 and the gap between 1996 and 2011 are noteworthy. In 2014, it appears the topic resurfaced. Nonetheless, the reason behind the lack of a significant number of studies within a 30-year period seems to be unclear. The country of origin of the authors was also analyzed. Table 4 lists the authors per country of origin.

The publication outlets were also identified. The 'Journal of Cleaner Production' is at the top of the list; it published three of the papers. In second place, the 'Journal of Green Building' published two papers. Other four journals published each, one paper, and the paper 'The implications of sustainable development and the zero option for health care waste' was published in the 7th Iswa International Congress Proceedings.

A certain prevalence amongst European countries is suggested, since four papers included Europe-based researchers. Two papers included researchers from North America and two are authors from South America. There are also researchers based in Africa, Asia and the Middle East. Considering the number of researchers per country of origin, recently there has been a certain predominance of researchers

Table 3 Authors and titles of the papers

Authors	Paper title
Berhanu et al. (2016)	Knowledge, experiences and training needs of health professionals about disaster preparedness and response in Southwest Ethiopia: a cross sectional study
Blass et al. (2017)	Measuring environmental performance in hospitals: a practical approach
Kangasniemi et al. (2014)	Towards environmentally responsible nursing: a critical interpretive synthesis
Laing and Kean (2011)	The greening of healthcare: fabrics used in health care facilities
Machado et al. (2015)	A proposal of an energy saving technology framework for the hospital
Pinzone et al. (2016)	Progressing in the change journey towards sustainability in healthcare: the role of 'Green' HRM
Ryan-Fogarty et al. (2016)	Greening healthcare: systematic implementation of environmental programmes in a university teaching hospital
Sadatsafavi et al. (2015)	Patient experience with hospital care - comparison of a sample of green hospitals and non-green hospitals
Townend (1996)	The implications of sustainable development and the zero option for health care waste
Yang et al. (2017)	Optimal design of distributed energy resource systems based on two stage stochastic programming

Table 4 Distribution of papers per country of origin

Authors	1st	2nd	3rd	4th
Berhanu et al. (2016)	Ethiopia	Ethiopia	Ethiopia	Ethiopia
Blass et al. (2017)	Brazil	Brazil	Brazil	Brazil
Kangasniemi et al. (2014)	Finland	Finland	Finland	
Laing and Kean (2011)	Canada	Canada		
Machado et al. (2015)	Brazil	Brazil	Saudi Arabia	Brazil
Pinzone et al. (2016)	Italy	UK	UK	
Ryan-Fogarty et al. (2016)	Ireland	Ireland	Ireland	
Sadatsafavi et al. (2015)	US	US	US	
Townend (1996)	UK			
Yang et al. (2017)	China	China	China	

from Brazil and Africa. The universities and/or research centers were also listed. Table 5 presents the data.

The set of papers was ordered according to citation numbers. Two sources were used to expand results and further the analysis. As the Web of Science™ Platform may not be available for every institution (subscription-based access), Google Scholar® was also used for quantification.

The most cited papers were: "Progressing in the change journey towards sustainability in healthcare: the role of 'Green' HRM" (cited 28/11 times) and "Towards environmentally responsible nursing: a critical interpretive synthesis" (cited 23/9 times). "Greening healthcare: systematic implementation of environmental pro-

Table 5 Affiliation of the authors

Authors	1st	2nd	3rd	4th
Berhanu et al. (2016)	Jimma University			
Blass et al. (2017)	Pontifical Catholic University of Parana	Pontifical Catholic University of Parana	Pontifical Catholic University of Parana	Unidavi
Kangasniemi et al. (2014)	University of Eastern Finland	University of Eastern Finland	University of Eastern Finland	
Laing and Kean (2011)	Practitioner	McMaster University		
Machado et al. (2015)	Faculdade Dom Alberto	Federal University of the State of Rio de Janeiro	American University of Sharjah	Universidade de Santa Cruz do Sul
Pinzone et al. (2016)	Politecnico di Milano	Università Degli Studi di Milano	Politecnico di Milano	Durham Business School
Ryan-Fogarty Y., O'Regan B. and Moles R. (2016)	University of Limerick			
Sadatsafavi et al. (2015)	Cornell University	Texas A&M University	University of Michigan	
Townend (1996)	Institutes of Wastes Management			
Yang et al. (2017)	Chinese Academy of Sciences	Chinese Academy of Sciences	University of Chinese Academy of Sciences	

grammes in a university teaching hospital" was cited 19 (Google Scholar®) and eight times (Web of Science™), respectively. "Measuring environmental performance in hospitals: a practical approach" obtained 13 and two citations. "Optimal design of distributed energy resource systems based on two stage stochastic programming" had 11/9 citations. The paper "Patient experience with hospital care—comparison of a sample of green hospitals and non-green hospitals" was associated with 4/2 citations. "The greening of healthcare: fabrics used in health care facilities" presented 3/1 citations. "Knowledge, experiences and training needs of health professionals about disaster preparedness and response in Southwest Ethiopia: a cross sectional study" was cited 2/1 times. Finally, "A proposal of an energy saving technology framework for the hospital" and "The implications of sustainable development and the zero option for health care waste" had no citations. Table 6 presents these results.

Table 6 Number of citations per paper

Google Scholar®	Web of Science™	Paper title
28	11	Progressing in the change journey towards sustainability in healthcare: the role of 'Green' HRM
23	9	Towards environmentally responsible nursing: a critical interpretive synthesis
19	8	Greening healthcare: systematic implementation of environmental programmes in a university teaching hospital
13	2	Measuring environmental performance in hospitals: a practical approach
11	9	Optimal design of distributed energy resource systems based on two stage stochastic programming
4	2	Patient experience with hospital care—comparison of a sample of green hospitals and non-green hospitals
3	1	The greening of healthcare: fabrics used in health care facilities
2	1	Knowledge, experiences and training needs of health professionals about disaster preparedness and response in Southwest Ethiopia: a cross sectional study
0	0	A proposal of an energy saving technology framework for the hospital
0	0	The implications of sustainable development and the zero option for health care waste

4 Content Analysis

The papers were analyzed using a two-fold approach. First, a summary of main objectives and outcomes was prepared, focusing on the review or proposal of frameworks for the environmental performance measurement in hospitals. Second, the abstracts of the papers were analyzed using WordCloud™. McNaught and Lam (2010) indicate that word cloud tools can be used to visualize text and supplement content analysis.

Berhanu et al. (2016) present a cross-sectional survey of health professionals working at health offices, hospitals and health centers in nine districts in Ethiopia. The study aimed to analyze the readiness of professionals while facing natural disasters. The authors found that although personnel presented a comprehensive view of disaster impacts, intervention strategies and considerable training were still required. The researchers underlined the importance of training and indicators related to disaster warnings. They do not propose, however, how to measure environmental performance in hospitals.

Blass et al. (2017) propose a practical approach to measure the environmental performance of hospitals. The authors developed a framework based on literature review, field studies, current legislation and best practices. Their approach was tested in six case studies in Brazil. The framework was regarded as adequate to provide meaningful indicators that measure and report hospital environmental performance.

"Towards environmentally responsible nursing: a critical interpretive synthesis" is a review paper by Kangasniemi et al. (2014). It is a study of peer-reviewed papers published between 2002 and 2012. It sought to review environmentally responsible practices by nurses. According to the researchers, the field of environmental management and policies require scientific contributions to evidence-based practices. The study includes theoretical frameworks; it does not directly address performance measurement.

Laing and Kean (2011) is a practitioner's paper. The authors discuss the use of environmentally responsible fabrics in healthcare, called 'healthcare textiles' in their paper. Considering the chemicals used in the fabrics manufacturing process, their utilization in hospitals can negatively affect the health of patients and healthcare workers. A third-party certification is recommended, highlighting the existence of other related issues such as local sourcing, durability and standards of performance. Environmental concerns are raised without a more in-depth discussion on performance measures.

Machado et al. (2015) focus on reducing energy consumption in hospitals. The researchers propose a three-fold approach based on (a) improvement plans and assessment management; (b) training and user awareness; and (c) energy diagnosis. It requires employee engagement. This seems to be the main component to be proposed and provided by the approach. Recommendations are made through guide-

lines. The need to monitor performance is underlined, but no framework of indicators is presented.

Pinzone et al. (2016) report the findings of a survey on the impact of the 'Green' Human Resource Management (GHRM) policies within NHS Trusts. The study showed that building competences and involvement practices have a positive influence at organizational level, improving the collective performance. The researchers focused on Green HRM and did not identify or propose performance measurement frameworks.

The paper by Ryan-Fogarty et al. (2016) describes the experience of the adoption of the 'Global Green and Healthy Hospitals Agenda' framework. The model was created by the coalition 'Salud Sin Daño' (Health Care Without Harm), an international network of healthcare systems, hospitals, communities, unions and environmental organizations. The framework encompasses 10 main objectives related to leadership, chemicals, waste, energy, water, transportation, food, pharmaceuticals, buildings and purchasing (GGHHA 2015). It lists a comprehensive set of objectives and actions that can be implemented for environmental performance improvements. However, no guidelines on how to develop specific indicators are presented. The experience proved to be successful, according to the authors, generating learning through a systematic approach to environmental management and evaluation.

Townend (1996) addresses healthcare waste and its impact on the environment. The researcher highlights the importance to address the topic, considering sustainability concerns. Even though it is regarded as a seminal paper, performance measurement frameworks are not directly cited or studied.

Sadatsafavi et al. (2015) compared patient satisfaction in the case of 'green' hospitals (green facilities) and traditional hospitals. Data showed that patients' satisfaction achieved higher levels in the case of green facilities. However, as stated by the authors, the impact of specific features on the experience of patients could not be verified.

The study by Yang et al. (2017) shows the development of a two-stage stochastic programming to evaluate the effect of uncertainties in load demands, energy prices and renewable energy intensity on a system's economy and optimal design. The system selected for testing the model was a hospital in Lianyungang, China. The results of the study indicated that the economy is overestimated if the system is designed without considering uncertainties. Other dimensions were not directly addressed in the model.

As per the analysis of set of 10 papers, it is possible to observe that frameworks are proposed and/or reviewed in four of the references: Blass et al. (2017), Machado et al. (2015), Ryan-Fogarty et al. (2016) and Yang et al. (2017). The remainder of papers addresses different aspects of environmental concerns associated with hospitals related to resources (material and human) and patient satisfaction.

Only in Blass et al. (2017), there is a systematic approach to determining indicators linked to organizational goals to report the environmental performance status to stakeholders. Moreover, only two of the papers tested the frameworks in the context of developing countries: Machado et al. (2015) and Blass et al. (2017).

To supplement the content analysis, the WordCloud™ tool was used. The words 'environmental'/'environment' (41), 'healthcare/health' (34), 'green' (22), 'hospi-

Fig. 2 Word cloud of the abstracts

tals' (20), 'energy' (16), 'performance' (13), 'framework' (13) and 'approach' (11) stood out, underlining the concerns on environmental performance in hospitals. Figure 2 presents the word cloud of the abstracts.

The analysis of the content of the papers indicated that the discussion on new approaches that address environmental performance in hospitals is present. Growing concerns on how health professionals deal and respond to the demands on mitigating the impact of hospital operations and improving practice/design were found to be relevant.

5 Conclusion

The bibliometric review on 'hospital environmental performance measurement' indicated the scarcity of studies over the last 30 years, that is, since the publication of the Brundtland Report (1987). A set of 10 papers were regarded as relevant to the topic. The majority of studies were placed in high-income countries; three of the papers showed that the concerns on the subject have grown in the case of developing countries. Nonetheless, the content analysis suggested that there is a knowledge gap related to frameworks that directly deal with the measurement of hospital environmental performance. Considering the topic has become paramount and the impact of hospital operations on the environment, this seems to be a crucial research opportunity. Only by proposing and testing meaningful frameworks, it will be possible to achieve a sustainable present and future for hospitals, especially in developing countries.

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Implementing Sustainable Development Through Environmental Camps: The Case of Skyros Project

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Abstract Today's utmost concern about the sustainability of our planet has made environmental education an even more imperative tool for changing our behavior to an optimal one. Environmental summer camps could help children to become acquainted with natural environment and to develop environmental ethics. Environmental summer camps are considered to increase participants' consciousness by promoting environmental conservation and sustainability skills. The current research was conducted in summer of 2017 at a northern Greece mountainous region with rich natural heritage, known as Nestorio. The purpose of this study was to

The specific project is an educational and communicational program, implemented by the University of the Aegean in collaboration with the Skyros Port Authority, aiming to increase the environmental awareness of local communities towards sustainable development. An administered survey provided results in order to assess knowledge and environmental awareness, prior to and after completion of this summer camp, using face-to-face interviews with participants. Recommendations on the effectiveness of Skyros Project were the outcome of the trial of this summer camp at Nestorio area.

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evaluate the effectiveness of promoting sustainable development through a week-long environmental summer camp known as “Skyros Project”.

Keywords Environmental summer camps · Sustainability · Environmental education · Skyros project · Greece

1 Introduction

The utmost challenge for environmental education is to create motivated, aware and dedicated trainees who would act in a pro-environmental manner. Thus, free-choice environmental learning experiences are used to arouse participants to associate with responsible environmental behavior (Ballantyne and Packer 2011). The camp experience has become an attractive context for experiential environmental learning. It provides a long-term effect on participants’ understanding, attitudes and conduct towards the environment, through a pleasurable educational way. Summer environmental camps could help children to become acquainted with nature and develop environmental ethics (Collado et al. 2013). As well as providing knowledge, they may augment consciousness to such an extent, that participants earnestly consider environment maintenance as their own responsibility. Summer environmental education programs expose children to unacquainted environmental setups and concepts in a fascinating context, which may induce exciting attitude alterations (Apostolopoulou et al. 2016). Therefore, nature camps might be more efficacious in promoting children’s emotional affinity to nature, ecological beliefs and environmental behaviors than in-class environmental education programs. Comprehending and cultivating children’s environmental consciousness may be vital to rectifying the environmental degradation and to promoting sustainability in youth (Collado et al. 2013).

The purpose of this study was to examine the effectiveness of promoting sustainability through a weekly environmental summer camp under the Skyros Project 2017, which through environmental activities boosts environmental awareness.

2 The Role of Education

2.1 Environmental Education (EE)

The most efficacious manner regarding environmental protection is through educating the population (Pollaki and Skanavis 2015). Increasing environmental knowledge, endorsing favorable environmental attitude, imposing environmental awareness, changing environmental behavior, supporting active participation in the solution

of environmental problems etc., are varied outputs, named as 'elements of environmental literacy', that bring about different approaches in environmental education (Okur-Berberoglu et al. 2014; Stevenson 2007; Storksdieck et al. 2005; Hadlock and Beckwith 2002; Kassas 2002; Dori and Herscovitz 1999). The active citizen environmental participation is a must. A satisfying deepening in environmental education should combine all three forms of education (formal, non-formal and informal) (Apostolopoulou et al. 2016).

2.2 Education for Sustainable Development (ESD)

Sustainable development is the ethically founded response to global private and economic interests and where these interests form the profile of academically literate young people (Barth et al. 2007). A new set of individual and societal choices and actions are thus essential to contribute to the solution of these problems. One of the most imperative and challenging tasks that governments, conservation organizations, industry and business confront, is how to effectively persuade individuals to rapidly espouse environmentally responsible practices in their daily routines. Though formal education programs are undoubtedly vital, they contribute only a small part to the public's understanding of environmental issues (Falk and Storksdieck 2005; Ballantyne and Packer 2011).

2.3 Outdoor Environmental Education

Today's youth and especially children are technologically adept, but without having a direct connection to nature (Pollaki and Skanavis 2015). Unfortunately they are getting more distant to the environment, and their image of human-nature interaction is more often based on television documentaries and other media images (Palmer 1998). Out of school experiences are therefore important stimuli (Trexler 2000). In order to become a conscious and an environmentally aware consumer and citizen, one needs to understand the true dimensions of relevant environmental issues. Teaching and learning approaches that take place outside the classroom, specifically outside the school building, have other values and qualities than the more traditional forms of education delivered inside the classrooms (Smeds et al. 2011). Young individuals should experience the power, fragility, interconnectedness and awe of nature, so they can become the environmental stewards of the future. Outdoor educational programs are commonly believed to be a suitable alternative to conventional biology learning settings that improve participants' environmental attitudes and knowledge (Skanavis and Kounani 2018).

2.4 Experiential Education

Experiential learning models assist heavily the current environmental education. According to Kolb (1984) experiential learning is a cyclical and holistic process of continual transactions between the environment and the trainee (cited in Garner et al. 2015). Learning experiences in natural environment that encompass changes in knowledge, attitudes, and behavior, are far more efficacious when they occur through experience-based, rather than teacher-directed, strategies (Ballantyne and Packer 2009). Hands-on environmental education may boost children's affective attitudes toward nature and their interest in protecting nature (Cheng and Monroe 2012). Numerous centers offer summer camp programs in outdoor settings with environmental education programming. It is believed that a 10-day ecology education program produces significant positive alterations in participants' basic ecological knowledge, minimal impact knowledge, attitudes about wilderness issues, and wilderness intentions and behavior (Hanna 1995; Garner et al. 2015).

3 Environmental Summer Camps

Learning through nature-based experiences under the supervision of caring adults who themselves are committed to the outdoors, has helped positively camp participants' experiences globally (Bialeschki et al. 2016). Participating in nature-related activities such as camping before the age of 11 benefit them later on as adults on improving their environmental attitudes and behaviors (Skanavis and Kounani 2018; Wells and Lekies 2006; Collado et al. 2013). An affective (emotion-based) association with nature has a stronger influence on ecological behavior than knowledge-based information (Mayer and Frantz 2004; Garner et al. 2015).

At summer camp, children are enthused by the fun and camaraderie of peer and staff interaction, interesting settings, and physically dynamic activities (Bialeschki et al. 2016). Long-term exposure to nature through a summer camp is an effective way of promoting children's emotional affinity to nature, as well as their ecological beliefs, both of which support their intentions to carry out environmentally friendly behaviors (Collado et al. 2013).

3.1 The Role of Outdoor Learning in Camps

The camp experience has always been associated with learning and human development. This learning frequently occurs in fun in-formal outdoor experiences, that

have a holistic, child-centered approach. The outdoors' style becomes a "classroom" or "laboratory" where questioning, exploration, and problem solving tasks are invigorated under the guidance of supportive adults and peers. All the above mentioned present excellent opportunities to build resilience, perseverance, and coping skills. Outdoor learning in camps can become an essential environmental experience. Whereas the scholars endeavor to define "outdoor", outdoor learning within both contexts arises from a wide range of activities in the outside, fundamental to the camp experience (Bialeschki et al. 2016).

4 Case Study: Project Skyros 2016

Skyros Project is a multi-awarded communicational program, based on the successful cooperation among the University of the Aegean and Skyros Port Authority. The scope of the specific program is to best implement a concise environmental campaign focusing on disseminating information, as well as increasing environmental awareness. It comprises environmental campaigns targeted at children, local residents, tourists and boat passengers. Several outdoor activities are organized aiming to trigger the public's environmental interest on various environmental issues, such as sustainable development, global warming and climate change.

4.1 Environmental Summer Camp at Nestorio

Having implemented sustainability in Skyros Island's youth, through a well-designed summer camp, for two consecutive years, the associated with the camp Skyros Team traveled in several Greek rural areas to spread the principles of sustainability through "camp experience" participation. Children joining the camp were confronted with several national and international environmental issues, such as biodiversity concerns, forest fires, food chain, water pollution, endangered species, air pollution, greenhouse effect, global warming, climate change, renewable energy and litter. Environmental education methods used during camp environmental instruction included lectures, brainstorming, outdoor education, environmental walks simulation and modeling, field study, and field games.

5 Methodology

5.1 Research Area

The current research was conducted in summer of 2017 at a Greek mountainous region with rich natural heritage, known as Nestorio. The village of Nestorio, a small picturesque village in northern Greece, is located 28 km southwestwards of the city Kastoria, at the banks of the river Aliakmon. Its population, 954 residents, whose main occupation is agriculture. Mount Grammos, with its peak at 2520 m, is the fourth largest mountain in Greece and "joins" the Prefecture of Kastoria River Aliakmonas and Sarantaporos. Gorgeous ravines, mixed forests, subalpine lakes, dense vegetation and rare species of fauna (brown bear, deer, wild boar, wolf, otter, wild boar, woodpecker, golden eagle, whitefish, birds of prey and other wildlife), place the area of study, among the most beautiful regions of Europe (Municipality of Nestorio 2018).

5.2 Research Sample

The research sample was composed of 22 children, aged 7–12 years as it appears in Fig. 1, while Fig. 2 presents the participants' gender.

Noteworthy to be mentioned is that most participants (59%) have never been in an environmental summer camp before. Their knowledge on environmental issues came strictly from school.

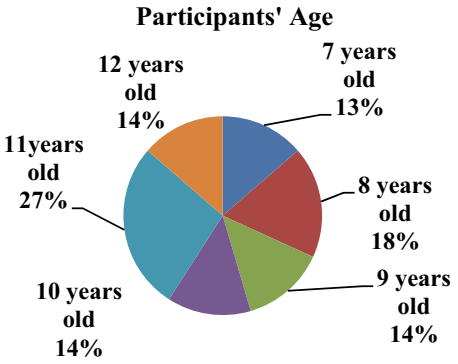

Fig. 1 Participants' age

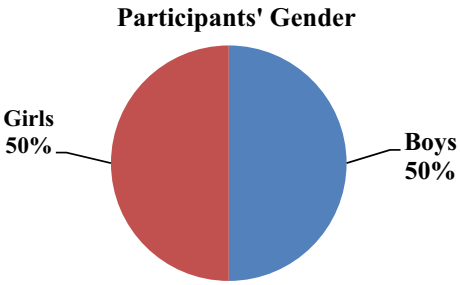

Fig. 2 Participants' gender

5.3 Research Instruments

The data were collected through personal interviews, which were held at the beginning and at the end of the camp experience. Two questionnaires were developed in order to evaluate the children's comprehension towards environmental issues before and after the camp's influence. The campers' attitudes and environmental behavior were assessed as well. Questionnaire number one was composed of 51 questions, which were carefully chosen after an extensive literature review (Murphy 2004; Alaydin et al. 2014; KPE Kastorias 2016; Simpson 1998; Mrema 2008). The first 7 questions were about the demographics, the next 21 questions were addressing participants' knowledge, the following 16 questions were about their attitudes and the last 7 questions were assessing their behavior towards several environmental issues.

The second questionnaire consisted of 44 questions, with a significant percent of them being similar to the ones in questionnaire number one (Murphy 2004; Alaydin et al. 2014; KPE Kastorias 2016; Simpson 1998; Mrema 2008). The first 24 questions were focusing on participants' knowledge, the following 11 questions were assessing their attitudes and the last 9 questions were based on evaluating their behavior towards several environmental issues.

6 Results

Participants in summer camp, studied in this project, were assessed on their knowledge, attitudes and behavior before the beginning of the environmental educational program and after its completion. The results assess knowledge, attitudes and behavior status of participants.

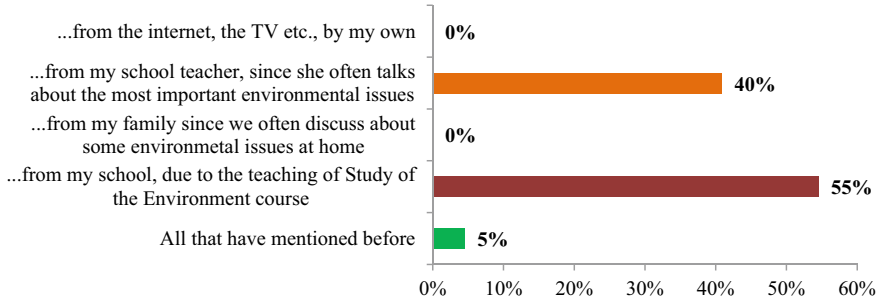

Fig. 3 The participants' answers based on sources that stimulated their environmental knowledge

6.1 Knowledge

6.1.1 Pre Camp Results

Participants in this particular environmental summer camp thought in their majority (82%) that their knowledge on environmental issues was increased after participating in this summer camp. Figure 3 depicts the participants' main source of information on environmental issues.

Participants were asked, prior to attending the summer camp, several questions regarding knowledge on their local environment and general environmental issues. Their responses—correct or wrong as answers—are recorded in Table 1.

Then they were asked to express why forests should be protected. The pertinent answers are shown in Fig. 4.

6.1.2 Post Camp Results

The 95% of the participants thought that their environmental knowledge increased after their participation to this environmental camp.

In order to assess the alteration on participants' knowledge, authors asked some similar questions with the pre camp questionnaire. After their participation to this environmental summer camp, children were asked the same questions regarding their local environment and general environmental issues (Table 2).

Concerning the necessity of maintaining forests on Earth, participants' answers were assessed based on responses shown in Fig. 5.

Table 1 Participants' responses on issues related to local environment or environmental issues in general (before attending the program)

	Correct answers (%)	Wrong answers (%)	Didn't know (%)
Know about the protected areas of their region	32	68	0
Which animal does not live in their region (brown bear or otter or caretta caretta)	86	14	0
Which animal is not a protected species (caretta caretta or dolphin or wolf or brown bear or cow)	68	32	0
What is the "water cycle"	77	23	0
The forms that water exists in nature	50	45	5
Most of earths' surface is covered by water	91	9	0
Most of earths' water is salty	59	27	14
Water mainly is polluted by humans' activities	86	9	5
Atmosphere is polluted by cars, factories and forest fires	68	32	0
The greenhouse effect and ozone hole is the same thing	77	18	5
Earth is a large greenhouse, as many plants grow on its surface	32	63	5
Atmospheric pollutants form a glass surface around the earth, which constantly increases its temperature	68	9	23
The causes of greenhouse effect	18	45	36
What would happen if earth kept warming	68	27	5
Global warming raises the sea level	77	23	0
Climate change causes floods and droughts in some areas of the planet	82	18	0
Climate change causes health problems to humans	91	9	0
Which materials are recycled	55	40	5
By recycling we save energy	77	14	9

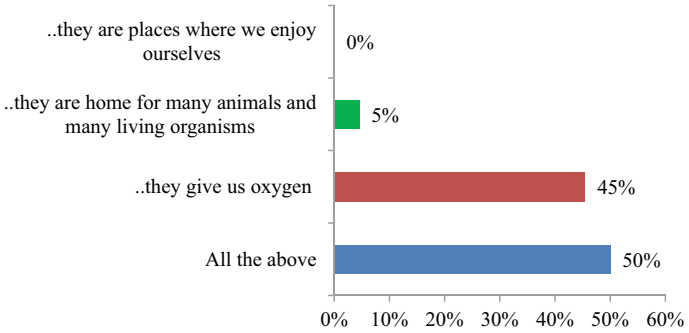

Fig. 4 Participants' answers to question "why are forests important?" (before attending the camp)

6.2 Attitude

6.2.1 Pre Camp Results

Campers were asked about their perception on environmental problems the planet is being confronted with. Their responses are depicted in Fig. 6.

They felt that they could strongly contribute to mitigating these environmental problems, in an 82%, while the 18% of the participants thought that they could slightly contribute.

Finally they were asked to express whether they agreed or not with several given statements. Their responses are presented in Table 3.

6.2.2 Post Camp Results

After the end of the environmental summer camp, campers were asked about their perception of the environmental problems the planet is being confronted with. Their responses are depicted in Fig. 7.

They felt that they could strongly contribute to mitigating these environmental problems in an 86%, while the 14% of the participants responded that they could slightly contribute.

Finally they were asked to express whether or not they agreed with several given statements. Their responses are presented in Table 4.

Table 2 Participants' post attendance responses (correct or wrong or did not know, about the issues related to the local environment or environmental issues in general)

	Correct answers (%)	Wrong answers (%)	Didn't know (%)
Know about the protected areas of their region	77	23	0
Which animal does not live in their region (brown bear or otter or caretta-caretta)	95	5	0
Which animal is not a protected species (carreta-caretta or dolphin or wolf or brown bear or cow)	100	0	0
What is the "water cycle"	100	0	0
The forms that water exists in nature	95	5	5
Most of earths' surface is covered by water	91	9	0
Most of earths' water is salty	95	5	0
Water mainly is polluted by humans' activities	100	0	0
Atmosphere is polluted by cars, factories and forest fires	77	23	0
The greenhouse effect and ozone hole is the same thing	68	32	0
Earth is a large greenhouse, as many plants grow on its surface	55	45	0
Atmospheric pollutants form a glass surface around the earth, which constantly increases its temperature	90	5	5
The causes of greenhouse effect	59	27	14
What would happen if earth kept warming	100	0	0
Global warming raises the sea level	100	0	0
Climate change causes floods and droughts in some areas of the planet	95	5	0
Climate change causes health problems to humans	100	0	0
Which materials are recycled	86	14	0
By recycling we save energy	91	9	0

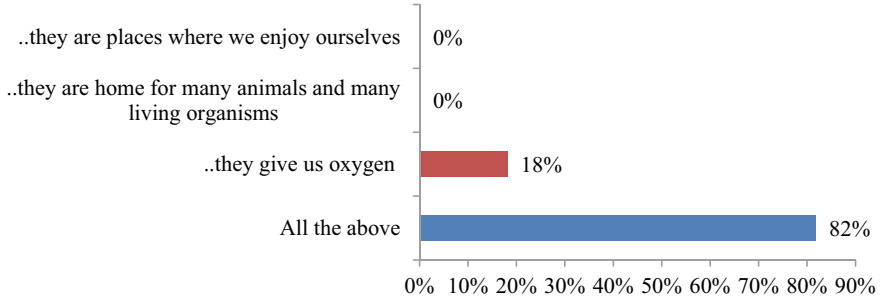

Fig. 5 Participants' answers to question "why are forests important?" (after attending the camp)

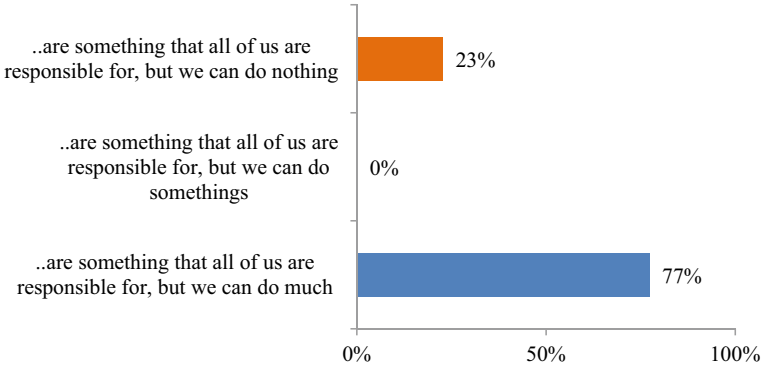

Fig. 6 Respondents' answers in question "what is their position on the environmental problems that they perceive"

Table 3 Reaction to given statements

	Agree (%)	Disagree (%)
All living organisms need clean air and water to live	100	0
Threatened species should be protected to avoid extinction	100	0
All humans should help tackling climate change individually	95	5
It is vital to protect forests	100	0

6.3 Behavior

6.3.1 Pre Camp Results

Campers were asked if they lived near their school and how they commuted to school. Their answers are shown in Figs. 8 and 9.

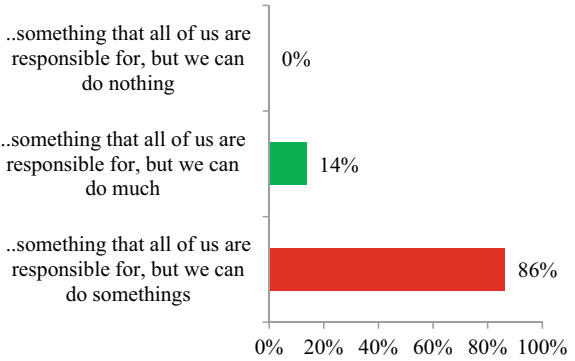

Fig. 7 Respondents' answers in question "what is their position on the environmental problems they perceive", after attending the summer camp

Table 4 Reaction to given statements

	Agree (%)	Disagree (%)
All living organisms need clean air and water to live	100	0
Threatened species should be protected to avoid extinction	100	0
All humans should help tackling climate change individually	100	0
It is vital to protect forests	100	0

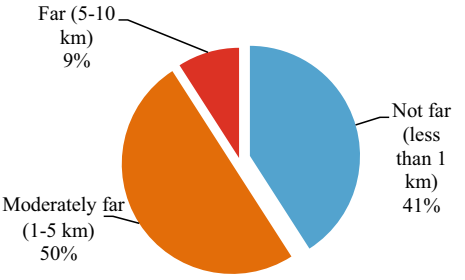

Fig. 8 How far is participants' house from their school

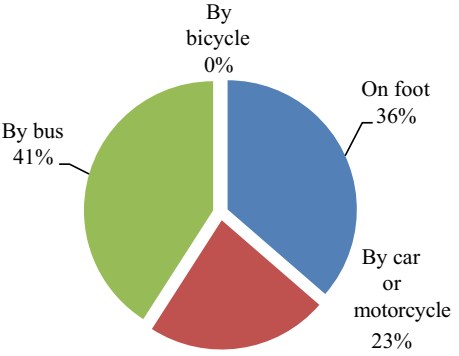

Fig. 9 The way participants commute to school

A 73% of the participants were enrolled in an environmental education program at their school, and the rest 27% who weren't, expressed a strong desire to participate in one in the near future.

When asked whether or not they recycled at home, and in case they did, how much they recycled, they responded as shown in Figs. 10 and 11.

All (100%) of the participants avoided keeping the refrigerator's door open for a long time. A 77% of them turned off the lights when they were exiting a room at their house.

When they were asked if they had ever tried to persuade others to do things that protect the environment, like not to throwing rubbish into the sea, a 77% of them replied that they had. A 64% of the campers appeared to participate along with friends in efforts attempting to convince adults on the urgency of various environmental issues. The participants' responses on how they would have acted if they had seen someone causing pollution and if they had some complaints about an environmental issue of their region, are shown in Figs. 12 and 13.

Finally they were asked whether there was an environmental team in their school, with 59% of them responding affirmatively. All of them were members of this team.

6.3.2 Post Camp Results

After attending the specific environmental program, when the participants were asked whether they would try to persuade their parents to let them go to school on foot or by bike, an 82% said that they would.

A 27% of the participants said that although they didn't attend an environmental education program they had the desire to persuade their teachers to start one in their

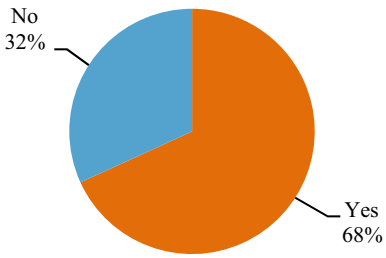

Fig. 10 Whether the campers recycled at home

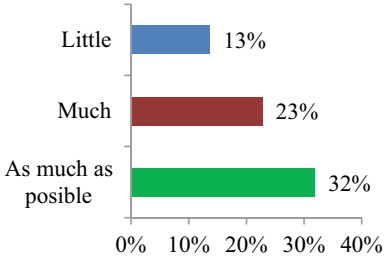

Fig. 11 How much participants recycled at home

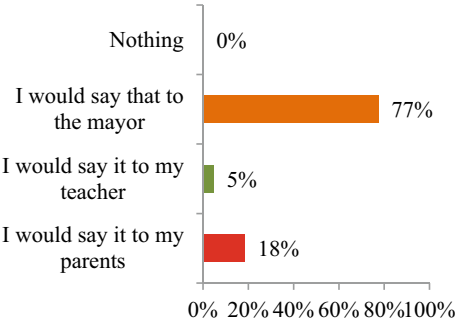

Fig. 12 How participants would act if they saw someone causing pollution in their region (pre camp)

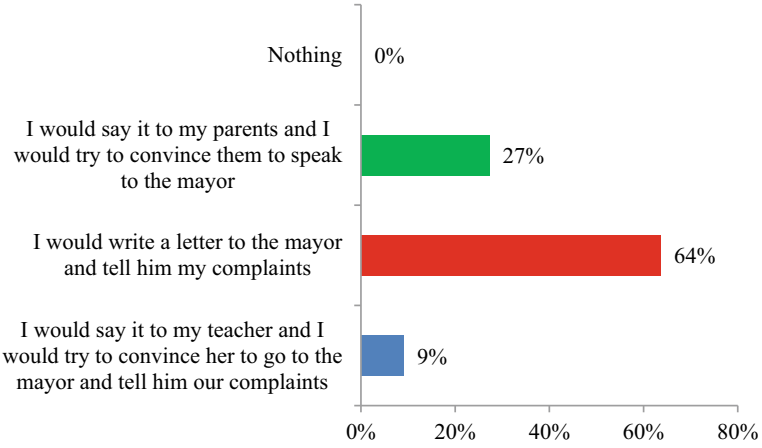

Fig. 13 How participants would act if they had some complaints about an environmental issue of their region (pre camp)

school. All replied that they would try to influence their parents to recycle more or to start recycling. When they were asked if they would persuade others to protect the environment, with actions like not throwing rubbish into the sea, all of them agreed. Also all would participate along with their friends in efforts convincing the adults to be concerned about the urgent environmental issues. Their responses on how they would have acted if they had seen someone causing pollution and if they had some complaints about an environmental issue of their region are presented in Figs. 14 and 15.

All campers expressed willingness, when asked whether they had the intention to be involved in activities related to the protection of natural environment in their area from now on. Also in their vast majority indicated that they would try to motivate their

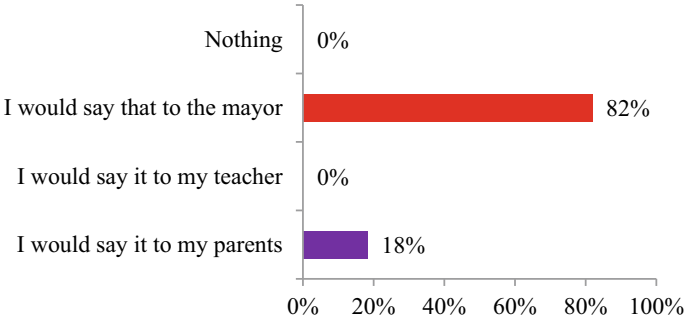

Fig. 14 How participants will act if they would see someone causing pollution in their region, after attending the summer camp

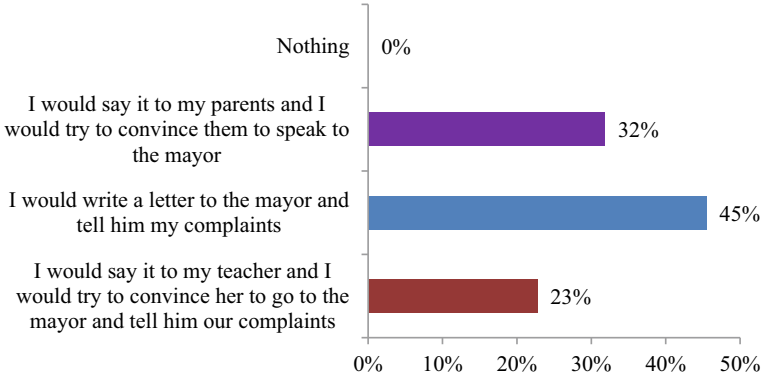

Fig. 15 How participants will act if they had some complaints about an environmental issue of their region, after attending the summer camp

school teacher to start an environmental newspaper dealing with the environmental issues of their region, even at cost of their free time.

7 Discussion

Participating in nature-based summer camps enhances the connectedness with the natural environment, increases environmental knowledge, attitude and behavior (Garner et al. 2015). Obviously in Nestorio's environmental summer camp there was a change on trainees' knowledge, attitudes and behavior towards the environmental issues, after attending this specific environmental program.

7.1 Knowledge

More specifically, as far as knowledge is concerned, comparing Tables 1 with 2 as well as Figs. 4 with 5, an increase is recorded. After the completion of the program, the participants seem to be more informed about the local environmental issues and general environmental issues as well. This outcome is realized from the individuals themselves, who were exposed to the benefits of the environmental camp. The issues that somehow puzzled them were the issues related to climate change, such as global warming, greenhouse effect etc. The correct answers on questions regarding climate change didn't show the expected increase. As Strazdins and Skeat (2011) noticed in their research, there are some barriers seen when someone attempts to communicate climate change, especially to children. One of the obstacles is associated with some misconceptions on the real meaning of climate change. If not addressed though, they may be led to a negative interpretation of climate change or to a wrong assumption of what it truly means (Leal Filho 2009).

7.2 Attitude

On the other hand, since knowledge alone has been shown to be approximately ineffective in modifying people's behavior, an effective environmental education program targeted at influencing or modifying participants' conducts should become a priority. Augmenting knowledge, while concentrating on the emotional sector as well is of prime importance (Orams 1995). Consequently, through an educational program it could be more effective to provide the real spirit of sustainability (Skanavis and Kounani 2017). This fact is backed up in this case study as well. Concerning the alteration of the participants' attitude after their participation in summer camp, comparing Tables 3 and 4, as well as Figs. 6 and 7, they appeared to have high environmental consciousness.

Consequently, nature camps might be more effective in encouraging children's emotional connection to nature, ecological beliefs and environmental behaviors than in-class environmental education programs. Spending time in nature through a camp provides restorative benefits to children which may, in turn, lead to increased emotions and cognition towards the environment (Collado et al. 2013) Understanding and cultivating children's environmental awareness may be vital to rectifying the environmental degradation and promoting the principles of sustainability (Garner et al. 2015). Furthermore, it has been found that nature-based outdoor education programs are effectively improving environmental awareness and sensitivity towards the natural environment (Apostolopoulou et al. 2016).

7.3 Behavior

There was a positive change at participating children's behavior, since campers said that after attending the specific environmental program they would try to persuade their parents to let them go to school on foot or by bike (82%).

Furthermore, comparing the results of Figs. 12, 13 and 14, as well as Figs. 13, 14 and 15 a rise is observed in their willingness to be more environmentally active. They even stated that they would send a letter to the mayor complaining about a potential pollution issue in their hometown. They also stated in their vast majority that they would try to motivate their teacher into starting an environmental newspaper dealing with the environmental issues of the region, even if they knew that they had to sacrifice their own free time.

The camp experience is always related to learning and human development, which takes place in an enjoyable informal outdoor sort of experiences and has a holistic, child-centered approach (Garner et al. 2015).

8 Conclusions

In the era of globalization and growing complexity, education for sustainable development (ESD) aims at supporting people not only to acquire knowledge, but also to alter their behavior and decision making towards a more responsible manner. Whether we view sustainable development as our utmost challenge or a subversive litany, every phase of education is now being urged to proclaim its support ESD (Barth et al. 2007).

The results of this study support the theory that intentional environmental education programming in a residential summer camp setting can accomplish augmented knowledge of environmental issues and increased the desire to learn about and discover nature (Garner et al. 2015). The main findings of the present survey revealed that Greeks are positive on participating in environmental programs, since the majority of the locals encouraged their children to participate in this weekly program addressed in the study. Moreover, as the results revealed, environmental education programs such as the one implemented by Project Skyros can play a crucial role in augmenting participants' knowledge, changing their attitudes and their willingness towards having a wise environmental behavior, and thus promoting sustainability in the nation. The activities exposed everyone to the importance of the interactive relationship between humans, natural and social environment. Priority is placed on the promotion of an environmental code of behavior that respects life and nature.

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Holistic Approaches to Sustainable Development

Strategies for the Promotion of Sustainable Urban Development: A Multicriteria Analysis

Samara da Silva Neiva, Jéssica de Souza Mauro, Wellyngton Silva de Amorim, Samuel Borges Barbosa, João Marcelo Pereira Ribeiro, Giovanna Guilhen Mazaro Araújo and José Baltazar Salgueirinho Osório de Andrade Guerra

Abstract Cities are centers of culture, science, commerce, productivity, social movements, industrial production, as well hubs for environmental and economic development. They are home to capable people providing social and technological advancements. Cities are self-organizing, adaptive and constantly evolving. Beyond playing an important role in the maximization of social and economic benefits of new ideas, cities are simultaneously extremely sensitive to human actions. This article aims to analyze the main indicators for the construction of a sustainable city through a multi-criteria evaluation. Through this analysis, and with the opinion of experts, this article will demonstrate the importance of strategic action for the promotion of a sustainable city.

Keywords Sustainable cities · Sustainability · Multicriteria analysis

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1 Introduction

Discussions regarding sustainable development gained visibility in the second half of the 21st Century (Duran et al. 2015), due do the perception that the exaggerated consumption habits may cause depletion of natural resources and damage to the environment, as well as financial and economic crises (Yanarella and Levine 1992). A change of thinking in development took place, no longer aiming for consumption only, but for a green growth (Kidd 1992).

In 1987 the report "Our Common Future" produced by the Brundtland Commission where sustainable development was first conceptualized as meeting the needs of the present without compromising future generations ability to meet their own needs (Sinakou et al. 2018). After receiving a clear concept, sustainable development was the center of several international treaties and programs as Millennium Development Goals, and later the Sustainable Development Goals, both created by the United Nations (Persson et al. 2016; de Andrade et al. 2016).

One of the Sustainable Development Goals is to make cities and human settlements more inclusive, safe, resilient and sustainable (Duvier et al. 2018). In 2016, roughly 50% of human population lived in cities, and estimates show that by 2050 around 67% of human population will live in urban centers (Yang et al. 2017). The growth in urban population may cause pressure on production and availability of key resources, as water, food and energy (UN 2018).

Cities are centers of culture, science, commerce and productivity (Sofeska 2016). However, they are also responsible for around 70% of available resources (Bibri 2018). Turning today's cities into sustainable cities is essential to maintenance of life (Zhang and Li 2018). To help in this process, several indicators contribute to a better understanding off all spheres which surround the city and which measures must be taken (Klopp and Petretta 2017). In this sense, a deepening in studies in sustainability indicators and sustainable development in cities was proposed.

This paper is justified for how important it is to understand which the main factors are to determine a sustainable city, and how important each of these factors are. Then, the goal of this research was to identify the main factors and indicators related to sustainability in cities by creating a multicriteria analysis tree, built based in a survey applied to specialists. The result of the research will support the decision markers, enabling them a better use of resources on the most important areas in a way that meets the principles of environmental sustainability in cities.

2 Methodology

This paper uses a multi-criteria analysis in order to identify indicators and create an assessment model to serve as a supportive decision tool for sustainable cities. According to this methodology, it will be possible to evaluate how much a city is close or far to be considered a sustainable city. The multicriteria methodology is part

of the Operational Research (OR) area and was first employed in decision making in complex situations, with many factors involved (Bell et al. 1988; Costa et al. 2000). Unlike traditional methods of OR optimization, which seek to define the best alternative in an analysis, the multi-criteria assessment aims to understand all the aspects involved in the decision making in complex situations (Clemen 1996).

To build a multicriteria evaluation model, the authors created a methodological process in four stages: (i) identifying factors related to sustainable cities; (ii) grouping of factors and building of evaluation three; (iii) creating indicators from indicated factors; and (iv) a careful evaluation of indicators and indicator groups. Then, we present with detail which step of this process in building the multicriteria evaluation model.

The first stage of multicriteria analysis corresponds in a research on the main factors related to "sustainable cities", in scientific databases such as Science Direct, Scopus, Web of Science and Emerald. The article has used scientific papers and reports of international programs aiming to find recent publications in sustainable cities. Based on such publications, the authors identified the main factors related to sustainable cities, which will be the base to create the evaluation model. Some criteria were also needed to establish factors to inclusion in the model, and only factors that were cited in at least three articles were used.

The second stage was grouping identified factors in an evaluation tree. An evaluation tree is a structure of the multicriteria evaluation model, which was created with factors identified in the first step. The result was the structure of the evaluation tree. The third stage was to create indicators so that indicators were created from factors identified. For each factor were found, in average, three indicators, which seek to calculate the level of the identified factor. In the fourth and last stage, the authors made a careful evaluation of indicators and groups of indicators, evaluated by specialist through a formal consultation. Thirty specialists from the sustainability area were consulted.

3 Sustainability in Cities

Cities are understood as communities under a given administrative delimitation, normally referred to as cities, municipalities or local governments (Bai et al. 2016). They are usually associated with their inhabitants, but environmental and socioeconomical factors are also part of their characterization in varying amounts depending on the city (Juraschek et al. 2018), as infrastructure, facilities for society and education, retail, living, health, open and commercial spaces, industries and factories (Bond and Morrison-Saunders 2011).

In 2010, buildings were responsible for 32% of all energy consumed (Futcher et al. 2017), in addition to 19% of greenhouse gas emissions. In municipal level, transportation and construction answer for 80% of the energy use and a similar proportion related greenhouse gas emission (Hui 2001). Uncontrolled urbanization can bring several negative effects, as natural disasters, climate change, energetic

crises, political instabilities, food instability and terrorist attacks (Zhang and Li 2018). Sustainable urbanization is not only about converting unmodified environments or agricultural land to build cities (Pickett et al. 2013); but involves radical changes in form, metabolism, economy and demography in urban ecosystems (Pan et al. 2016).

Radical changes happening in each environment may be characterized as urbanization, as restructuring settlements or converting agricultural land into urban centers (Meijering et al. 2018). Planning sustainability in a city level allows cities to elaborate visions for the future in an affordable and sustainable manner, considering all aspects involving economy, society and environment and interacting in different geographic scales than their own (Bibri 2018; Bai et al. 2016).

As of 2010s, the concept of sustainable cities has gained much more recognition and interest from international society than before (de Andrade et al. 2016). It is increasingly considered as crucial for sustainability goals to be achieved and assure the well-being of all population, assuring that this topic is discussed in many international conferences (Sofeska 2016). Table 1 presents some concepts found in literature for sustainable cities.

For the building of a sustainable city, some standards need to be met. There are indicators for measuring the sustainability of a city (Klopp and Petretta 2017). Each index is related to at least one sustainable development goal (Alshuwaikhat and Nkwenti 2002). Using indicators might be the best way to measure how sustainable

Table 1 Sustainable cities concepts

Authors	Concept
Ribeiro et al. (2018)	The concept of sustainable cities requires the commitment to improve and preserve the quality of urban life and guarantee the basic needs of all
Cheshmehzangi (2016)	Sustainable city's comprehensive nature and its extended consideration for environmental and ecological protection, its overall framework encompasses a large scope for existing cities and city development and the integration—and not the combination—of 'eco', 'green', 'resilient', 'low carbon' and 'smart' would create a better possibility of meeting the goals of sustainable cities
Ibrahim et al. (2015)	Sustainable city is a city that can provide the basic needs of city inhabitants such as infrastructure, civic amenities, health and medical care, housing, education, transportation, employment, good governance and ensure the populations needs are met benefiting all sectors of society
Martos et al. (2016)	A sustainable city must not only integrate methods to mitigate their effect on the environment, but also become a space which promotes a better quality of life for its citizens, promoting active participation in the development of the means to satisfy their needs in a sustainable way
Bibri (2018)	Sustainable city can be understood as a set of approaches into practically applying the knowledge of urban sustainability and related technologies to the planning and design of existing and new cities or districts

cities are, since each city is singular in its activities, consumption, treatment of waste, ecological footprints (Verma and Raghubanshi 2018).

4 Main Factors in Sustainable Cities

In the first part of the research, a survey was made with publications with the goal of creating a conceptual model for sustainable cities. The authors searched scientific articles and documentation from national and international programs related to sustainable cities. In the articles we obtained, eleven main factors where obtained regarding sustainable cities. These central factors were grouped according to three main axes related to sustainability: economic, social and environmental. In the economic axis, the main factors found were governance, transportation and access to public goods. In the social axis, transparency, social equality and community involvement. In the environmental axis, the main identified factors were residues, land use, emission of Greenhouse Gas, energy and hydric resources. In Table 2 the main references are presented, as well as a description of the eleven identified factors.

Figure 1 presents the initial structure of the evaluation model. It is a tree structure, which presents in its first level economic, social and environmental axis. In the second level, factors highlighted in literature, which are related to social, economic and environmental axis.

With the structure presented in Fig. 1, evaluation indicators will be developed. The indicators will be in a third level; in a manner, that each will be connected to factors in the second level.

The creation of these indicators was made with the aim to unfold eleven factors identified in indicators which are easy to measure. In each of the eleven identified factors, the authors aimed to create quantifiable indicators. For instance, for the factor of access to public goods, three indicators were found: (i) access to education; (ii) access to health; (iii) security.

This building, starting from economic, social and environmental axes, unfolding later in eleven factors, and then to indicators, allows the creation of a model that represents all aspects related to sustainable cities. From this model, it is possible to create an evaluation model for sustainable cities.

The economic axis of sustainable cities is made by factors *access to public goods*, *governance* e *transport*. Three indicators were created to support these eleven indicators, in the following way: to *access to public goods*, the indicators created were *access to education*, *security* and *access to health*; to *governance* the indicators created were *public participation in green polices*, *production of sustainable constructions*, *education* and *urban planning*; to *transport* were created *average travel time and cost*, *number of vehicles per paved road unit*, *develop alternative mobility (cycle paths)* and *promotion of public transport*.

The social axis is built by factors *transparency*, *social equality* e *community involvement*. To these three factors, ten indicators were created, grouping in the following way: for *transparency* were created *economic development*, *public finances*

Table 2 Main factors in sustainable cities

Main factors	Justification	Authors
Governance	Governance or complementary governance, which consists in practicing governance in economic, social and environmental levels, is important for sustainable development, since it consists in implementation of policies which bring benefits to citizens. Good governance will bring improvements into public transportation, for instance, promoting its use by population and diminishing problems around transport and polluting gas emissions	Öberg et al. (2018), Koopmans et al. (2018), de Aguiar and de Souza Freire (2017), Delina and Sovacool (2018)
Access to public goods	Considering how important technology is for developing a more sustainable future, as well as the fact that large portions of populations of women, children and elders are excluded from access to technology or even basic subsistence resources as basic sanitation or health care, we can consider that a large portion of society is still not included in advances of sustainable development	Fiorini and Hoekman (2018), Chapman and Shigetomi (2018), dos Santos and Balestieri (2018), di Bella et al. (2016)
Transport	There is growing interest in studying which indicators would be more likely to achieve this feat, such as use of energy, amount of CO_2 that each kind of transport issues, emission of toxic and harmful substances, disturbance and fragmentation of natural areas, possible residues, noise pollution, safety in traffic, contribution of transport sector to economic welfare and accessibility	Programa Cidades Sustentáveis (2018), de Andrade et al. (2016), Steg and Gifford (2005)

(continued)

Table 2 (continued)

Main factors	Justification	Authors
Transparency	Transparency is about the need of honesty that people can expect and is linked to projects as fighting corruption, financial responsibility and illegal transactions. In the context of climate change, it is possible to increase transparency among individuals and support a better climate justice: warrant government transparency in using financial resources coming from climate funds	Cimpoeru and Cimpoeru (2015), Corrigan (2017), Alves and Mariano (2018)
Social equality	Social indicators reflect the capability in generating benefits for local communities, including jobs and food security, equal income distribution, opportunities for all and inclusion of vulnerable populations, applicable in regional, global and sectorial scales	Valenti et al. (2018), Verma and Raghubanshi (2018)
Community involvement	When it comes to community involvement, the same is important for sustainable city development, because it addresses how the population is acting and contributing about its implementation.	Sustainable cities plan (2018)
Waste	It is estimated that every year around the world 11.2 billion tons of solid waste is collected and decomposition of the organic matter contributes to around 5% of GHGs internationally	Öberg et al. (2018), Welie and Romijn (2018)
Land use	Land use change directly influences the provision ecosystem services (e.g. provision of food and timber, climate regulation, nutrient cycling, and cultural identity)	Millenium Ecosystem Assessment (2003), Lambin et al. (2001)

(continued)

Table 2 (continued)

Main factors	Justification	Authors
Greenhouse gas emission	Greenhouse gas emission are 50% higher than they were in 1990. This high number is a reflex of the still high deforestation rates, which releases more carbon to the atmosphere, and it is important to look for ways to reduce this emission, which is crucial for world community	Emerging and Sustainable Cities (2018), UN (2015), Thornbush et al. (2013)
Energy	Energy efficiency is getting the most from each unit of energy purchased. It is mainly a technical process, in which newer, more efficient technologies replace old equipment. In general, energy efficiency is a byproduct of other social goals: productivity, comfort, monetary economics, or energy competition	Ribeiro et al. (2018), Martos et al. (2016)
Water resources	Potable water is still a finite, scarce resource and the consequences of lack of water are visible in many countries, especially in Africa. Many NGOs take the role of promoting basic sanitation and take potable water to the most affected locations, but this action can only help, not solve the problem	Ribeiro et al. (2018), Welie and Romijn (2018)

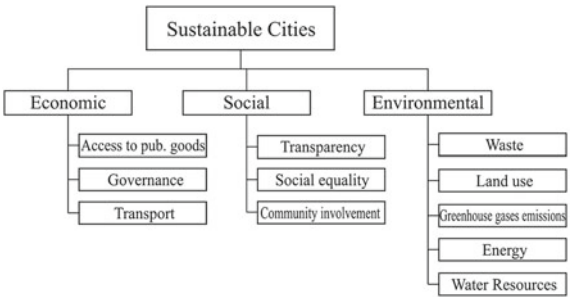

Fig. 1 Main factors in sustainable cities

e *social justice*; to *social equality* were created *employment*, *child mortality*, *quality of* life and *families below the poverty line*; for *community involvement* were created *territorial resilience*, *encouraging sustainable production and consumption* e *culture*.

The environmental axis is formed by factors *waste*, *land use*, *greenhouse gases emission*, *energy* and *water resources*. For this five factors, fifteen indicators were created, in the following way: to *waste* were created *recycled waste*, *waste reduction policies*, *access to basic sanitation* and *municipal waste production*; to *land use* were created *land use policy*, *urban density*, *green public spaces* and *accessibility to parks*; to *greenhouse gases emission* were created CO_2 *emission*, CO_2 *reduction strategies*, CO_2 *intensity*, *industrial pollution* and *air quality policies*; to *energy* were created *policies for renewable energy* and *renewable energy consumption*; to *water resources* were created *water waste rate*, *water efficiency*, *public water supply* and *access to drinking water*.

In this way, 40 indicators were defined, which represent all aspects related to sustainable cities. In this way, we established means of measuring each of these indicators. Defining levels of importance of each one makes it possible to create a global index of evaluation of sustainable cities. In this paper, the authors also considerer levels of importance to each of these indicators.

5 Multi-criteria Assessment Tree for Sustainable Cities

To consider the level of importance of each indicator and factors, which are groups of indicators, a consultation was made to specialists in the sustainability area. In applying the survey, specialists were asked about the level of importance of each indicator and group of indicators, in a scale of 1–5. After applying 30 surveys, with the results obtained, the authors considered to calculate the level of importance of each. The result of the considerations may be observed in Fig. 2, which presents the main result of this research, which is the structure tree of the multicriteria model of evaluation for sustainable cities, as well as the weights of each indicator or groups of indicators (factors) obtained through consulting specialists.

With the structure presented in Fig. 2, it is possible to verify the most important indicators to sustainable cities. According to calculations to obtain indicators with higher level of importance, the ones considered to be most important were the following: *access to education* (3.8%), *access to health* (3.9%), *social justice* (3.8%) and *encouraging sustainable production and consumption* (3.8%). In the level of groups of indicators, the best rated were *social equality* (11.4%), *access to public goods* (11.1%) and *governance* (11.1%).

These results show that from the experiences of the specialists consulted, these indicators are the most relevant for a construction of a sustainable cities. Then, investing in access to education, access to health, social justice and producing and consuming in a sustainable way are the points of higher importance to a sustainable development.

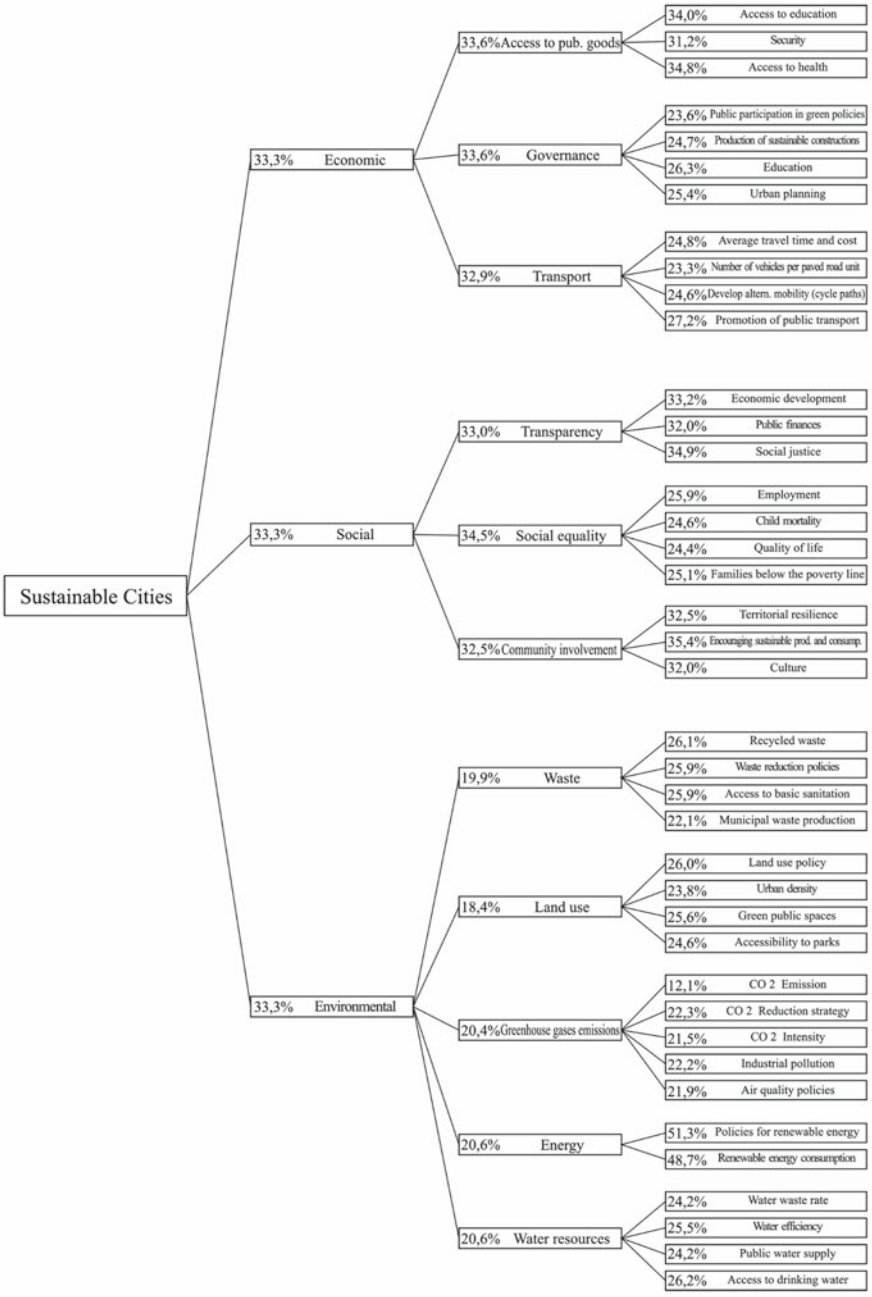

Fig. 2 Sustainable cities multicriteria tree and indicators weights

6 Final Considerations

Modern cities are facing intense challenges in the last decades. With environmental, social and economic pressures, public policies have been founding difficulties to solve all challenges in the great urban centers. Problems such as transportation, energy, residues, land use, access to education and health and several other questions are priorities in public policies in the world's largest cities. However, there is still a long way to go for cities to be sustainable, seeking to satisfy aspects in a balanced way in environmental, social and economic axes.

During the last decades, a varied list of indicators has been created for the measurement of sustainability in urban centers. However, selection of the most interesting ones has always been an intriguing question. Indicators for assessing the environmental performance of cities may include greenhouse gas emissions, water and energy consumption, water quality, energy efficiency, waste volume and recycling rate, transport style and driver rate among others. They can be both quantitative and qualitative, and what differentiates the indicators is the area in which they are focused, they help to monitor progress and allow a deeper monitoring of the data, the indicators help in the sustainability goals and inform the policymakers, as well as the public on the current state of the environment, and their weaknesses and strengths, in addition to highlighting the priority area.

They also can play a scientific role in deepening understanding of cities, can shape dialogues and debates, legitimize or delegitimize political actions, be multi-purpose, and become part of an assessment and comparison of conditions and trends in space and time, monitoring progress towards goals, informing planning and decision-making, raising awareness, encouraging policy and behavioral change, promoting public participation and improving communication.

This paper allows to identify the main factors regarding sustainability in cities, creating an evaluation model that allows prioritizing employment of resources in the most important areas. Based in the developed model, it is possible to conclude that cities must prioritize access to education, health, social justice and encouraging production and sustainable consumption. The main of the paper is that this model will be useful to guide public policy-makers in order to prioritize investment. Future researches may advance the development of indicators, in a way to create levels of measuring which will allow comparisons in different cities' sustainability levels.

Cities need to constantly develop so that their actions will be integrated and aligned with sustainability theories. Today, it is common for urban centers to have problems in develop in their institutional practices the idea that a sustainable development is needed and must be followed by all citizens within a community. It is important too that municipal decision-makers are involved in creating projects, programs and spreading a sustainable development. They also can implement several initiatives for promoting a sustainable development.

The authors recommend for future studies that each category, indicator and sub-indicators should be analyzed individually. Other projects can also bring specific plans of action for each indicator, adapting it to the studied reality. Implementing

a sustainable development in urban centers is a time-consuming process, which demands incentive from decision-makers and the community. However, a sustainable city will be capable of meeting all the basic needs of their population, and will integrate methods for mitigating environmental impacts, promoting and active participation in a sustainable development of means.

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International Transdisciplinary Approach to Sustainability Research Related to Place: Sustainable, Affordable Homes and Ecosystem Services in the U.S. and Brazil

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Abstract Cities are the defining ecological phenomenon as they are continuously growing both in area and population while increasing the demand and impact on natural resources. Design has a great potential towards ecological regeneration within and of cities. In this context, an ecosystem services approach may be a comprehensive framework for guiding design processes and practices to achieve the highest ecological performance where multiple ecosystem services are provided within a system. Bringing together ecology, design and project realization requires a transdisciplinary approach. Ecological issues embracing the triple bottom line of sustainability, especially for social equity, vary across the globe in response to place-based characteristics. As a representative case that embraces design in relation to ecology, sustainable, affordable houses located in the U.S. and Brazil are compared for their performance towards ecosystem services provision in respect to energy efficiency solutions. This is a collaborative effort between universities from these two countries, brings together researchers, students, practitioners and community stakeholders, engaging in a process that actively seeks to define relevant questions, accelerates knowledge of solutions and engages and empowers effective solutions. Results outline successful methods and strategies employed in each context and an approach for ongoing, meaningful collaboration.

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1 Introduction

Cities are the defining ecological phenomenon—they are continuously growing both in area and population while increasing the demand and impact on natural resources. As cities grow and re-urbanization continues, housing is a fundamental need and impact on resources. The Universal Declaration of Human Rights (1948) states that:

> Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control. (UDHR, Article 25 (1), 1948)

Environmental degradation, natural resource depletion, and the devastating effects of climate change—including on human health, safety and welfare—threaten the basic right to housing. The *Habitat Agenda* emphasizes that "provisions [and appropriate action] of adequate housing requires action of governments, the private sector, non-government organizations, communities and local authorities, entities of the international community" (*Habitat Agenda*, Paragraph 61). Yet housing affordability remains an international struggle. Sustainability must be considered as integral to solutions. The UN Sustainable Development Goals (SDG) inform a way forward.

Affordable housing is certainly central to SDG #11: Sustainable Cities and Communities, and by extension the remaining sixteen SDGs. Most obviously, affordable sustainable housing has a role in eliminating poverty (SDG #1), could contribute to "good health and well-being" (SDG #3), "affordable and clean energy" (SDG #7) and "climate action" (SDG #13). The *Habitat Agenda* advocates for "strong institutions" (SDG #16) and "partnerships" (SDG #17). Once the provision for housing is assured and sustained through long- and short-term affordability, other goals can be prioritized, including providing adequate nutrients (SDG #2, Zero Hunger), Quality Education (SDG #4), and related industry and processes informed by SDG #12: Responsible Consumption and Production, #8: Decent Work and Economic Growth, and #9: Industry, Innovation and Infrastructure—leading to more "gender equity" (SDG #5) and "reduced inequalities" (SDG #10). Design has a great potential towards ecological regeneration within and of cities, contributing to Sustainable Development Goals that respect non-human life (SDG #14: Life Below Water and SDG #15: Life on Land) and purify water (SDG #6: Clean Water and Sanitation).

In this context, the ecosystem services approach may be a comprehensive framework for guiding design processes and practices to achieve the highest ecological performance where multiple ecosystem services are provided within a system (MA 2005). Ecological issues embracing the triple bottom line of sustainability, especially for social equity, vary across the globe in response to place-based characteristics. As a representative case that embraces design in relation to ecology, sustainable,

affordable houses located in the U.S. and Brazil are compared for their performance towards ecosystem services provision with respect to energy efficiency solutions. This is a collaborative effort between universities from these two countries, brings together researchers, students, practitioners and community stakeholders, engaging in a process that actively seeks to define relevant questions, accelerates knowledge of solutions, and engages and empowers effective solutions. Bringing together ecology, design and project realization requires a transdisciplinary approach. This paper outlines successful methods and strategies employed by author's home universities, in the U.S. and Brazil, as an approach for ongoing, meaningful collaboration.

2 Ecosystem Services Provision and Energy Efficient Solutions

Ecosystem services "are critical to the functioning of Earth's life-supporting system" although defined with respect to humans (Constanza et al. 1997, 253). The term "ecosystem services" started being used following authors who were referring to "ecological concerns in economic terms in order to stress societal dependence on natural ecosystems and raise public interest in biodiversity conservation", as a demonstration for the disappearance of the biodiversity affecting ecosystem functions and, consequently, human well-being (Braat and de Groot 2012, 7).

Ecosystem services are the product of ecological structures, processes, and functions that support life as a result of the interaction of living and nonliving elements while benefiting humans (Miller and Spoolman 2009; Myers 2013). They include the services from ecosystem functions such as waste assimilation, and ecosystem goods, being food an example.

There is a gap into considering ecosystem services in the local scale, especially in the urban and architecture scale. Urban ecosystem services provide many benefits that are directly aligned with sustainability and resilience; being locally sourced, those ecosystem services contribute with reconnecting cities to the biosphere, decreasing reliance on externally produced services from global trades and large support areas, reducing cities ecological footprints and their ecological debt, and securing the long-term quality of life and health of urban population (McPhearson et al. 2015; Andersson et al. 2015; Gómez-Baggethun et al. 2013).

As urban ecosystem services are deeply related to humans, understanding their ecological, cultural, and social values is fundamental to support decision-making in design, planning, and management within and around urban areas for ecosystem services resilience (McPhearson et al. 2015). It is important to recognize the social-ecological systems, as "ecosystem services are co-produced by people and nature" (Kremer et al. 2015, 150). Urban ecosystem services provision, value, and utilization are dependent on context and human perception, for example, "location, spatial organization of elements, the arrangement of design elements and amenities, as well as individual background and preferences" (Kremer et al. 2015, 150).

Considering and understanding the impact and interactions of energy systems with ecosystems services provision is fundamental for sustainability, resilience, and moreover, for enhancing ecological and social systems on which we depend (Howard et al. 2013). The impact of energy systems to ecosystem services may vary from local, to regional, and global scales in association to technical, economic, and social aspects. For that, the energy demand, production and supply are informative for the analysis and may include actual and potential energy sources, energy transportation pathways, energy demand across a local area, capability of linking the energy system to the ecosystem goods and services (Howard et al. 2013).

The full range of ecosystem services may be related to the energy system considered. The ecosystem services are organized in four categories (MA 2005; TEEB 2011; Gómez-Baggethun et al. 2013; Hansen et al. 2015): (1) *Provisioning Services*, including the material goods or outputs from ecosystems, as food, water, timber, and fiber; (2) *Regulating Services*, the ecosystem processes that serve as regulators of ecological systems as climates, floods, diseases, wastes, and water quality; (3) *Cultural Services*, the intangible and non-material benefits obtained from human contact with ecosystems, as spiritual, recreational, and aesthetic benefits; (4) *Supporting Services (or Habitat)*, the ecological functions responsible for the production of other services, including soil formation, photosynthesis, and nutrient cycling, and the provision of living spaces and maintenance of plant and animal diversity (MA 2005).

The energy systems are a type of ecosystem service as they provide energy, and they may also contribute to greenhouse gas emissions that have overwhelmed ecosystems' ability to cycle carbon. They also are capable of providing an educational service for bringing awareness of the land carrying capacity and our living demand impact on earth and need to not reduce that but enhance the systems functionality with our presence (Howard et al. 2013; Silveira 2018).

3 Sustainable Affordable Houses in Brazil

In Brazil, the building sector is responsible for 4 to 7% (4–7%) of the GDP (Gross Domestic Product). As the construction sector expands, 26% of the money in the Brazilian construction sector goes to real estate loans for housing, while the country's housing deficit is 6 million considering low-income citizens whose monthly income is below $500 (Gianetti et al. 2018).

Energy and material resources required over a building life-cycle put an enormous environmental load on Earth. Therefore, social housing is needed not only to ensure its most basic function, being shelter, but it should consider sustainability and resilience. However, the main constraints in the Brazilian construction industry is economic. In this sense short-term economic benefits are the priority over long-term social and environmental benefits (Gianetti et al. 2018). Therefore, it is really demanding to integrate the low-income housing construction practice in Brazil to its social

and environmental impacts. Herein the thermal and energy performance of those buildings are considered with respect to design solution.

Most houses in Brazil are naturally ventilated. However, the sales of domestic air conditioning systems are increasing by 16% per year (Abrahão 2015). Besides that, the air conditioning usage is not considered relevant for the low-income population, as less than 10% of dwellings has artificial cooling (Paulsen and Sposto 2013). Therefore, energy efficiency for Brazilian social housing is focused on thermal comfort based on metabolic activities as eating, sleeping, and sanitizing (Sorgato et al. 2016).

In 2008, the Brazilian federal government established the Minha Casa Minha Vida Program, which translates into "My House My Life," in order to deal with the Brazilian housing deficit. An evaluation with the residents from the Minha Casa Minha Vida Program mentioned overheating among the three worst performance aspects of the houses (IPEA 2014).

A standard architectural design is not required by Caixa Econômica Federal (CAIXA), the main institution that funds housing construction in Brazil. However, CAIXA does provide a standard design proposal as a strategy for cost reduction, and suggests the importance of adapting the design according to place-based conditions including local climate. Since CAIXA does not state what design changes should be made as a response to place-specific conditions, most of the times they are not conducted. The work of Paulsen and Sposto (2013), Giglio et al. (2014) and Cota and Silva (2016) show that the same housing typology and popular materials are used in many developments located in different places of the country without any distinction.

One of the main reasons that compromise those buildings' quality is economic. The maximum amount of money made available from the funding agency for construction per month from is equivalent to 10% of the monthly income for families making up to 3 minimum wages (Caixa Econômica Federal 2010). The poor housing quality made CAIXA establishes a list of criteria including durability and minimum room areas. However, thermal criteria were not included.

In this context, CAIXA developed a certification system entitled "Selo Casa Azul", which stands for "Blue House Label", aiming for the increase in the quality of built houses while encouraging best practices in design and sustainable construction. Selo Casa Azul is a voluntary-based certification launched in 2010 that may be applied to any housing development but since CAIXA is the main funding agency for social housing, the system prioritizes social housing quality requirements among other typologies (Caixa Econômica Federal 2010).

Selo Casa Azul presents sustainability criteria for six quali-quantitative categories including required and optional solutions. A certified development may get a Bronze label for 19 required criteria attended; Silver, for additional 6 optional criteria, or Gold for additional 12 optional criteria. The system is comprised by 53 criteria. *Design and Comfort* and *Energy Efficiency* are two categories among five others that comprise 12 criteria, being 5, mandatory (Caixa Econômica Federal 2010).

The design criteria related to energy efficiency and thermal performance are site plan, solar orientation, fenestration areas, and materials and colors for the enclosure and roof. These criteria are aligned to NBR 15220—Thermal Performance (ABNT

2005) which was the only national performance regulation by the time the system was launched. The energy efficiency category involves technical systems and renewables, for example, individual gas and water measuring in multifamily buildings, domestic hot water (DHW), and energy generation (Caixa Econômica Federal 2010).

By the time Selo Casa Azul was launched, the Brazilian labeling program for buildings, which is called PBE Edifica, defined criteria for energy efficiency in the residential sector focused on natural air conditioning and water heating. As Selo Casa Azul, PBE Edifica based its quantitative design requirements following the parameters from NBR 15220 including those for enclosure materials and colors, internal inertia use, fenestrations for natural lighting and ventilation (ABNT 2005). However, the program presents different requirements for better performance of naturally conditioned buildings according to one of the 8 climate zones. The requirements for more efficient equipment use are considered as they increase energy efficiency performance of the housing unit (INMETRO 2010).

While PBE Edifica does not distinguish requirements for social housing, as Selo Casa Azul, some criteria are clearly dedicated to that design scope including the incorporation of an energy efficient refrigerator in the building for avoiding that a low-income resident installs a non-efficient one that may be cheaper. Though, the purchase of low efficient refrigerators are avoided and old ones are removed from the market and use. In addition, it is important to highlight that PBE Edifica indicates the energy efficiency level of the artificially conditioned housing as an informative item that is not used for the final energy performance level (INMETRO 2010).

In 2013, NBR 15575—Housing Performance was launched complementing content included in NBR 15220. NBR 15220 defines general criteria for thermal performance and indicates measures for better thermal performance of social housing. NBR 15575 presents performance criteria for any housing, including thermal issues among others as maintenance, durability, fire safety, structure, lighting, and acoustics. Therefore, it establishes a minimal performance threshold for minimum housing quality.

NBR 15575 had a better adoption by the construction industry than Selo Casa Azul and PBE Edifica, which are volunteer programs for sustainability and energy efficiency, respectively. A comparative research between Selo Casa Azul and PBE Edifica requirements applied to the same housing development demonstrated that the energy efficient and comfort measures from PBE Edifica for a level A labeled unit increased the number of hours with thermal comfort by 22% based on ASHRAE 55 (ANSI/ASHRAE 2010) against 5% increase for Gold label housing unit from Selo Casa Azul (Telles and Pessanha 2012). However, Selo Casa Azul criteria have a more friendly language and organization for laypeople and design professionals (Telles and Carlo 2012). Indeed, PBE Edifica for commercial buildings and housing defined a paradigm shift for the Brazilian professional practice.

The main obstacles for PBE Edifica criteria adoption are in the design phase. This fact was observed through an experiment to improve the thermal quality in low-income multifamily housing located in hot and humid climate while aiming for sustainability. In this experiment two main aspects are related to materials and natural ventilation. Based on that it was observed that:

(1) The constructive and structural system was made of 10 cm thick walls with a U-value equal to 4.0 W/m^{2}K which was not consistent with the Brazilian energy efficiency regulation for any of the country's climate. The use of thermal insulation changed the construction process that was planned to be fast as a cost-saving strategy.
(2) The constructive and structural system did not allow for spans large enough to promote natural ventilation.
(3) The constructive and structural system did not allow for spatial flexibility for different users which is basic for social housing sustainability as the user should be able to adapt the number and dimensions of the rooms according to the family size and needs.
(4) The constructive and structural system did not allow for increase in the window size for natural ventilation in the bedrooms as the room should fit at least two beds and a wardrobe in a small area not leaving room for a larger window.
(5) The use of side-scrolling opening window would be a great solution for increasing natural ventilation with low-tech and -cost. However, PBE Edifica requires shutters for ventilation and energy efficiency, and the shutters should open to the outside while glass would scroll to the inside of the building. Though, this solution is not possible for the rooms' small areas.

All these issues may be resolved with more expensive solutions, but they would go beyond the budget limit of the federal program. Moreover, it is important to highlight that this may not be considered a standard case in Brazil, as other contractors adopt ceramic or concrete blocks that allow for more flexibility of the design. The designed constructive and structural system did not follow the thermal criteria of the regulations, although it did have some advantages, as a fast-paced construction. The cost reduction with the fast construction process did not balance the problems related to thermal comfort and energy efficiency. As many cases in Brazil, the impact of construction speed and standardization of social housing development for cost reduction supersedes sustainability and energy efficiency.

4 Sustainable Affordable Houses in the U.S.

Affordable housing in the United States is defined by federal and state governments' laws and regulations as housing that does not cost more than 30% of an individual or family's earnings for associated gross costs. According to the Centre County Affordable Housing Coalition (no date):

- *When residents experience a housing **cost burden** paying more than 30% of their income, several situations tend to occur.*
- *Residents rent instead of own, thus losing opportunities to experience the financial benefits of owning a home.*
- *They have less income to spend on items beyond fulfilling their immediate needs [i.e. food, clothes, life-sustaining medications].*

- *They live in less expensive regions… typically a greater distance from employment opportunities, which results in increased transportation costs [and needs].*
- *They live in housing that is substandard or in poor physical condition.*

Throughout the United States, more than 30% of homeowners and half of all renters struggle with housing cost burden, many of these families are severely burdened—paying more than 50% of their incomes for housing (Harvard University 2017). Monthly gross housing expenses include "carrying costs," such as utilities, in addition to direct expenses (mortgage, rent) associated with monthly/annual housing expenses. The law and economic consulting firm Fisher et al. (2016) established a method for assessing "carrying costs" of housing, specifically factoring energy expenses into the equation. Their calculations take into consideration energy-related end uses including space heating; space cooling; domestic hot water; and electrical appliances including lighting and refrigeration. They conclude that no more than 6% of housing related expenses (2% for heating) should be dedicated to paying for energy. Their findings have shown that "home energy is a crippling financial burden for low-income households (…) home energy un-affordability, however, is not only the province of the very poor." Even higher income households often pay more than affordable amounts for expenses associated with home energy (Fisher et al. 2016). It is no wonder, therefore, that people need to make difficult, sometimes life-threatening choices, about where to spend. Poor energy-efficiency results in a number of social problems, including fuel poverty and ill health, as well as excess energy consumption which leads to high levels of energy-related environmental emissions; the policy context for these air pollutants is now well established" (Healy 2003). The building sector accounts for 40% of the overall U.S. energy consumption and contributes significantly to greenhouse gas (GhG) emissions associated with global climate change. "The largest source of GhG emissions from human activities in the United States is from burning fossil fuels for electricity, heat, and transportation" (EPA 2017). "In 2012, the residential sector accounted for 21% of total primary energy consumption and about 20% of carbon dioxide emissions in the United States (computed from EIA 2013)" (EIA 2015). Production of energy is associated with poor air quality and significantly contributes to GhG emissions associated with Climate Change. Therefore, energy-efficiency measures, associated with sustainable housing must be addressed in building and retrofitting affordable housing.

Although not a primary consideration, energy has been an implicit or explicit consideration since the inception of U.S. affordable housing policy and has gained momentum since the 2003 International Energy Conservation Code. In 2010, the U.S. Department of Energy (DOE) introduced their Better Building Initiative and the U.S. Department of Housing and Urban Development (HUD), the federal agency responsible for affordable housing policy, revised its mission to include sustainability: "create strong, sustainable, inclusive communities and quality affordable homes for all." Related concepts of resilience also rose in priority starting in 2013, with significant CDBG (Community Development Block Grant, one of HUDs the longest-running programs) dedicated to disaster recovery (Iulo and O'Brien 2015).

Sustainability and resilience are both important and interconnected goals for short- (first costs, i.e. construction) and long-term (carrying costs, i.e. utility expenses) of housing affordability. Sustainable, resilient affordable housing share goals for improved energy efficiency, durability, and healthfulness. To achieve this, a wholistic and integrative approach to housing design, construction, and operation is necessary.

The National Institute of Building Sciences Whole Building Design Guide (WBDG) is a web-based portal that "provides up-to-date information on integrated 'whole building' design techniques and technologies." It presents eight Design Objectives, including *sustainable, pertaining to environmental performance of building elements and strategies*, and outlining related topics:

- Optimize Site Potential
- Optimize Energy Use
- Protect and Conserve Water
- Optimize Building Space and Material Use
- Enhance Indoor Environmental Quality (IEQ); and
- Optimize Operational and Maintenance Practices.

These topics are consistent with categories of sustainable development guidelines including credits associated with USGBC LEED and imperatives of the International Living Future Institute Living Building Challenge. Two nationally-recognized sustainability systems relevant to affordable housing include the ICC/ASHRAE 700–2015 National Green Building Standard (NGBS) and Enterprise Green Communities (Enterprise). Both cover "above-code, voluntary sustainable design and construction practices and programs into residential single-family and multi-family buildings and are "recognized alternative compliance paths for demonstrating that HUD- or USDA housing meets agencies' energy-efficiency standards" (NAHB 2017). Recommendations are outlined in each of the sustainable design and development categories with emphasis on energy efficiency. The basis for energy performance standards and energy efficiency in most residential construction in the U.S. is established by the RESNET HERS (Home Energy Rating System) index. It measures a home's energy efficiency based on comparative data against a similar 'reference home' based on a 100-point scale (RESNET 2018). A score of 100 is comparable to a 2006 IECC (International Energy Conservation Code) code-built home. The lower the score, the better the energy efficiency. The U.S. EPA (Environmental Protection Agency) and the U.S. Department of Energy (DOE) have worked together to establish the ENERGY STAR® program as "America's resource for saving energy". The program sets efficiency standards for products as well as for homes and buildings. Energy Strategies for buildings and plants are established based on the ENERGY STAR Portfolio Manager®, which benchmarks properties based on a 100-point score. The ENERGY STAR program also provides a verified process for improving energy performance in homes and apartments (https://www.energystar.gov/newhomes). To be ENERGY STAR certified, housing (including single family detached housing to multifamily buildings up to 5 stories above-grade) must be at least 30% more energy efficient than a code-based home. More recently the U.S. DOE introduced the Zero Energy Ready Home program, which "represents a whole

new level of home performance, with rigorous requirements that ensure outstanding levels of energy savings, comfort, health and durability" (EERE, no date). The goal of the Zero Energy Ready Home program is to further reduce energy efficiency use to a point that demand can be met using on-site renewable energy. "DOE Zero Energy Ready Homes are verified by a qualified third-party and are at least 40–50% more efficient than a typical new home. This generally corresponds to a HERS Index Score in the low- to mid-50s, depending on the size of the home and the region in which it is built." DOE Zero Energy Homes must comply with ENERGY STAR for Homes Program requirements and meet strict requirements for thermal enclosure, HVAC systems and installation, water management, energy efficient appliances and fixtures, and climate-specific high-performance window standards. Factors for home size, associated with increased energy use, are also considered (IBID, Program Requirements). Moreover, Zero Energy Ready Homes generally comply with EPA programs for water and indoor air quality:

- WaterSense, to reduce residential water consumption and energy use and losses associated with hot water (https://www.epa.gov/watersense); and
- Indoor airPLUS, a voluntary labeling program requiring construction practices and product specifications that minimize exposure to harmful airborne pollutants and contaminants (https://www.epa.gov/indoorairplus), contributing to improved resident health and well-being.

The Office of Energy Efficiency & Renewable Energy Buildings (EERE), Zero Energy Ready Home (ZERH) program website, identifies the synergies between related programs for energy efficiency (ENERGY STAR). Rigorous standards set forth by the International Passive House standard, and PHIUS (Passive House Institute US) are also recognized. DOE ENERGY STAR architect Sam Rashkin, describes a staircase approach that builds of a strong foundation of improved energy codes (IECC) and ENERGY STAR then ascending to ZERH "coordinated with Passive House "to form a continuum of high-performance label options for home builders". The foundation for this "High-Performance Home Staircase," encourages U.S. homebuilders to make commitment, not only to energy performance but also to quality housing management programs and disaster resilience (Rashkin 2015). The Envelope-first approach to energy improvements has significantly reduced energy demand. This results in significantly lower operating expenses for the owner and can be realized for little if any increased cost in construction. However, the approach requires mechanical systems be used for thermal comfort and ventilation. Natural and manmade disasters frequently result in detrimental power outages, compromising ability to run mechanical systems.

To accomplish resilience in housing design, we need to return to some of the tenets of historical patterns and passive solar design, including designing for adaptability, flexibility and an enhanced understanding of place. The term "Passive Survivability" is gaining some ground in informing resilience strategies. The term, defined by Wilson (2006), refers to "buildings ability to maintain critical life-support conditions in the event of extended loss of power, heating fuel or water". To achieve this, general sustainable design and development standards (such as USGBC LEED for Homes

and National Association of Home Builders, ICC 700/ASHRAE National Green Building Standard, and others outlined above), must be taken into consideration. In addition, topics of sustainable design and development are to be aligned with premises of ecosystems services for an integrated design solution with the natural environment.

5 Relation Between American and Brazilian Energy Efficient Affordable Houses

In housing—in Brazil and the U.S.—most design decisions are funneled to short-term economic concern. A cultural change is needed to ensure sustainability and resilience by relating the built and natural environment. Considerations about materials source, durability, and performance need to come to the front of design and construction priorities, together with developments location both for social integration of the community with the town and for commuting and its environmental impact. Natural ventilation is already part of the Brazilian national culture. However, its benefits are getting lost to artificial air conditioning and automatically controlled building systems. If design solutions ensure adequate levels of thermal comfort, this process can be reverted. This is directly related to envelope improvements associated with energy efficiency and, therefore, with sustainability and resilience. In this sense, long-term benefits that are related to environmental and social impacts need to become an essential part and value in the construction sector when it comes to affordable housing.

Tenets of passive solar design, and associated ideas for "Passive Survivability" are central to achieving affordable housing in Brazil and the United States. Differences in how this is achieved is informed by climate. Equally important are an understanding of material availability and variability of details. Therefore, cultural knowledge is paramount. Housing, therefore is an affordable, sustainable housing therefore, is a complex social-ecological challenge. According to Brandt et al. (2013), social-ecological systems requires a transdisciplinary research approach.

6 Transdisciplinary Approach Between Ecology, Design, and Project Realization

Transdisciplinary work is a powerful means to address sustainability, resilience and making life better for people through their most personal and valuable possession—their homes. Moreover, it is necessary for deep ecological thinking and realizing the mutually beneficial gift provided by ecosystems services. To design in a way that is culturally and ecologically responsible deep we must build knowledge through

interaction with people: with input from residents, builders, and decision-makers in policy and regulations. Recently, Irwin et al. (2018) articulated an

> …emerging research agenda for sustainable urban system…emphasizing a new framework that conceptualizes these systems as multiscale, interdependent, social, engineered and natural systems. This research calls for convergence research on urban systems—that is, research that moves beyond interdisciplinary collaboration to achieve deep knowledge integrations across discipline to create new systems frameworks for integrative work.

Their work is consistent with the National Science Foundation's (NSF) definition of convergence science: it is defined as "*Research driven by a specific and compelling problem*," and requires "*Deep interaction across disciplines*" (NSF, no date). A transdisciplinary approach brings together researchers, practitioners, community members considerations and points of view in two different countries, the U.S. and Brazil, with contrasting culture and environmental characteristics. Importantly, transdisciplinarity transcends expertise—"disciplinary, multidisciplinary, pluridisciplinarity, and interdisciplinarity" (Max-Neef, M.A. 2005). Importantly, this engagement must involve with people in communities—those most familiar with paramount local conditions and relationships. As recognized by Irwin et al. (2018) in *Bridging barriers to advance global sustainability*, "we need new structures to foster knowledge that is deeply integrated across disciplines and co-produced with non-academic stakeholders". Applying ecosystems services to sustainable housing through a transdisciplinary approach empowers residents through increasing housing stability and affordability, directs efforts towards SDG #11: Sustainable Cities and Communities, and by extension all SDGs.

7 Conclusion

It is highly recommended to consider the relation between energy systems in respect to ecosystem services. Ecosystem services comprehend the basics for human welfare and all living beings' survival. The energy systems, including the components of energy sources, transport and storage, and demand management varies across countries and globally. It is fundamental to understand the ecological impact of each system locally, regionally, and globally. Most studies about ecosystem services are conducted within a habitat or bio-region scale; however, it is important to bring attention to the topic at the local urban scale for designers, developers, and stakeholders. The social and economic context is still in the core of design decision and energy system adoption. The criteria for human comfort and welfare is very limited in developing countries as seen in the Brazilian case due to economic limitations. The potential of ecosystem services to contribute to human welfare in short- and long-terms may offer multifunctional solutions, with locally sourced resources, and multiple and diverse benefits from nature.

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Analysis of Behavioral Changes Observed in Users of Sustainable Practices

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Abstract This study has the main objective to analyze changes in social behaviors resulting from the application of sustainable methodologies in family and business environments. The work will be focused on understanding how the personal advantages acquired by individuals who opted to exchange unsustainable daily practices for more actives ones in a general scenario of collective change extend. Through real clients of companies related to selective garbage collection and generation of photovoltaic solar energy, it was possible to observe that the interest in studying and informing about the respective themes increases as the use of them becomes simpler, didactic and recurrent. This fact can be confirmed by creating an analogy with home garden productions, where the closer approximation of users to issues such as health, environmental, consumerism and even planting techniques is visible. This acquired knowledge takes on greater dimensions in the long run, but they are rooted more permanently, unlike most current proposals of study that offer passive and momentary learning. As people who coexist with these users are influenced, collective behavioral changes become real and palpable. Having only the existence of environmental values, with the absence of changes in habits and automatisms, there is no change in behavior on the part of people. The present work will try to show the reader that these statements are in fact real through the intersection of interviews with theoretical foundations, as well as data acquired from the already existing and functioning projects. Combining economic, social and environmental

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aspects, one can observe in an effective way the real impact of certain daily activities on nature and in the community. The last decades have been marked by the broadening of the debates that approach the natural resources preservation that man uses, where studies show that the present one already represents a real ecological crisis and irreducible dimensions in some cases. Climate change and countless ecosystems undergo daily destabilization and their reflections can be found anywhere in the world. The media has become increasingly emphatic, often for sensational reasons, in presenting situations such as the natural resources reduction, the increase of various types of pollution, global warming, the potable water reserves reduction, the waste excessive production, among others. These themes, related to environmental degradation, have fostered the population's interest, since they always present the consequences that, due to the decline of environmental quality, will be imposed on the life of modern society. Is that the sustainability concept can be translated into a tripod aspects relating to these reflexes (triple bottom line), and the resulting social, environmental and economic analyzes financial, separately and jointly.

Keywords Sustainability · Socio-cultural development · Environmental psychology

1 Introduction: Socio-Cultural Development Based on Sustainable Practices

The last decades have been marked by the broadening of the debates that approach the preservation of the natural resources that man uses, where studies show that the present one already represents a real ecological crisis and of irreducible dimensions in some cases. Climate change and countless ecosystems undergo daily destabilization and their reflections can be found anywhere in the world (Raskin et al. 2010). The media has become increasingly emphatic, often for sensational reasons, in presenting situations such as the reduction of natural resources, the increase of various types of pollution, global warming, the reduction of potable water reserves, the excessive production of waste, among others. These themes, related to environmental degradation, have fostered the interest of the population, since they always present the consequences that, due to the decline of environmental quality, will be imposed on the life of modern society. It has been that the concept of sustainability can be translated into a triplet of aspects related to these reflexes (triple bottom line), resulting from social, environmental and economic-financial analyzes, separately and jointly (Menezes et al. 2018).

It is undeniable that much of the environmental degradation comes from mass production of companies little concerned with the subject, but some research fronts address the fact that only "political" changes would not be enough to obtain conclusive favorable results. That is, in order for there to be a solid and palpable social transformation, there must be not only economic changes, but also cultural modifi-

cations. According to (Ester et al. 2004), public attitudes and behaviors towards the environment can be impact generated through cultural factors, being these fundamental factors both to study environmental issues and to understand and deal with possible environmental problems.

Research shows that the strength of the environment-related attitudes that each person presents is directly related to their perception of environmental issues in moral terms (Stern et al. 1999). What is really necessary are profound changes in lifestyle, which propose not only intentional pro-environmental behavior but also behavioral changes that are not directly related to the environment (Gatersleben et al. 2010). Environmental awareness and ecological values are not translated directly into responsible environmental behavior, this analysis is called the value-action gap. The individual who is most likely to be feeling moral obligations to the environment is the one who voluntarily puts the interests of others ahead of his own (Feinberg and Willer 2013; Karp 1996; Schultz and Zelezny 1998). Moral obligation is a response to a sense of personal responsibility and awareness of the consequences to others. In addition, it is generally known and validated that modern society has as its main focus the valuation of comfort and economic prosperity, as well as exposure of values that promote the continued acquisition of material possessions. This hegemonic model based on intense technological developments, large-scale consumption and unbridled exploitation of natural resources generates profound imbalances in both micro and mega-scale (Pinheiro 1997). It is vitally important for the current moment to promote the pro-environmental behavior and to reduce the current levels of consumption in order that there is a real transformation (Gatersleben et al. 2014). "Paradoxically, the increasing level of public concern and willingness to support environmental actions is growing simultaneously with levels of energy consumption and scarce resource use" (Ester et al. 2004).

Pro-environmental behaviors are those that have a minimal impact on the environment, which include, for example, energy conservation, waste recycling and sustainable food consumption, among others (Steg and Vlek 2009). Literature offers through psychology two ways of analyzing the understanding of this behavior. One of them examines changes in psychological factors as a consequence of behavioral choices, assuming that changes in attitude provide changes in behavior (Ajzen 1991). The other notes how such behavior can be encouraged through existing psychological constructs such as values, norms, and identities (Fudge et al. 2013). Psychology provides immeasurable contributions to understanding and solving environmental problems. This article intends to contribute so that the explanation is based on the subjectivities and experiences of the individuals who characterize themselves as people who try to have a sustainable lifestyle.

2 Understanding the Economic Scenario Through the Impacts Generated by Individual and Collective Behavioral Changes

Nowadays, we live in a society that began to seek better trading practices and a better relationship with nature, because during the several years after the industrial revolution and domination of the market culture, it was understood that the bust ungoverned by accumulation of wealth was ending with the resources that fed him. According to Misoczky and Bohm (2012) in their brilliant essay, this awareness was developed during the 1970s, "a decade in which spread the concern about the limits of the instrumentalist approach, which treated nature as a source of resources and the deposit of remains" (Misoczky and Bohm 2012).

On the one hand, the world economy began to worry about the revitalization of degraded areas and scientific clarification of the damages caused by the activities. On the other hand, a business opportunity was seen, according to Bakker (2010) there was a redirection "of the accumulation strategies for the commodification of new types of nature and for the conversion of environmental externalities into sources of profit, in articulation with well established strategies of ecological arrangements" (Bakker 2010).

With the growing awareness of environmental issues, the capital market, the main predator of natural resources, noted the need to ally somehow to this movement, with which the term "sustainable development" was established. From several events and studies this term was consolidated in society. One example is the Brundtland Report (Wced 1987), which laid the groundwork for the debates and negotiations that took place at the International Conference on Environment and Sustainable Development (Eco-92). In this Report the central argument say that the best way to respond to environmental destruction and poverty was development (Bruntland 1987).

However, several criticisms were woven about the idea of unlimited growth on a limited planet, for Lander (2011) it was an act of "extraordinary conceptual juggling" in the concept of "sustainable development" (Lander 2011). The concept mixes the technical characteristics of a particular path of development with a moral injunction that defines it as the optimal choice for any society. For Misoczky and Bohm (2012), real environmental ideas should be associated with a reduction in high consumption patterns, especially in the Northern countries. Fading to this logic environmental protection, and the values of different cultures with respect to their environments, have become formally expressed in terms of market and prices, in which capital is taken as a measure of the environmental degradation that it produces (Misoczky and Bohm 2012).

The fact is that, despite all contradictions and criticisms, instead of a reduction of human activities on nature, a new market was created, with several opportunities, high profitability and, most importantly, with the support and admiration of society. Costanza et al. (1997) estimated that the annual global value of ecosystem services would be 16–54 trillion dollars, evidencing the possible profits to be obtained in this new market (Costanza et al. 1997).

3 Environmental Psychology

The concept of environmental psychology first appeared in 1943, proposed by Brunswik (Gifford 2007), where he approached the fact that psychologists should increase the volume of research dedicated to the representativeness of design, emphasizing that the environmental stimuli diffused by design were more complex than they were considered at the time (Alves and Bassani 2008). Thus, it can be said that environmental psychology has its roots not only in traditional psychology, but in other diverse areas, such as architecture, urbanism, landscaping, sociology, biology, geography, ergonomics, among others. It is a multidisciplinary approach in almost all cases, since the complexity of environmental problems often requires an approach from different points of view, lacking the collaboration of other disciplines. A good example is the fact that one of the accepted conceptions for the term environment, from the point of view of psychology, comes from a biologist who defined the environment being always related to an organism that perceives and acts, and this corresponds to the structure of its "inner world," which he named Umwelten (Kruse 2005; Uexukll 1921).

The main objective of the analyzes that use this concept is to study the individual in its context, focusing on the study of the interrelations between people and the environment, both physical and social. It is evident that the sociocultural dimensions are always present in the observation and definition of the environments, mediating and measuring the perception, the evaluation and the attitudes of the people in front of them. It is noteworthy that environments also exert intense effects on human behaviors, so it can be said that environmental psychology extends and studies precisely this reciprocity between individual and means (Moser 1998). It is also clear that it is the behavior of individuals that cause and aggravate environmental problems, and that these changes will consequently modify their own qualities of life. In this way it is emphasized that these problems are, in reality, problems of humanity (Pinheiro 1997; Rodriguez 1997).

4 Research Methodology

The present work was developed from theoretical analyzes applied in qualitative field researches, carried out on users of products and services of two real companies, **Eletrosol** and **Ciclo Gestão de Resíduos**, both active in relation to the theme proposed by the article, in this case in the production of solar energy and in the selective collection of garbage, respectively. The companies are located in the State of Minas Gerais and the surveys were carried out in November 2018.

Because it is a qualitative and non-quantitative research, there is in the process of approach a very wide range of possibilities of choice. To define the form that would follow the questionnaires initially was thought of a simpler process, in the sense of how much technical the questions would be and how comfortable would be

the respondents to answer the questions. This way it was chosen to perform only a single question, but composed. That is, five questions asked together and sequentially premeditated, allowing the individual to follow a clearer line of reasoning. Following this consideration, the question was:

- What prompted you to join a more sustainable lifestyle?
- What advantages can you see from this change in your day-to-day life?
- Do you think someone in your life was impacted by your new environmental attitudes? If so, give a little opinion on.
- What in your opinion still offers resistance to individuals who want to start using sustainable practices?
- Finally, do you plan to extend and adhere to other sustainable practices? If so, what would it be?

An interview time was also defined, aiming again at simplicity and comfort, of ten minutes with a tolerance of twenty percent (2 min). This methodology was performed with five clients of each company and their names were omitted to preserve their identities and to allow them greater freedom of expression. The interviews were recorded with permission of the interviewees, the parts that gave form to the analyzes sought are highlighted in italics in the results section.

It was used a theory-based approach to the collection and analysis of interviews, that is, it means that interviewees could tell their stories and their views on their own terms, thus generating insights more grounded in their people perspectives on the subject (Evans and Abrahamse 2009; Glaser and Strauss 1967).

5 Common Denominators

In relation to the characteristic of narrative structure, the individuals interviewed tended to initiate the discussion about areas that they considered more important and where they were placed as more significant actors, referring to personal efforts. Everyone, without exception, was keen to make it clear that the main cause that motivated them to engage in ecological activities was the financial issue.

> At first I was only looking for the economy, because with the high costs of energy I found myself needing to be looking for alternatives to reduce this value, I joined the useful to the pleasant. (Man, 33)
>
> The main fact that I have adhered to the sustainable lifestyle of solar energy without any shadow of doubt was the savings I would have with the system installed. (Man, 40)

In addition to the concern with personal accounts, based on monthly savings, the respondents were aware of possible fluctuations and increases in the price of electricity in Brazil. This fact exemplifies a branching of knowledge absorbed by these individuals, starting from the developed home economy and reaching the understanding of economic market volatilities.

> In my opinion is the protection against the inflation that I would have of the cost of electricity because if an agent goes to look at each passing day the energy bill is increasingly expensive, not to mention that it already has up to scheduled readjustments… with the system I am also armored against these readjustment effects, if agent is to look at the tendency of this happening is more and more frequent, due to lack of water of course. (Man, 35)
>
> What led me to make this sustainable decision with reference to the use of energy was that constant increases in electricity prices. (Man, 43)
>
> It has a certain security regarding the account of the end of the month, as now I am practically exempt from the increase of the price of the energy, even when the energy rises I will not be impacted with this. (Man, 40)

The fact that the interviewees are not alienated to the economic issues that revolve around the theme, brings as a consequence a reflection on how these activities can generate a certain independence with respect to the practices of the companies that previously provided services to them.

> The main advantage I found was that with this large increase in the cost of electricity by CEMIG it was very feasible to use the photovoltaic panels, greatly reducing the value of my bills. (Man, 43)

Another observation was that in some cases the economy made by the individuals coming from the sustainable practices, was reverted in an increase quality of life. In this case bringing up an antithesis present in the fact that one of the activities that make up the pro-environmental behavior is precisely a transformation in the level of consumerism and an increase in environmental awareness as a whole, not limited to practices that are directly connected to sustainability. The shift from lifestyle to more sustainable is characterized by changes in various domains, is a set of coherent, cohesive and consistent activities of social practices.

> The advantages that I was able to observe of this change in my day to day was basically a certain tranquility that the system brought me because today obviously I consume more than I consumed so obviously I have greater comfort. (Man, 40)
>
> Lifestyles can be understood as the set of social practices that represent a particular way of life and give substance to the narrative self-identity and self-realization of an individual. (Evans and Abrahamse 2009; Giddens 1991)

6 A Sustainable Lifestyle, A Continuous Process

The change to a pro-environmental behavior, that is, a transformation to a more sustainable lifestyle requires interrupted modifications and maintenance, so that the individual has in this process a continuous activity related to social practices, not only those that are directly associated environmental causes. It can be said that there is no end when it comes to personal improvements in relation to the subject, no person reaches the point where he can claim to be living totally in a sustainable way and thus has the right to stop with his particular evolution.

> In my opinion the resistance is in the initial barrier, in the first step. Whether it is by inertia and a tendency to want to continue with the same habits, or by the financial contribution necessary for this first step. As soon as this first barrier is overcome, the tendency to continue and even the search for other forms of a more sustainable life becomes evident. (Man, 35)

> I believe that even today the subject of sustainable practices is little talked about and does not reach many people. Even when we see reports on the subject, they do not help us understand how to begin to change our daily practices and it seems very difficult to make these changes. When we talk about sustainable practices, I feel that we indicate a specific lifestyle, with which only a portion of the people seems to identify. In this sense, the challenge may be to address these issues in a way that indicates that it is not a lifestyle, a drastic change in the system, but routine little practices that help us take care of the environment. To do so, I believe that public or private policies at the municipal level would reach the population more through the dissemination of possible practices, as well as facilitating selective collection. (Woman, 33)

When they were approached about which factor they were able to point out as what most prevented them from proceeding with this continuous process of personal environmental improvements, all put the Brazilian state as not fomenting such a theme. On the contrary, many centralized that the high tax rates imposed in Brazil were the main disincentives of personal projects of sustainable lifestyle.

> I intend to over time adhere to new sustainable practices, but the state also has to contribute. (Man, 40)

> I think there is a lack of support from the government in order to be able to encourage these sustainable practices more. Guide more people, disseminate more information. The government and the state should focus more on this, instruct the Brazilian more to adopt these measures more. (Man, 35)

> I think what else prevents the person from putting this type of project in your house, and I think everyone has desire, it is the price that is still high, in Brazil the tax rate is very high, so this makes it a bit difficult, but I'm sure everyone feels like it. (Man, 33)

> I believe that the greater difficulty of the use by the people is the high cost still, because the material has to be imported. (Man, 43)

> Although government intervention is legitimate, it is not trivial. In the case of conservation of biological diversity, intervention is even more complex since our theoretical and managerial knowledge is still insufficient. (Motta 1998)

In addition to being linked to the fact that the state has a fundamental role in relation to socio-environmental issues, respondents also expressed a significant concern about the lack of knowledge on the part of the population of the financial return that some initiatives offer. One of the interviewees presents himself as an investor when he comments on his installation of photovoltaic panels and says:

> The greatest resistance that the population has today to creating a solar system is the lack of knowledge, taking as an example my own experience, you see, my system cost me a value of 21,000.00 reais. This money spent on savings would give me an average of 78.00 reais a month, but saving is not an investment. So putting a value of 1 percent per month, which is a considered high value, we will put this investment of mine, returning me 210.00 reais. That is a more expressive value than the savings, but what saves monthly with value of energy bill is around 480.00 reais. So in my opinion, the population did not mind that fact. (Man, 40)

Respondents became involved with each particular domain in different ways, both in intensity and in creativity. Some promoted daily abdications, bringing the notion that their suffering through habit change would already be seen as a form of "payment" in the socioecological scenario. Others who perceptibly did not seek recognition for these behavioral changes have broadened their viewpoints by implementing new, environmentally sustainable activities whenever possible, as they did not measure or evaluate their commitment to environmental causes. Even though there are different ways of acting sustainably, they have all shown that they have gained a more holistic view of the environment after initiating even small changes in their lifestyles.

7 Conclusion

The present article sought to ascertain, through qualitative analysis, the complexity of the personal evolution developed by users of ecologically sustainable practices. Crossing studies of the wide range of areas that environmental psychology addresses, one could observe the extent to which these practices can provide the individual, not only in environmental sustainability, but also moral issues, which form the basis of society. At the same time it was also possible to point out palpable characteristics absorbed by real users, creating connections with the theory, which, as it currently undergoes daily transformations, lacks all possible complements in order to reduce its complexity. According to Giuliani (2005), (…) in order for research and society in general to interact profitably, there must be an interest and ability on the part of society to make research formulate interpretive models and not only provide specific solutions. The sphere of research, on the other hand, must have the interest and ability to recognize the important problems and make the creative effort to discover its less obvious aspects. I believe that only in these conditions can the problem-oriented nature of Environmental Psychology be widely shared and not remain in a more or less delusional aspiration of individuals (Giuliani 2005).

As much as individuals deliberately choose their own models of sustainable practices, of distinct intensities and shapes, their motivations and consequences can be generalized, since they compose not only a study restricted to the environment, but a package of multidisciplinary research fronts. Thus, it can be said that this work used not only the obvious environmental analyzes, already expressively disseminated, but an ecopsychological scenario as a whole as well. The constant development of technologies that provide more efficient productivities of resources, which consequently nullify the need for changes in lifestyles, do not prevent society from interrupting its current environmental and social habits (Hobson 2002). In addition to the continuous sense of self-realization, the pro-environmental behavior also seems to lack a more intense sharing of experiences, having as centrality the fact that there is not a single model that represents a sustainable lifestyle, but multiple sets of social practices.

This article also addressed, through interviews, how the participation of the state is fundamental, and how the role of it is not effectively practiced in Brazil. The

qualitative results presented here, together with the appropriate analysis, were aimed at helping the theory to encompass more the global sustainability model, including Brazil more and more. This observation raised another important question, referring to the reality of the diffusion of information and knowledge acquired by individuals due to their new habits. Not being alienated in relation to the indissociability of the population-state may be one of the characteristics absorbed by the pro-environmental users.

The interviews demonstrated in a unanimous and punctual way that the main obstacle existing in processes that aim at sustainability is the financial question. Since the answers and lines of reasoning presented by the interviewees always started with economic obstacles, and they arrived at the irresponsibility of the state in the face of the current situation of the subject in Brazil, with little diffusion and with low stimuli. Clearly the task of management to be developed by families, companies and governments is not simple, the manager has to be able to solve the problem of allocating investments in limited budgets and often even in scenarios that have different priority expenditures. "To ensure the continued availability of the ecosystem, the use of associated should be limited to sustainable use levels. The ability of ecosystems to provide goods and services depends on the ecosystem-related processes that provide components and the limits of sustainable use are determined by ecological criteria such as integrity, resilience and resistance" (Groot et al. 2002). Although our analysis has not been able to find discernible patterns, it has been possible to promote interesting analyzes and conclusions, besides presenting perspectives that can become starting points or aids for future work. As previously mentioned, the main objective of this research was to contribute to the theory with data and analyzes, in order to seek a more complete view of the ecopsychological scenario.

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Measuring the Implementation of Sustainable Development Goals at a Local Level: The WeGIx Index

Gisela Marta Oliveira, Diogo Guedes Vidal, Lilian Monteiro Ferrari Viterbo and Rui Leandro Maia

Abstract The broadness and ambition of the UN 2030 Agenda for Sustainable Development calls for commitment and effort from all society sectors. Either at national or local level, where the action of communities and governance is of the utmost importance for the implementation and operationalization of such an interconnected and transformative agenda, adequate means for monitoring, measurement and accountability of plans and actions are also required. Academia, being one of the strongest pillars of the contemporary societies, should embrace its role as both a promoter and supporter of this universal Agenda, not only by developing fundamental scientific knowledge and educational resources but by also acting as advisers for governmental decisions and the establishment of proper and tailored public policies. This work describes the design and application processes of WeGIx—a composite indicator aiming to be a global objective measure of communities' quality of life, at municipality level. WeGIx quantifies a combination of forty-three variables contributing to tackle municipalities' global progress, in an integrated manner, on SDGs 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 15 and 16. Results of the WeGIx application on Portugal demonstrate development asymmetries in municipalities and help to identify implementation gaps and improvement opportunities.

Keywords Composite indicator · Local level · Sustainable development · Objective quantification · SDGs indicators

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1 Introduction: Measuring Sustainable Development at National, Regional and Municipality Level

Sustainable development aims for the universal wellbeing of humanity and for integral human development thus it is becoming an important issue of the modern world due to the urgent need of ecosystems preservation for future generations and of a fair distribution of wealth to eliminate inequalities (United Nations General Assembly 2015). Currently, the challenges of the universal implementation of sustainable development are political, social, economic and environmental interrelated. Moreover, individual objectives of sustainable development plans of action do not always converge with the human development goals, sometimes even aggravate actual social and gender disparities, even at national scale. Balanced and integrated solutions are needed when approaching different perspectives of a reality that must consider the human being and human rights as the core issue, while taking into account communities' and territories' characteristics and particularities (Salvia et al. 2019). Sustainable development policies must be considered as the point of convergence for plans and actions aiming to pursue objectives for healthy, economic welfare and successful societies while safeguarding natural resources and ecosystems. There should not be "a one solution fits all" but, on the opposite, tailored and oriented plans and actions which properly address sustainability. The effectiveness of sustainable development policies has to be measured on a regular basis to follow and to account for the progress of the defined political commitments. Either at regional or at local level, where the action of communities and the local governance is of the utmost importance, the promotion, support and operationalization of the interconnected and transformative UN 2030 Agenda for Sustainable Development should rely on adequate means for monitoring, measurement and accountability of plans and actions.

The management and implementation of this multidisciplinary and complex matter cannot be left, exclusively, in the hands of government bodies and the UN motto "leaving no one behind" also relates to the participation and engagement from the academia and from different civil society stakeholders (Salvia et al. 2019). Sustainable solutions to improve environmental and life quality may even require additional technological resources but, most important, require cooperative action between local authorities, central governments, industrial, economic and academic stakeholders and, of course, citizens (Leal Filho et al. 2018). Countries' governments have the responsibility to manage official statistical data and to implement sustainable development plans that pursue the defined political commitments, both internally and before international bodies such as the UN, the World Bank, or the EU. However, many sustainable development policies are implemented at the municipality scale, thus monitoring has also to occur at this local range. Objective measures of the life conditions determined only for a country level may conceal very important inequalities within a country population such as the uneven access to health or to education programmes as well as unbalanced levels of income.

A considerable volume of discussion and, even criticism, encircles the building and application of composite indicators (OECD and JRC European Commission

2008). These critics are grounded on acknowledged composite indicators limitations and drawbacks, especially concerning the selection of variables and the aggregation methods of additive type which tend to perform compensation between indicators (Mazziotta and Pareto 2013; Munda and Nardo 2009).

Despite the referred problems, composite indicators usefulness is real and recognized by the UN, the World Bank, the WHO, the OECD or the EU as important tools to monitor countries evolution when well defined targets exist, to assist policy analysis and to further improve public communication. The UN monitoring system (United Nations General Assembly 2014; United Nations Statistical Commission 2017) relies on specialized organizations and on several tools such as the framework of indicators designed to be applied in countries at a national scale, addressing all Sustainable Development Goals (SDGs) and their specific targets (Leadership Council of the Sustainable Development Solutions Network (SDSN) 2015; United Nations General Assembly 2018).

Within this context, the present work describes the conception, methodological procedures and application, to the entire Portuguese territory, of the composite index WeGIx—Wellbeing Global Index that aims to measure the quality of life at the local scale. Portugal is a democratic country, in peace since 1974 and is a state member of the EU since 1985, benefitting from the Community peace, policies, economy and solidarity. Meanwhile, even under the protective shield of the EU, the country economy and financial situation crashed in 2008, caused by poor governance and the international financial crisis, inhibiting from progress in several dimensions of life conditions. Three years have passed since the UN 2030 Agenda declaration, so it is time to keep track on the country progress on SDGs, concerning a municipal scale and to assess the inequalities in the country (SDG 10).

2 Methodology Used in the Process of Designing and Implementing the WeGIx Index: Step by Step

This work describes the process of designing WeGIx, a composite indicator, within the scope of the SDG objectives and their correspondent one hundred global indicators defined by the UN Inter-agency and Expert Group on SDG Indicators (Leadership Council of the Sustainable Development Solutions Network (SDSN) 2015), and its application to Portugal as a case study. SDGs were built upon the Millennium Development Goals (MDGs) established to solve important problems, which threat human dignity such as famine, absence of potable water, sanitation and electricity or even lack of habitable land. Despite all the effort put on MDGs, nowadays, some of the infamous problems and lack of basic needs still persist or have been aggravated in some regions experiencing extreme poverty and violence. Poverty has range both in concept and in reality (Mair et al. 2018): while some countries still experience extreme poverty, others, like Portugal, where homelessness remains a concern, general poverty is no longer associated with the lack of basic needs such as the access

to potable water, but rather linked to equal access to education, healthcare, income and general wellbeing conditions. Therefore, SDGs were defined globally, considering our planet the home for humanity, offering the appropriate conditions for the wellbeing and flourishing of societies, while assuming that the planet resources and ecosystems' preservation should guaranty the sustainability of Earth for future generations (United Nations General Assembly 2015). The UN Agenda is so inclusive that touches every country's ambition regarding sustainable development, however, each country's trajectory, efforts and targets are not necessarily similar, depending on its development level and pathway (Salvia et al. 2019).

Regarding the measure of SDGs, when considering the local scale, or the communities inserted in the municipality, some SDGI (SDG Indicators) may not apply because of territories' geographical conditions (absence of marine resources, for example), or may be extremely difficult to evaluate due to the lack of reliable and appropriate information from official databases. The sustainable development dimensions considered in the WeGIx are aligned with the seventeen SDGs but the process of variables selection took into consideration the development level of the country as well as data availability.

WeGIx period of analysis is from 2009 to 2017 and the study target area is Portugal (92,212 km^2) a country located on the south-eastern region of Europe. Portugal has two Atlantic archipelagos: Açores and Madeira and the mainland is part of the Iberian Peninsula. Considering the relative position to the Atlantic, four territory typologies are defined (Fig. 1): insular (N = 30) all the municipalities in Açores and Madeira

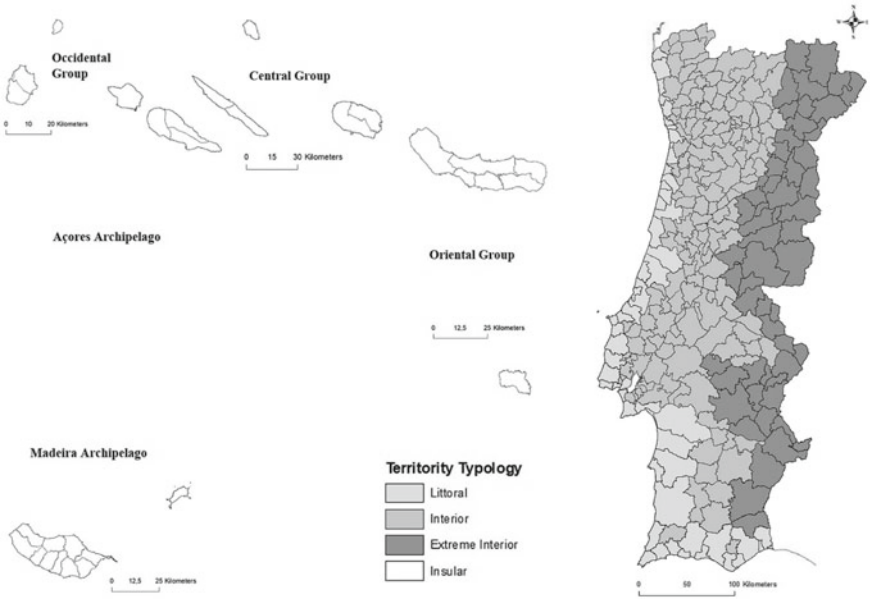

Fig. 1 Classification of Portuguese municipalities by territory typology

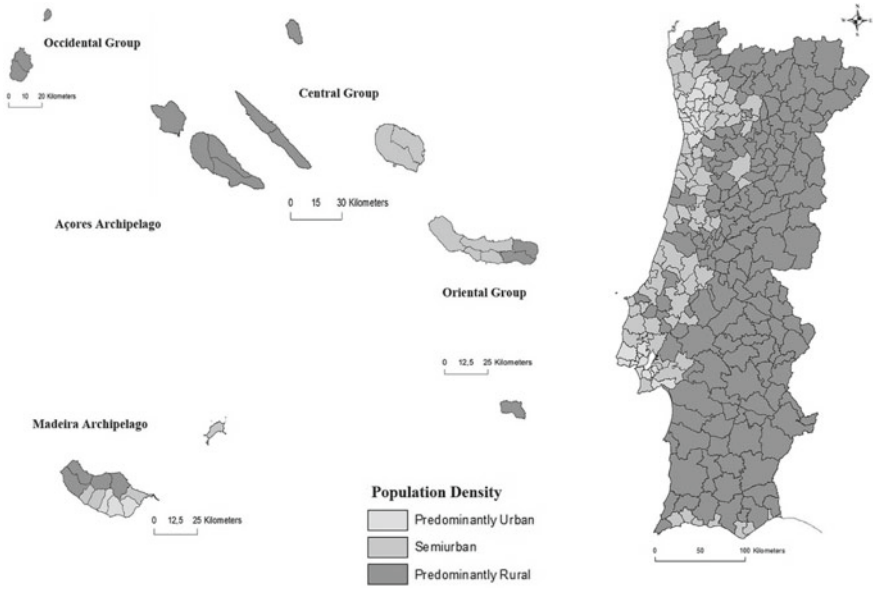

Fig. 2 Classification of Portuguese municipalities by population density according to INE (INE—Instituto Nacional de Estatística I.P. 2014)

archipelagos; littoral (N = 53) all municipalities by the sea; interior (N = 169) referring to municipalities without ocean coastline frontiers; and extreme interior (N = 56) corresponding to municipalities at the Portugal-Spain border or distant from the Atlantic.

According to the latest census (2011), the country registered a population of 10,557,560 inhabitants, distributed by 308 municipalities. The Portuguese National Statistics Institute (www.ine.pt) distinguishes between rural/urban territories using the following criteria (INE—Instituto Nacional de Estatística I.P. 2014): predominantly urban territory (N = 36) are characterized by population density higher than 500 inhabitants/km^2; semi-urban territories (N = 86) correspond to regions of 100–500 inhabitants/km^2 and predominantly rural territories (N = 186) have population density under 100 inhabitants/km^2. The cartographic representation of municipalities by territory typology according to these criteria is presented at Fig. 2. All cartographic representation was performed with ArcMap™.

2.1 WeGIx Variables Selection

An extensive exam of the SDG Indicators (Leadership Council of the Sustainable Development Solutions Network (SDSN) 2015) and the confirmation of the necessary correspondent data, at local level, in the official national databases was the

basis for selecting WeGIx variables. Official statistics data sources were used to construct a WeGIx specific database: INE—National Statistics Institute (www.ine.pt), PORDATA—Contemporary Portuguese Database (www.pordata.pt) and APA—Portuguese Environmental Agency (www.apambiente.pt). Collected information also came from the Natura 2000 network database provided by the European Commission Directorate-General for Environment (http://ec.europa.eu/environment/nature/natura2000/data/index_en.htm). There is a notorious shortage of updated official data concerning the Portuguese archipelagos of Açores and Madeira, which limits the selection of variables. Furthermore, some of SDGs could not be addressed at all, due to the complete lack of corresponding data: these are the cases of SDGs 2 and 12. Evaluating SDG 14 was not possible at the local scale as previously referred.

Besides the global and complementary SDGIs, other variables considered relevant to the Portuguese reality were included in the selection: "Area burnt by fires" is included because fires have been a significant problem in Portugal, causing death and destruction at levels that severely degrade life conditions. Additionally, fires have great impact in desertification, thus making it harder to achieve SDGs 13 and 15 (European Environment Agency 2017).

The environmental dimension is present in almost every SDG as the environment has impact in diversified domains of life (Leal Filho et al. 2018). The SDG 11 aims that, by 2030, cities and generally, all human settlements should become inclusive, secure, resilient and sustainable spaces. To pursue this goal, it is necessary to reorganize societies in several dimensions including industrial and infrastructures development and urban lifestyles related to daily consumptions and mobility. Excessive vertical urbanization, poor urban designs and the lack of green spaces, among others, define the environmental quality of cities by conditioning space, light and natural atmospheric air flows (Fontes et al. 2016) which affects air quality and threatens human health (Barreira et al. 2018). Moreover, intensive road traffic in cities is the main pollutants' source contributing to poor urban air quality. Housing barriers established due to deficient urban planning and road design often aggravate this situation. In Europe, it is acknowledged that the number of premature deaths from respiratory diseases, in urban populations, could be reduced if measures to limit emissions from vehicles were implemented (Anenberg et al. 2017). This is the reason for including "NO_X emissions", which main emission source is road traffic.

Urban sustainability and its related environmental dimension, has been at the centre of discussion at a national (Cavaco et al. 2015; Direção-Geral do Território 2018) and international plan (Deakin and Reid 2014; Mori and Christodoulou 2012; Science for Environment Policy—European Commission 2015; Yang et al. 2018). The global problems threatening sustainable development adopt special importance in urban spaces, because urban metabolism is deeply dependent on ecosystems and resource utilization (Science for Environment Policy—European Commission 2015). As more people are continuously moving to cities, they trend to grow in number and in population density and, consequently, infrastructure problems and socio-economic asymmetries tend to evolve in scale and in complexity. "Incinerators" and "Landfills" are associated to the urban metabolism and its infrastructures: these waste disposal and treatment facilities are vital, but tend to lie in cities suburbs, thus usually con-

tributing to air degradation by emitting pollutants. According to the World Bank (Kaza et al. 2018), waste management is an urban critical issue affecting the health of communities and the quality of life in cities, thus, "Incinerators" and "Landfills" were added to the variables set.

The initial forty-two variables selected for the WeGIx index, their database sources, and variables characteristics are presented in Table 1. A positive (+) or negative (−) character was attributed to each variable in accordance with the impact of that variable in population life conditions. As an example: the variable "Selective Urban Waste collection" was classified as positive because waste is duly separated by material type and then directed to reuse, to recycling facilities or to energy valorisation. On the contrary, the variable "Undifferentiated Urban Waste collection" contributes negatively to the environment, because urban waste is collected in the same container, without any material type differentiation, and then disposed in a landfill. All variables that concern consumption, such as water (19 WSC), electricity (21 DEC) and fuel (22 FUEL), have negative polarity because within the sustainable concept of development, consumption has to be penalized (Yang et al. 2018). Portugal has, for long, a complete territorial coverage of safe water and electricity supply, thus the approach to these variables must consider sustainable consumption rather than the supply of basic needs.

Most of the variables are of "output" type and a few of "process" type. Only the variables relating to investments (37 IWMM and 41 IPBL) are of "input" type.

To enable aggregation, a standardization process was applied to each variable: by the resident population in each municipality or by the geographical area of the correspondent municipality. Equations (1) and (2) translate these standardization steps. All data calculation was performed with Excel and statistic treatment was made using IBM® SPSS® Statistics vs. 24.0 software.

Standardization of variables by the resident population in a municipality i:

$$\boldsymbol{I_{i,j}} = \frac{\boldsymbol{v_{i,j}}}{\boldsymbol{P_i}};\ i \in [1, 308]; j \in [1, 42] \tag{1}$$

where:

$I_{i,j}$ is the standard value of a variable v_j for a municipality i
P_i is the resident population (number of inhabitants) in a municipality i
$v_{i,j}$ is the value of a variable v_j for a municipality i.

Standardization of variables by the geographical area of a municipality i:

$$\boldsymbol{I_{i,j}} = \frac{\boldsymbol{v_{i,j}}}{\boldsymbol{A_i}};\quad i \in [1, 308]; j \in [1, 42] \tag{2}$$

where:

$I_{i,j}$ is the standard value of a variable v_j for a municipality i
A_i is the geographical area (km^2) of a municipality i
$v_{i,j}$ is the value of a variable v_j for a municipality i.

Table 1 Variables selected to organize WeGIx

SDGs	WeGIx individual indicators (v_j)	Correspondence to UN SDGs Indicators	Link to cross-cutting SDGs issues	Time series available	Polarity
1	1. SSB: Social Security beneficiaries of Guaranteed Minimum Income and Social Integration Benefit	4	11	(2009–2017)	–
3	2. IMR: Infant mortality rate	17	1	(2009–2017)	–
	3. DC: Deaths by HIV and Tuberculosis	20; 21	1; 4; 8; 11	(2009–2016)	–
	4. DNC: Deaths by circulatory, cancer, diabetes and chronic respiratory diseases and suicide	23	11; 16	(2009–2016]	–
	5. DCA: Deaths by car accident	25	9; 11	(2009–2017)	–
	6. HP: Number of health care professionals	3.33		(2009–2017)	+
	7. H: Number of hospitals	3.29		(2009–2016)	+
	8. PHC: Number of primary health care centres	3.29		(2009–2012)	+
4	9. IP: Number of illiterate persons	4.5	1; 5	2001; 2011	–
	10. BE: Number of persons enrolled in basic education	33	5; 8	(2009–2017)	+
	11. PGS: Number of persons enrolled in pre-graduate studies	35	5; 8	(2009–2017)	+

(continued)

Table 1 (continued)

SDGs	WeGIx individual indicators (v_j)	Correspondence to UN SDGs Indicators	Link to cross-cutting SDGs issues	Time series available	Polarity
	12. HE: Number of persons in higher education	37	5; 8	(2009–2017)	+
	13. DR: Dropout rate (%)	4.3	1; 5; 8; 16	2001; 2011	–
	14. LLL: Number of persons in lifelong learning	4.6	1; 5; 8; 16	(2008–2017)	+
5	15. GGW: Gender gap in wages	5.1	8	(2009–2016)	–
	16. GGPP: Gender gap at professional position	5.2	8	(2009–2016)	–
6	17. PWSS: Population connected to public water supply systems (%)	45	1; 2; 3; 9; 11	2009	+
	18. PSS: Population connected to sewerage systems (%)	45	1; 2; 3; 9; 11	(2009–2016)	+
	19. WSC: Water supplied/consumed	46	1; 2; 3; 9; 11	(2009–2016)	–
	20. WQH: Water quality for human consumption (%)	46	1; 2; 3; 9; 11	(2009–2016)	+
7	21. DEC: Domestic electricity consumption	51	1; 3; 9; 11; 12	(2009–2016)	–
	22. FUEL: Consumption for motor fuel by inhabitant	7.1	1; 9; 11; 12; 13	(2009–2016)	–

(continued)

Table 1 (continued)

SDGs	WeGIx individual indicators (v_j)	Correspondence to UN SDGs Indicators	Link to cross-cutting SDGs issues	Time series available	Polarity
8	23. PIB: Purchasing power per capita	8.1	1; 11	2009; 2011; 2013; 2015	+
	24. IYP: Inactive young population (15–34 years)	8.8	1; 4; 11; 16	2001; 2011	–
	25. AMS: Average monthly salary	8.4	1	(2009–2016)	+
9	26. PWI: Number of persons working at industries	9.2	8	(2009–2016)	+
	27. IE: Number of industrial enterprises	9.2	8	(2009–2016)	+
11	28. NO_x: NO_x emissions	a	9; 11; 12; 13	2009; 2015	–
	29. PM_{10}: PM_{10} emissions and $PM_{2.5}$ emissions	69	9; 11; 12; 13	2009; 2015	–
	30. CO_2: CO_2 emissions	62	9; 11; 12; 13	2009; 2015	–
	31. BA: Burnt Area[a]	a	13; 15	(2009–2017)	–
	32. SUW: Selective urban waste collection	71	14	(2009–2016)	+
	33. UUW: Undifferentiated urban waste collection	71	14	(2009–2016)	–

(continued)

Table 1 (continued)

SDGs	WeGIx individual indicators (v_j)	Correspondence to UN SDGs Indicators	Link to cross-cutting SDGs issues	Time series available	Polarity
	34. I: Incinerators[a,b]	a	12	2016	–
	35. LF: Landfills[a,b]	a	6; 12	(2014–2016)	–
	36. PMOT: Area of land used for urban equipments and parks identified in the PMOT	70	13; 17	(2009–2013)	+
	37. IWMM: Investments on waste management of municipalities	71	14	(2009–2016)	+
	38. NCD: Non-conventional dwellings	66	1; 6; 7	2001; 2011	+
15	39. NATURA: Natura 2000 land area[a]	87		(2011–2016)	+
	40. RFF: Rural forest fires	83	2; 13	(2009–2017)	–
	41. IPBL: Investments on protection of biodiversity and landscapes of municipalities	a		(2009–2016)	+
16	42. CRIMES: Crimes Registered	88	3; 5; 11	(2009–2016)	–

[a]This indicator is not identified as SDG Indicator (Leadership Council of the Sustainable Development Solutions Network (SDSN) 2015)
[b]This indicator is not available in databases. Data was collected from technical reports (Agência Portuguesa do Ambiente I. P. 2015, 2018a, b)

Some variables' raw data are already standardised in their database formats, as is the case of variables expressed as "rate" such as "Infant mortality rate (2 IMR)" or "Dropout rate (13 DR)". For these situations, no standardization procedure was applied. Descriptive statistics of all individual indicators $\boldsymbol{I_{i,j}}$ in the period of observation are presented in Table 8 (Appendix).

2.2 WeGIx Model Construction and Validation

The normalization method adopted for WeGIx (Eq. 3) is of the type "Distance to a reference". For each year of analysis, the reference value for every standardised variable $\boldsymbol{I_{i,j}}$ is the correspondent national mean value AV_{jP} listed in Table 8 (Appendix).

Normalization by "Distance to a reference" method was used for all indicators:

$$\boldsymbol{NI_{i,j}} = \frac{\boldsymbol{I_{i,j}}}{\boldsymbol{AV_{j,P}}}; \quad i \in [1, 308]; j \in [1, 42] \tag{3}$$

where:

$I_{i,j}$ is the value of the standard individual indicator I_j for the municipality i in a certain year

AV_{jP} is the value of the indicator I_j for Portugal (mean value for the country) for a determined year

$NI_{i,j}$ is the normalized value of the indicator I_j for the municipality i.

With this normalisation procedure, for each of the forty-two individual indicators $NI_{Portugal,j} = 1$. For every municipality i, each $NI_{i,j}$ indicator is a relative value to the national reference that is always one for each year of analysis.

Interaction between all the individual indicators $NI_{i,j}$ was statistically tested and analysed, in order to build up a coherent composite model integrating just the necessary dimensions. *Spearman correlation test* was applied to verify the statistic dependence among normalised $NI_{i,j}$ indicators. For all comparative analyses, a confidence level of 95% or 99% ($\alpha = 0.05$; $\alpha = 0.01$) was used. Data distribution was analysed by *Kolmogorov-Simirnov test* but normality in data distribution was not verified. Some of the indicators (such as 21 DEC) showed skewness distributions. Nevertheless, parametric tests were still applied, because the condition N > 30 was verified for each group in analysis. *Spearman correlation test* reveals strong, moderate and weak associations between the indicators. Correlations above 0.9 and significant at 0.01 level are presented in Table 2. Table 9 (Appendix) lists only the correlations that can be consider moderate (> 0.5) and strong, all weak correlations were erased for easier reading. WeGIx indicators without at least one moderate correlation were also removed from Table 9.

The set of forty-two indicators chosen for the WeGIx model was tested using a factor analysis of exploratory type. Wellbeing is a very complex issue; thus, this analysis had the purpose of knowing data structure and interaction. *Kaiser Meyer-Olkin*

Table 2 *Spearman test* correlations (above > 0.9) between WeGIx indicators

Rho Spearman	6 HP	9 IP	10 BE	16 GGPP	21 DEC	22 FUEL	24 IYP	26 PWI	27 IE	28 NO_X	29 PM_{10}	33 UUW
6 HP												
9 IP												
10 BE												
11 PGS			0.969									
16 GGPP												
21 DEC	0.933			0.947								
22 FUEL												
24 IYP	0.956	0.906		0.929	0.951							
26 PWI				0.958	0.982	0.900						
27 IE								0.985				
28 NO_X												
29 PM_{10}										0.973		
30 CO_2										0.987	0.971	
33 UUW					0.961		0.917	0.943	0.955			
42 CRIMES	0.922			0.921	0.963		0.940	0.954	0.957			0.935

(KMO) sample adequacy measurement and *Bartlett Sphericity Test* were applied to evaluate the observed correlation coefficients. A KMO value of 0.935 was found, indicating an almost perfect sample adequacy (varying between 0 and 1, the closer KMO is to 1, the better the sample). *Bartlett's Test of Sphericity* returns a null significance value thus, rejecting the null hypothesis ($p < 0.05$) and confirming no relation between the set of variables. Additionally, the *Anti-Image Correlation Matrix* test was applied to determine variables suitability in the WeGIx model. Twelve indicators with values under 0.5 of *Measures of Sampling Adequacy* (*MSA*) were identified: 41 IPBL, 39 NATURA, 37 IWMM, 36 PMOT, 35 LF, 34 I, 31 BA, 20 WQH, 18 PSS, 17 PWSS, 15 GGW and 13 DR. In accordance, all these indicators were removed from the initial WeGIx set of variables. Table 3 presents the three components extracted by the factor analysis using eigenvalues higher than 1.0 as the extraction criterion. The three components of Table 3 explain 83.5% of the variance.

Component 1—"Urban Issues"—aggregates twenty-two variables from different dimensions that strongly contribute to WeGIx objectives, explaining 53.7% of data variability. This component includes important issues in urban areas, spaces where social and environmental problems are aggravated due to higher population density and consequently enhanced consumer behaviour and road traffic.

The second component extracted—"Emissions and Income"—explains 19.1% of data variance, suggesting that income and power purchasing growth relates to the increase in CO_2 and pollutants' emissions, revealing the direct relationship between income, general consumption and gaseous emissions.

Last component—"Accidents and Fires"—explains 10.1% of data variability, associating two apparently unlikely variables: 5 DCA and 40 RFF. One possible explanation may relate to the lack of infrastructures and geographical isolation of some rural or insular areas, characterized by limited transport accessibility due to large distances and to poor quality of roads' paving. These factors may contribute to the increasing number of deaths by car accidents because, in such geographic isolated regions, the extensive time needed to reach victims by emergency health assistance aggravates these situations and their outcomes (Vidal et al. 2018). On the other hand, rural forest fires also tend to occur in geographic isolated areas.

A simple linear additive method of aggregation was used to combine the final set of twenty-nine WeGIx indicators by addition of two arithmetic means of $NI_{i,j}$ indicators: twelve positive $NI^{+}_{p|i}$ and seventeen negative $NI^{-}_{n|i}$ indicators, for each municipality i, according to Eq. 4.

$$\boldsymbol{WeGIx_{|i}} = \frac{\sum_{p=1}^{12} \boldsymbol{NI^{+}_{p|i}}}{12} - \frac{\sum_{n=1}^{17} \boldsymbol{NI^{-}_{n|i}}}{17}; i \in [1, 308] \tag{4}$$

For each year of analysis, Portugal always has a reference value of zero $WeGIx_{|\text{Portugal}} = 0$ and the $WeGIx_{|i}$ value for each municipality i floats above or below. For a specific municipality i, if $WeGIx_{|i} > 0$ then, life conditions in that territory are better than the national average. On the other hand, if $WeGIx_{|i} < 0$ it means that the municipality life conditions are drifting from the SDGs when compared with the national mean value for a certain year.

Table 3 Factor analysis of WeGIx final set of twenty-nine indicators $NI_{i,j}$ grouped by their correlations

WeGIx indicators	I	II	III	Communalities
Urban issues (53.7%)				
1 SSB	0.655			0.746
3 DC	0.861			0.905
4 DNC	0.881			0.971
6 HP	0.929			0.939
7 H	0.854			0.775
8 PHC	0.885			0.857
9 IP	0.757			0.910
10 BE	0.790			0.963
11 PGS	0.865			0.954
12 HE	0.921			0.888
14 LLL	0.765			0.729
16 GGPP	0.825			0.947
19 WSC	0.799			0.851
21 DEC	0.780			0.947
22 FUEL	0.615			0.733
24 IYP	0.780			0.961
26 PWI	0.895			0.914
27 IE	0.874			0.980
33 UUW	0.770			0.903
32 SUW	0.790			0.841
38 NCD	0.826			0.857
42 CRIMES	0.889			0.970
Emissions and income (19.1%)				
23 PIB		0.651		0.679
30 CO_2		0.860		0.760
28 NO_X		0.867		0.847
29 PM_{10}		0.625		0.507
25 AMS		0.748		0.651
Accidents and fires (10.1%)				
5 DCA			0.513	0.459
40 RFF			0.869	0.772

Extraction method: principal components. Varimax rotation with Keiser Normalization. Extraction criterion: eigenvalues > 1. Total variance explained by extracted components: 83.5%; KMO = 0.935

3 The Outcomes of WeGIx Application to Portugal: Results Analysis

The best and worst ten scores for Portuguese municipalities are presented in Table 4. These results correspond to WeGIx calculation, according to Eq. 4, with the final set of twenty-nine indicators selected by the described Factor Analysis.

For the observed timeline, it is worth to mention that all the best-scored positions correspond to the largest cities in the country and that the worst scores are associated to urban densely populated areas or to rural industrialized areas. Table 5 presents results of *One-way ANOVA with post hoc Tukey HSD* (Honestly Significant Difference) to compare WeGIx scores by population density (according to Fig. 1), for years 2009, 2015 and present. Significant statistical differences were found for 2009 ($F = 3.8$; $p = 0.025$), revealing higher mean scores in predominantly urban areas compared to semi-urban and to predominantly rural regions. For the other time measures, no significant differences were found.

Another *One-way ANOVA with post hoc Tukey HSD* was performed to compare territory typologies according to Fig. 2 criterion. Within the timeline under analysis no significant statistical difference was found ($p > 0.05$), as is visible at Table 6.

Clusters' existence based on WeGIx scores was verified using a *K-Means Cluster Analysis* (Table 10—Appendix), revealing two groups in each year. Outliers were found associated with the lowest WeGIx scores means, which correspond to the higher populated municipalities in the country.

Another important reflection is to evaluate how the country's inequalities are evolving in time, as more population are associated to WeGIx scores below the national average. Table 7 exhibits the share of population whose municipalities are positioned above or below the reference value $WeGIx_{|\text{Portugal}} = 0$, for each period of analysis. At present, the scenario is worse than in 2009 (at the time the country was in financial crisis), now, almost two-thirds of the country population experiences life conditions below the national average. It is worth to remark that the WeGIx benchmark is the country itself, thus these results reflect a worsening of the country inequalities, unfolding a legitimate concern regarding the country's strategies and policies towards achieving the SDGs.

Figures 3 and 4 mirror the results of Table 7 for easier comprehension.

Table 4 Ten best and worst WeGIx scores considering the final set of twenty-nine indicators

	Municipality	Present		Variation 2015 to present		2015		Variation 2009–2015		2009	
		$WeGIx_i$	Rank	Value	Rank	$WeGIx_i$	Rank	Value	Rank	$WeGIx_i$	Rank
$WeGIx_i$ Best Scores	Lisboa	7.93	1	0.49	1	7.44	2	−0.33	7	7.77	2
	Porto	6.44	2	−1.45	10	7.89	1	−0.21	3	8.10	1
	Coimbra	3.34	3	0.13	4	3.21	3	−0.34	8	3.55	3
	Portimão	1.06	4	0.01	8	1.05	4	0.33	1	0.72	12
	Portalegre	0.86	5	0.22	2	0.64	7	−0.35	9	0.99	4
	Bragança	0.77	6	0.19	3	0.58	8	−0.39	10	0.97	5
	Vila Real	0.72	7	0.05	6	0.67	6	−0.22	4	0.89	6
	Braga	0.66	8	0.08	5	0.58	9	−0.29	6	0.87	7
	Viana do Castelo	0.50	9	−0.02	9	0.52	10	0.04	2	0.48	15
	Évora	0.49	10	0.03	7	0.46	13	−0.24	5	0.70	10
	$WeGIx_{\|Portugal}$	0.00				0.00				0.00	
$WeGIx_i$ Worst Scores	Funchal	−2.10	299	0.05	6	−2.15	299	1.79	3	−3.94	297
	Ílhavo	−2.16	300	0.03	7	−2.19	300	−1.52	6	−0.67	259
	Almada	−2.91	301	0.31	2	−3.22	301	−0.76	5	−2.46	294
	Estarreja	−3.66	302	0.00	8	−3.66	302	−3.40	9	−0.26	139
	São João da Madeira	−4.91	303	0.06	5	−4.97	303	28.98	1	−33.95	308
	Sines	−9.65	304	0.13	4	−9.78	304	−2.81	8	−6.97	302
	Matosinhos	−9.94	305	0.25	3	−10.19	305	−2.40	7	−7.79	304
	Odivelas	−10.65	306	−0.02	9	−11.63	306	6.58	2	−18.21	306
	Entroncamento	−15.05	307	−0.03	10	−15.02	307	−8.45	10	−6.57	301
	Amadora	−27.12	308	0.81	1	−27.93	308	−0.68	4	−27.25	307

Table 5 *One-way ANOVA with Tukey HSD* tests to compare WeGIx scores by territory population density

WeGIx	Descriptive statistics			*Tukey H.S.D.*				*One-way ANOVA*	
	Population density	N	Mean	Population density		Mean difference	*p*	F	*p*
2009	Predominantly urban	36	3.6	Predominantly urban	Semi-urban	3.4	**0.043**	3.8	**0.025**
	Semi-urban	86	0.3		Predominantly rural	3.5	**0.021**		
	Predominantly rural	186	0.2	Semi-urban	Predominantly rural	0.1	0.998		
2015	Predominantly urban	36	0.6	Predominantly urban	Semi-urban	0.8	0.446	0.8	0.448
	Semi-urban	86	−0.1		Predominantly rural	0.7	0.472		
	Predominantly rural	186	−0.0	Semi-urban	Predominantly rural	−0.1	0.975		
Present	Predominantly urban	36	0.6	Predominantly urban	Semi-urban	0.8	0.416		
	Semi-urban	86	−0.1		Predominantly rural	0.8	0.330	1.1	0.351
	Predominantly rural	186	−0.2	Semi-urban	Predominantly rural	0.0	0.998		

Note Statistically significant differences ($p < 0.05$) are marked in bold

Table 6 *One-way ANOVA with Tukey HSD* tests to compare WeGIx scores by territory typologies

WeGIx	Descriptive statistics			*Tukey H.S.D.*				*One-way ANOVA*	
	Territory typology	N	Mean	Territory typology		Mean Difference	*p*	F	*p*
2009	Littoral	53	1.5	Littoral	Interior	1.0	0.801	0.5	0.677
	Interior	169	0.5		Extreme interior	0.8	0.940		
	Extreme interior	56	0.7		Insular	1.9	0.639		
				Interior	Extreme interior	−0.2	0.997		
	Insular	30	−0.4		Insular	0.9	0.919		
				Extreme interior	Insular	1.1	0.895		
2015	Littoral	53	0.6	Littoral	Interior	0.7	0.495	0.7	0.539
	Interior	169	−0.1		Extreme interior	0.5	0.862		
	Extreme Interior	56	0.1		Insular	0.8	0.711		
				Interior	Extreme interior	−0.2	0.966		
	Insular	30	−0.2		Insular	0.1	1.0		
				Extreme interior	Insular	0.3	0.976		
Present	Littoral	53	0.6	Littoral	Interior	0.9	0.273	1.2	0.329
	Interior	169	−0.3		Extreme interior	0.6	0.699		
	Extreme interior	56	−0.0		Insular	0.9	0.559		
				Interior	Extreme interior	−0.2	0.960		
	Insular	30	−0.3		Insular	0.0	1.0		
				Extreme interior	Insular	0.3	0.978		

Table 7 Share (%) of population living above and under WeGIx reference value ($WeGIx_{|\text{Portugal}} = 0$). Corresponding number of municipalities in brackets

Time	$WeGIx_{\|i} > 0$	$WeGIx_{\|i} < 0$
2009	39.9% (N = 55)	60.1% (N = 253)
2015	36.8% (N = 54)	63.2% (N = 254)
Present	35.0% (N = 50)	65.0% (N = 258)

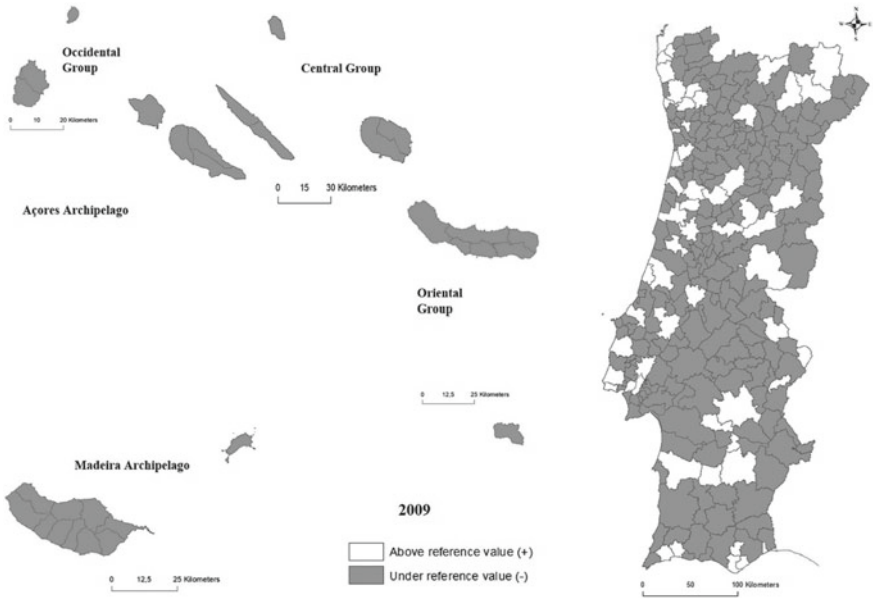

Fig. 3 Cartographic representation of WeGIx scores for the year 2009

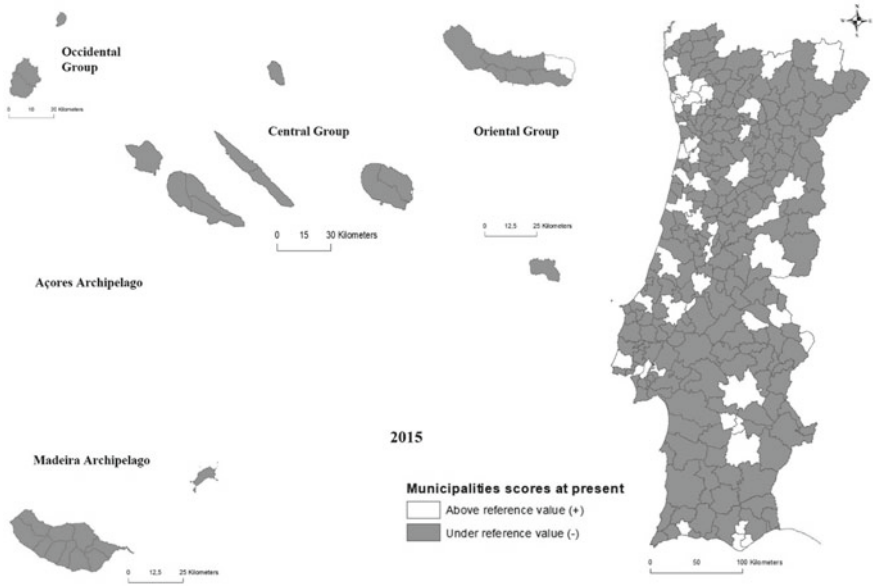

Fig. 4 Cartographic representation of WeGIx scores for the year 2015

4 Conclusions

WeGIx is tailored designed for Portugal, however it is quite an ambitious endeavour, even for a country small in territory and in population, but with a considerable geographic diversity either on the mainland and the archipelagos. This diversity is clearly translated by the variability of the individual indicators' values (Table 8—Appendix) and by WeGIx scores, of which a sample is presented in Table 4.

4.1 The Benefits and Limitations of WeGIx

The most limiting difficulty in WeGIx construction is the scarcity of updated official data in national databases, especially concerning the archipelagos of Açores and Madeira. For these regions, data related to forest fires (40 RFF) and to health care infrastructures services (7 H, 8 PHC) is not available. Açores archipelago population still suffers from lack of specialized health care services, such as oncology treatments, which forces patients to move to the country capital for treatment. This is also a marked inequality within the country (SDG 10): some regions of the archipelagos still suffer from the consequences of geographical isolation, mirrored in the absence of statistical data (Vidal et al. 2018).

Another data limitation concerns pollutants emissions, which are vital parameters to evaluate air quality, and therefore the wellbeing conditions: as listed in Table 1, official data is absent, except for 2009 and 2015. WeGIx periodicity of calculation is also restrained by variables availability in time. Data availability limitation is the cause of a certain unbalance among SDGI: for some dimensions such as "education" or "health" there is substantial information while for others, such as SDG 2, official statistics were not found. Scarcity of official data is, however, a restriction of extrinsic cause to the WeGIx concept.

One of the index strengths, common in composite indices, is the simplicity of providing a single score to rank a municipality, although it addresses the complex multidimensional nature of sustainable development. The cartographic representation of WeGIx scores translates, in an even easier way, these results: the country is evolving at different velocities with the majority (65%) of the population living under the average national reference level.

An abridged SWOT analysis of WeGIx is presented in Fig. 5.

WeGIx aims to be useful as a simple communication tool to inform the status of Portuguese populations' life conditions within the context of the SDGs and the UN 2030 Agenda, thus there is no presumption to replace any other existing index. WeGIx enables the ranking of all municipalities, in a relative position to the national average and allows the identification of each region's strengths and weakness within the index dimensions. This simple and easily understandable measure of a region status, calculated for each year of analysis, keeps track of public policies in a prompt way, eventually assisting local government stakeholders' decisions. The value and

Strengths	Weakness
▪ Simplicity of a single score outcome ▪ Tailored designed for Portugal ▪ Focused on local communities and territories ▪ Based only on credible data sources (the national statistical office) ▪ Adaptable to other regional scales ▪ Easy reading graphical presentation	▪ Does not cover all SDGs ▪ Unbalance of individual indicators ▪ Variables selection dependent on data availability ▪ Poor punctuality of some data: time lag over 7 years ▪ Allows only comparative analysis
Opportunities	**Threats**
▪ Allows the follow-up of local interventions and plans at a year basis ▪ Shows the need to improve data collection and management	▪ WeGIx is one more in a myriad of indices ▪ May be replaceable by other local indexes ▪ Being used for political action instead of serving for information

Fig. 5 SWOT analysis of WeGIx

importance of the detail included in common assessment reports (environmental or other type) are unquestionable but, these evaluations, due to their nature, are resource and time consuming, even though, they are seldom applied and used with the needed periodicity. Within this scope, the yearly WeGIx may provide useful information to monitor the implementation of the UN 2030 Agenda at the local level.

4.2 Final Comments

This work proposes a composite index—WeGIx as tool to measure the sustainable development inequalities in a country and within the framework of the UN 2030 Agenda taking Portugal as a case study. WeGIx was tailored designed for Portugal, an EU member, a small country, predominantly rural but rather diverse in geographic, cultural and even economic characteristics, that has experienced a deep financial crisis. The methodology for WeGIx construction is explained step by step and the final model applied to the country, revealing that, at present, 65% of the population lives below the national average of life conditions. In the observation period, the country asymmetries were accentuated, drifting from the SDG 10.

These WeGIx outcomes are in contrast with results from the Portuguese Wellbeing Index (*Índice de Bem-estar IBE-INE*) created by the National Statistics Institute (INE—Instituto Nacional de Estatística I.P. 2017) covering a time period from 2004 to 2016. IBE-INE comprises seventy-nine indicators, takes the year 2004 as the reference value of 100 and refers to the country global statistics, not detailing at the local level. Although not comparable with WeGIx because of the index concept and model, IBE shows that the country has been in a positive evolution from 2009 to 2016,

in the "Quality of Life" domain comprising health, work-life balance, education, social relations and subjective wellbeing, civic engagement and governance, personal security and environment. On the other domain evaluated by IBE—"Material Life Conditions" aggregating: economic wellbeing, economic vulnerability, work and salary—, the slowdown is notorious, but with a recovery phase started in 2015. The message IBE promotes is quite different from the WeGIx, but the comparison of the two indexes' results should not be interpreted as a contradiction because the two indexes address different variables at different scales. However, the reality in analysis is the same: the Portuguese population. WeGIx focus on local communities' characteristics within the framework of the SDGs, taking the country as reference, while IBE analyses the national reality in a broader scope of wellbeing, but without taking into account that Portugal is not a homogenous country.

Notwithstanding the fact that Portugal is small and mainly rural, the country considerable diversity becomes clear through WeGIx results. The design of governance strategies and public policies should express, enhance and strengthen this diversity and, most important, should not be the cause of inequalities reproduction nor an opportunity for asymmetries worsening. The value of WeGIx should be considered in this context: the objective measurement of life conditions at a local scale.

WeGIx results unveiling a sharpening of sustainable life conditions inequalities in the country stress the importance of adopting tools to monitor the implementation of the UN 2030 Agenda at a local level. One significant structural gap found in this work was the lack of sufficient and updated data in the national official statistical databases. In order to set monitoring tools to follow up the UN 2030 Agenda for Sustainable Development implementation in an adequate manner, there is a need to integrate different databases of governmental origin. Furthermore, considering that academic databases are reliable and credible sources, these should also be integrated in the official statistical system to enhance monitoring and report capacity.

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Appendix

See Tables 8, 9 and 10.

Table 8 Descriptive statistics of WeGIx forty-two indicators

Indicators $I_{i,j}$(units)	Mean Portugal indicator $AV_{jP} \pm$ Std. deviation			Range (Min–Max)		
	2009	2015	Present	2009	2015	Present
1. SSB (no. persons/inhabitants)	$4.5 \times 10^{-2} \pm 2.8 \times 10^{-2}$	$2.8 \times 10^{-2} \pm 2.3 \times 10^{-2}$	$2.9 \times 10^{-2} \pm 2.3 \times 10^{-2}$	6.77×10^{-3}–0.174	0.00–0.180	0.003–0.196
2. IMR (no. infant deaths/1000 births)	4.27 ± 1.11	3.29 ± 8.03	2.62 ± 6.60	0.00–125	0.00–71.4	0.00–66.7
3. DC (no. deaths/inhabitants)	$4.7 \times 10^{-5} \pm 8.1 \times 10^{-5}$	$4.3 \times 10^{-5} \pm 6.1 \times 10^{-5}$	$3.7 \times 10^{-5} \pm 5.8 \times 10^{-5}$	0.00–9.85×10^{-4}	0.00–3.33×10^{-4}	0.00–4.24×10^{-4}
4. DNC (no. deaths/inhabitants)	$8.9 \times 10^{-3} \pm 2.9 \times 10^{-3}$	$1.0 \times 10^{-2} \pm 2.7 \times 10^{-3}$	$9.5 \times 10^{-3} \pm .4 \times 10^{-3}$	4.05×10^{-3}–2.16×10^{-2}	0.00–2.00×10^{-2}	0.00–2.69×10^{-2}
5. DCA (no. deaths/inhabitants)	$9.6 \times 10^{-5} \pm 1.3 \times 10^{-4}$	$6.7 \times 10^{-5} \pm 1.1 \times 10^{-4}$	$7.5 \times 10^{-5} \pm 1.1 \times 10^{-4}$	0.00–7.22×10^{-4}	0.00–9.08×10^{-4}	0.00–1.05×10^{-3}
6. HP (no. professionals/ inhabitants)	$6.6 \times 10^{-3} \pm 5.3 \times 10^{-3}$	$9.4 \times 10^{-3} \pm 6.6 \times 10^{-3}$	$5.6 \times 10^{-3} \pm 9.8 \times 10^{-3}$	1.82×10^{-3}–5.23×10^{-2}	0.00–6.00×10^{-2}	0.00–7.00×10^{-2}
7. H (no. facilities/km^2)	$1.9 \times 10^{-3} \pm 1.2 \times 10^{-2}$	$3.0 \times 10^{-3} \pm 1.6 \times 10^{-2}$	$2.6 \times 10^{-3} \pm 1.5 \times 10^{-2}$	0.00–0.169	0.00–0.169	0.00–0.150
8. PHC (no. facilities/km^2)	$8.5 \times 10^{-3} \pm 1.9 \times 10^{-2}$	$8.4 \times 10^{-3} \pm 1.9 \times 10^{-2}$	$8.5 \times 10^{-3} \pm 1.9 \times 10^{-2}$	0.00–0.170	0.00–0.170	0.00–0.170
9. IP (no. persons/inhabitants)	$1.3 \times 10^{-1} \pm 6.1 \times 10^{-2}$	$7.9 \times 10^{-2} \pm 4.0 \times 10^{-2}$	$7.9 \times 10^{-2} \pm 4.0 \times 10^{-2}$	3.23×10^{-2}–0.351	0.02–0.220	0.02–0.220
10. BE (no. persons/inhabitants)	0.121 ± 0.05	0.115 ± 0.02	0.104 ± 0.02	0.00–0.225	0.06–0.200	0.100–0.200

(continued)

Table 8 (continued)

Indicators $I_{i,j}$(units)	Mean Portugal indicator $AV_{jP} \pm$ Std. deviation			Range (Min–Max)		
	2009	2015	Present	2009	2015	Present
11. PGS (no. persons/inhabitants)	$3.6 \times 10^{-2} \pm 2.4 \times 10^{-2}$	$3.0 \times 10^{-2} \pm 1.7 \times 10^{-2}$	$3.0 \times 10^{-2} \pm 1.7 \times 10^{-2}$	0.00–0.121	0.00–0.110	0.00–0.099
12. HE (no. persons/inhabitants)	$1.0 \times 10^{-2} \pm 3.2 \times 10^{-2}$	$9.1 \times 10^{-3} \pm 3.2 \times 10^{-2}$	$9.7 \times 10^{-3} \pm 3.3 \times 10^{-2}$	0.00–0.233	0.00–0.260	0.00–0.260
13. DR[a] (%)	1.74 ± 0.82	1.74 ± 0.82	1.74 ± 0.82	0.00–4.97	0.00–4.97	0.00–4.97
14. LLL (no. persons/inhabitants)	$7.7 \times 10^{-3} \pm 8.8 \times 10^{-3}$	$3.2 \times 10^{-3} \pm 3.8 \times 10^{-3}$	$3.1 \times 10^{-3} \pm 3.8 \times 10^{-3}$	$0.00–6.72 \times 10^{-2}$	$0.00–1.70 \times 10^{-2}$	$0.00–2.58 \times 10^{-2}$
15. GGW (€/inhabitant)	$1.8 \times 10^{-2} \pm 4.3 \times 10^{-2}$	$1.6 \times 10^{-2} \pm 2.4 \times 10^{-2}$	$1.8 \times 10^{-2} \pm 4.3 \times 10^{-2}$	-5.0×10^{-3}–0.668	-1.7×10^{-2}–0.179	-1.5×10^{-2}–0.631
16. GGPP (no. persons/inhabitants)	$7.6 \times 10^{-3} \pm 3.2 \times 10^{-3}$	$5.9 \times 10^{-3} \pm 2.8 \times 10^{-3}$	$6.0 \times 10^{-3} \pm 2.6 \times 10^{-3}$	$0.00–1.98 \times 10^{-2}$	-1.0×10^{-3}–1.50×10^{-2}	-1.8×10^{-3}–1.4×10^{-2}
17. PWSS (%)	73.9 ± 40.3	73.9 ± 40.3	73.9 ± 40.3	0.00–100	0.00–100	0.00–100
18. PSS (%)	61.6 ± 38.3	72.7 ± 28.2	70.4 ± 30.8	0.00–100	0.00–100	0.00–100
19. WSC (m^3/inhabitant)	$5.0 \times 10^{-2} \pm 4.0 \times 10^{-2}$	$4.7 \times 10^{-2} \pm 2.9 \times 10^{-2}$	$4.7 \times 10^{-2} \pm 2.9 \times 10^{-2}$	0.00–0.242	0.00–0.202	0.00–0.202
20. WQH (%)	93.5 ± 20.5	89.3 ± 29.4	89.4 ± 29.4	0.00–100	0.00–100	0.00–100
21. DEC (kWh/inhabitant)	1260 ± 310	1150 ± 231	1300 ± 357	830–3100	788–2620	804–4150
22. FUEL (TPE/inhabitant)	0.577 ± 0.907	0.575 ± 0.950	0.554 ± 0.918	0.00–13.6	0.00–13.2	0.00–13.6
23. PIB (€/inhabitant)	75.7 ± 24.0	80.3 ± 18.4	80.3 ± 18.4	47.4–233	55.8–215	55.8–215

(continued)

Table 8 (continued)

Indicators $I_{i,j}$(units)	Mean Portugal indicator $AV_{jP} \pm$ Std. deviation			Range (Min–Max)		
	2009	2015	Present	2009	2015	Present
24. IYP[a] (no. persons/inhabitants)	$9.3 \times 10^{-2} \pm 1.8 \times 10^{-2}$	$8.3 \times 10^{-2} \pm 1.3 \times 10^{-2}$	$8.3 \times 10^{-2} \pm 1.3 \times 10^{-2}$	5.2×10^{-2}–0.145	5.0×10^{-2}–0.131	5.0×10^{-2}–0.131
25. AMS (€/inhabitant)	708 ± 110	749 ± 119	762 ± 130	559–1450	608–1600	618–2060
26. PWI (no. persons/inhabitants)	0.269 ± 0.106	0.269 ± 0.093	0.281 ± 0.097	0.118–1.07	0.120–1.11	0.125–1.16
27. IE (no. facilities/km^2)	32.7 ± 104	30.8 ± 94.6	28.8 ± 82.0	1.00–1060	1.00–994	1.00–919
28. NO_x (ton/km^2)	5.21 ± 13.1	3.78 ± 9.90	3.78 ± 9.90	0.22–133	0.07–95.4	0.07–95.4
29. PM_{10} (ton/km^2)	2.54 ± 7.35	1.31 ± 3.21	1.31 ± 3.21	0.08–67.1	0.02–24.6	0.02–24.6
30. CO_2 (ton/km^2)	1183 ± 3826	1065 ± 4133	1065 ± 4133	21.0–5.04×10^4	0.00–6.22×10^4	0.00–6.22×10^4
31. BA (ha/km^2)	1.14 ± 2.59	0.837 ± 1.93	6.72 ± 14.5	0.00–27.5	0.00–184	0.00–78.0
32. SUW (ton/inhabitant)	$5.3 \times 10^{-2} \pm 4.8 \times 10^{-2}$	$5.7 \times 10^{-2} \pm 4.8 \times 10^{-2}$	$6.9 \times 10^{-2} \pm 5.9 \times 10^{-2}$	0.00–0.254	0.00–0.320	0.00–0.419
33. UUW (ton/inhabitant)	0.435 ± 0.142	0.390 ± 0.105	0.149 ± 0.357	0.00–1.11	0.00–1.04	0.00–1.00
34. I (no. facilities/km^2)	$1.6 \times 10^{-2} \pm 1.5 \times 10^{-3}$	$1.6 \times 10^{-4} \pm 1.5 \times 10^{-3}$	$1.6 \times 10^{-4} \pm 1.5 \times 10^{-3}$	0.00–1.85×10^{-2}	0.00–2.00×10^{-2}	0.00–2.00×10^{-2}
35. LF (no. facilities/km^2)	$6.3 \times 10^{-4} \pm 2.3 \times 10^{-3}$	$6.3 \times 10^{-4} \pm 2.3 \times 10^{-3}$	$6.3 \times 10^{-4} \pm 2.3 \times 10^{-3}$	0.00–2.08×10^{-2}	0.00–2.08×10^{-2}	0.00–2.08×10^{-2}

(continued)

Table 8 (continued)

Indicators $I_{i,j}$(units)	Mean Portugal indicator $AV_{jP} \pm$ Std. deviation			Range (Min–Max)		
	2009	2015	Present	2009	2015	Present
36. PMOT (ha/km^2)	3.03 ± 18.8	3.15 ± 19.5	3.12 ± 19.5	0.00–298	0.00–299	0.00–299
37 IWMM (€/inhabitant)	$2.4 \times 10^{-3} \pm 5.5 \times 10^{-3}$	$1.9 \times 10^{-3} \pm 1.6 \times 10^{-2}$	$9.0 \times 10^{-4} \pm 3.2 \times 10^{-3}$	0.00–4.04×10^{-2}	0.00–0.270	0.00–3.32×10^{-2}
38. NCD[a] (no. NCD/km^2)	0.991 ± 4.60	0.991 ± 4.60	0.991 ± 4.60	0.00–60.5	0.00–60.5	0.00–60.5
39. NATURA (ha/km^2)	18.5 ± 25.2	18.5 ± 25.2	18.5 ± 25.2	0.00–179	0.00–179	0.00–179
40. RFF (No. events/km^2)	0.570 ± 1.03	0.377 ± 0.604	0.381 ± 0.573	0.00–7.85	0.00–3.73	0.00–3.78
41. IPBL (€/inhabitant)	$3.2 \times 10^{-3} \pm 2.4 \times 10^{-2}$	$2.1 \times 10^{-3} \pm 1.1 \times 10^{-2}$	$9.0 \times 10^{-4} \pm 3.2 \times 10^{-3}$	0.00–0.390	0.00–0.140	0.00–3.32×10^{-2}
42. CRIMES (no. records/inhabitants)	$3.2 \times 10^{-2} \pm 1.3 \times 10^{-2}$	$2.9 \times 10^{-2} \pm 1.0 \times 10^{-2}$	$2.9 \times 10^{-2} \pm 1.0 \times 10^{-2}$	6.85×10^{-3}–0.123	1.00×10^{-2}–9.00×10^{-2}	1.00×10^{-2}–9.00×10^{-2}

[a]Indicator only available by Census

TPE Tonnes of Petroleum Equivalent. Common unit to express energy quantities: 1TPE = 41,868 million joules. (41.9×10^9 J)

Table 9 *Spearman correlation test* applied to WeGIx initial set of forty-two indicators. Only correlations > 0.5 are presented

INDICATORS	DC	DNC	HP	DCA	H	IP	BE	PGS	HE	LLL	GGPP	WSC	DEC	FUEL	PIB	IYP	CO_2	NO_X	PM_{10}	PWI	IE	AMS	UUW	SUW	NCD	CRIMES	RF
1 SSB	0.676	0.615	0.843	0.512		0.802	0.741	0.724	0.547	0.648	0.781	0.556	0.835	0.778	0.538	0.884	0.629	0.629	0.633	0.834	0.840		0.839	0.710	0.789	0.831	
3 DC		0.585	0.691	0.517	0.513	0.696	0.673	0.658		0.560	0.689	0.538	0.735	0.664	0.542	0.703	0.540	0.536	0.538	0.719	0.739		0.723	0.643	0.689	0.722	
4 DNC			0.624	0.545		0.665	0.590	0.589		0.546	0.628	0.524	0.677	0.643	0.556	0.644				0.662	0.685		0.662	0.599	0.651	0.653	
6 HP				0.600	0.579	0.848	0.831	0.828	0.642	0.729	0.896	0.642	**0.933**	0.843	0.629	**0.956**	0.685	0.682	0.682	0.925	0.939	0.499	0.902	0.758	0.840	**0.922**	0.566
5 DCA						0.662	0.719	0.700		0.634	0.657	0.583	0.671	0.642	0.504	0.615				0.674	0.674		0.633	0.569	0.588	0.638	
7 H						0.530	0.551	0.567	0.583	0.522	0.524		0.542	0.523		0.550				0.530	0.551		0.531		0.511	0.526	
8 PHC							0.658	0.644		0.599		0.574															0.510
9 IP							0.792	0.786	0.579	0.707	0.844	0.654	0.872	0.795		**0.906**	0.511	0.501	0.503	0.840	0.863		0.830	0.728	0.775	0.843	0.622
10 BE								**0.969**	0.530	0.859	0.877	0.779	0.885	0.782	0.564	0.849	0.600	0.605	0.629	0.881	0.881		0.818	0.714	0.781	0.840	0.708
11 PGS									0.561	0.880	0.844	0.765	0.854	0.759	0.565	0.834	0.545	0.547	0.577	0.848	0.855		0.787	0.684	0.748	0.804	0.677
12 HE										0.546	0.561		0.589	0.525	0.506	0.601				0.576	0.592		0.563		0.551	0.585	
14 LLL											0.731	0.660	0.739	0.645		0.737				0.729	0.732		0.681	0.594	0.650	0.693	0.637
15 GGW															0.592							0.751					
16 GGPP												0.672	**0.947**	0.859	0.595	**0.929**	0.741	0.727	0.744	**0.958**	**0.943**		0.890	0.789	0.820	**0.921**	0.568
17 PWSS												0.529															
18 PSS												0.523															
19 WSC													0.710	0.640	0.542	0.642				0.689	0.703		0.653	0.605	0.648	0.656	
21 DEC														0.893	0.698	**0.951**	0.722	0.711	0.722	**0.982**	**0.989**	0.557	**0.961**	0.853	0.879	**0.963**	0.539
22 FUEL															0.712	0.867	0.685	0.668	0.676	**0.905**	**0.900**	0.581	0.876	0.772	0.815	0.875	
23 PIB																0.566	0.511		0.532	0.702	0.707	0.765	0.716	0.658	0.669	0.652	
24 IYP																	0.728	0.724	0.722	0.943	0.951		**0.917**	0.770	0.854	**0.940**	0.604
30 CO_2																		**0.987**	**0.971**	0.760	0.715	0.504	0.701	0.619	0.661	0.764	
28 NO_X																			**0.973**	0.749	0.706		0.693	0.596	0.656	0.759	
29 PM_{10}																				0.761	0.715	0.518	0.699	0.620	0.674	0.756	
26 PWI																					**0.985**	0.570	**0.943**	0.829	0.865	**0.954**	0.523
27 IE																						0.553	**0.955**	0.832	0.874	**0.957**	0.531
25 AMS																							0.577	0.513	0.563	0.534	
31 BA																											0.797
33 UUW																								0.873	0.869	**0.935**	
32 SUW																									0.770	0.814	
38 NCD																										0.870	
42 CRIMES																											0.554

Table 10 K-Means Cluster analysis of WeGIx scores mean with the final set of twenty-nine indicators

Time	Cluster	N (no. municipalities)	Mean ± Std.D
2009	1	297	−0.2 ± 0.9
	2	9	−8.4 ± 4.2
	Outliers	2	−30.6 ± 4.7
	Total	308	−0.7 ± 3.0
2015	1	303	−0.3 ± 0.9
	2	4	−11.6 ± 2.4
	Outlier	1	−27.9
	Total	308	−0.5 ± 2.2
Present	1	302	−0.3 ± 0.8
	2	4	−8.8 ± 2.6
	Outliers	2	−21.1 ± 8.5
	Total	308	−0.5 ± 0.1

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Sustainable Behavior and Its Antecedents: A Systematic Literature Review

Aline Alvares Melo, Ubiratã Tortato and Fabrício Baron Mussi

Abstract The demand for organizations to assume greater environmental responsibility has increased in recent years. This demand comes from different segments: clients, suppliers, governments, and the general public. However, many organizations face challenges with the human resources needed to implement environmental initiatives, making it necessary to understand which factors can positively influence the sustainable behavior of those involved in the process. In this perspective, this study aims to raise the theoretical references available on the theme of sustainable behavior of individuals, to better understand the precedents. Techniques of systematization of literature review were used next to the searches made in two scientific databases: *Web of Science* and *Scopus*. Upon all the selections made using filters, the search returned 34 articles, published between 2008 and 2017, which were subsequently analyzed so as to identify similarities and major differences between them. It was found that most studies rely on a psychological perspective to understand the precedents of sustainable behavior. Besides that, values, beliefs, and worldviews are still perceived as the main influencers.

Keywords Sustainable behavior · Antecedents · Implement of environmental initiatives

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1 Introduction

The issue of sustainability has been increasingly debated by society in general, mainly because there seems to be a consensus that the climate on the planet is changing and that therefore something else needs to change as well. However, the results are still not as noticeable in regard to people's behavior. Sustainable behavior has costs, and not always people are willing to pay them, or know how to. According to Juárez-Nájera et al. (2010, p. 2), sustainable behavior can be understood as:

> a set of effective, deliberate, and anticipated actions accepting the responsibility for the conservation and preservation of physical and cultural resources. These resources include the integrity of animal and plant species, as much as individual and social well-being, and safety of present and future human generations.

In this sense, this study aims to raise the theoretical references on the subject of sustainable behavior of individuals to understand their antecedents. The importance of this theme resides on the fact that, in addition to people being the driving force in actions and programs that envisage results favorable to sustainability, questions about what leads an individual to engage in such initiatives remain obscure. A better understanding of this subject can help in the elaboration of policies and in the operation of sustainable actions and programs, taking into account the antecedents of the sustainable behavior which, after all, is expected of individuals. This behavior in turn will lead to the success of said actions and programs, and to the change of routine habits, leading the way to more effective and long-lasting outcomes, as in the case of sustainable consumption.

To this end, this study analyzed 34 scientific articles, using the systematic review of literature techniques, and went through several stages of selection of articles, originating from two scientific databases: *Web of Science* and *Scopus*. The articles analysed were published between 2008 and 2017. The analysis is followed by the presentation of the theoretical references used, the methodological procedures, the findings, and their final discussion.

2 Theoretical References

The main areas of knowledge so far devoted to studying human behavior in relation to sustainability are economics and psychology. While economics argues that individuals opt (in a rational way) for cooperating for sustainable ends according to their own interests (that is, depending on the personal return that such decision might bring them in the future, which does not necessarily refer to financial returns, but may be connected to prestige, or social approval to which that individual feels entitled), psychology has been concerned with relating the psychological variables with

sustainable behavior, arguing that the individual can present sustainable behavior as long as they have values and beliefs that collaborate. Meanwhile, even psychology, which defends the need of values and beliefs as the antecedents of referred behavior, argues that for it to occur some requirements are made necessary (Juárez-Nájera et al. 2010).

The Norm-Activation Model, one of the most accepted theories to explain this type of behavior, relates 2 necessary requirements: an individual's awareness of the consequences of their actions (emphasizing that their actions can directly affect the well-being of other individuals), and the awareness of their responsibility in acting. These two requirements activate kept personal moral norms, and as a consequence, sustainable behavior is likely to occur. The awareness present in the cited requirements is formed from the process of acculturation of an individual, and the experiences the individual has as they get through life.

In general, the importance of raising awareness on the benefits of implementing sustainability refers to the idea that the internalization of community norms makes the need of vigilance by authorities and/or managers to be minimal, and so individuals tend to feel less coerced. Juárez-Nájera et al. (2010, p. 6) emphasize the importance of this process by arguing that in addition to a unilateral educational process, this makes the process more participatory, and thus the acceptance of people is greater in relation to their responsibilities and their expectations that positive outcomes may be greater:

> People internalize the group's norms because they have participated in their creation, saw the value to them and their community, and because the norms have become part of the meaning of community, hence sharing with others helps maintain trusted relationships.

Another factor that shows a direct impact on the individual's ability to carry out a course of action is Bandura's (1999) concept o self-efficacy, according to which the individual forms a conviction about their ability to mobilize all possible (cognitive and material) resources to reach a determined goal. The success of this mobilization depends then on the specificity of the task to be undertaken and the context in which it occurs. Therefore, the belief of efficacy on the part of the individual can be developed because it is contextualized. The notion that it is impossible to accomplish a task, or that it shows a small probability of success, can negatively impact one's actions and generate a great repercussion in the processes of implementation of sustainability programs (Meijers and Stapel 2011).

3 Method and Materials

3.1 Scientific Literature Review

Considering that the main objective of this project was to carry out a broad theoretical review of the theme of commitment of higher education institutions' stakeholders with sustainability, the first four months were used to collect bibliography to this end.

As this analysis has the purpose of, among others, finding gaps in the literature and to propose new theoretical contributions for the future, it was decided to determine what type of materials to be used and that these would be scientific articles, once this type of materials is usually more specific and up-to-date. Thus the research was carried out on the following scientific databases: *Web of Science—Social Sciences Citation Index* (*WoS-SSCI*) and *Scopus*. The choice of such databases was due to their coverage of peer-reviewed journals, and their wide acceptance in the scientific milieu.

In keywords used to perform the searches were: *sustainable* behavior* (and) *psychological**, which were collated from the topics of articles (including their titles, abstracts, and keywords). These terms were selected due to the extent to which they select the literature on the subject, and the symbol (*) was used after the term *sustainable*, so that it could search for, besides the exact word, also its possible variations.

One of the main difficulties to accomplish the task at hand was the excess of articles found in the databases under each chosen keyword, what was already expected given the comprehensiveness of the theme. Thus, it was necessary to further filter them in order to arrive to a more reasonable number of documents for the proposed analysis. As regards the period stipulated for the research of the literature on the subject under analysis, it was decided to limit it to a period of 10 (ten) years, from 2008 to 2017. In addition, it was also decided to filter materials published in journals in the business area.

Three hundred and fourty one (341) articles were initially found in the *Web of Science* citation index, and seven hundred and fourty five (745) in the *Scopus* database. The 2 chosen filters used in the scientific databases were: the categories related to social sciences and business (and only articles were selected), upon the use of which one hundred and sixty eight (168) articles were obtained in the first database, and two hundred and ninety six (296) in the second one. Additional filtering was performed to eliminate duplications and JCR from journals, which were selected by having a JCR greater than 1.3 in order to prioritize articles from high impact and good reputation journals and subsidize the current study with considered high quality research. Beside a high JCR, the journals needed to have an H-index value greater than 24, all of them therefore located in the Q1 *qualis*.

Table 1 Results of the systematic literature selection process

Scientific databases	We-of-Science	Scopus	Total accepted
Seleção inicial	341	745	1.086
After filters used in the extraction	168	296	464
Databases	23	11	34

Source The author

After these steps we proceeded to the collection of data and coding phase, in order to be sure that the materials that really mattered to the research would be used, further determining the final quantity of articles used.

3.2 Extraction and Analysis of Articles

With regard to the collection of data and the results of the first filtrations, the amount of bibliographic materials (scientific articles) described in Table 1 was found.

After the initial filtering in the above mentioned scientific databases, the software *Start* version 3.0 (*State of the Art through Systematic Review*) was used to organize systematic literature review from the articles initially selected. The software itself, based on criteria involving similarity of terms and authors, separated the articles in quadrants by criterion of similarity and with the studied subject. Therefore, the articles classified in quadrants 3 and 4 automatically disqualified, resulting in a rejection of 115 articles. In ddition, the software identified 16 articles in duplicate. After this stage there were 333 articles left. In the following stage, the JCR (*Journal Citation Reports*) of the journals in which the articles had been published was used as criterion. We opted to accept articles published in journals with a JCR with value equal or superior to 1,3. Two hundred and sixteen (216) articles published in journals with a JCR inferior to 1,3 were identified and rejected. Besides a high JCR, the journals had a H-index value higher than 24, all located in the classification of journals criterion called *qualis* Q1 (first quartile of the citation of the journals consulted in *Scimago*). Only one hundred and seventeen (117) articles were then left. The following stage was dedicated to reading the abstracts and the analysis of the approaches used in the articles in relation to the theme, to be sure that they corresponded to the objectives of the current project. After this reading, we reached the final number of thirty four (34) articles.

3.3 Findings and Discussion

The thirty four (34) articles analyzed came from twenty six (26) journals. The journal with the greatest number of published articles used was the *Journal of Environmental*

Psychology, with a JCR of 1.72, and 3 (three) articles. Figure 1, relates the journals with the highest number of published articles used in this study.

By and large, after the first reading of the articles selected (ater all filtering stages), it is observed that the implementation of programs and actions is still one of the major obstacles in the theme of sustainability. Some authors argue that a great many of these difficulties are due to the behavior of people directly involved in these actions and programs, since the factors that influence the involvement of the actors in the process are actually still being questioned. Due to these questionings, many studies proposed to investigate the antecedents of the so-called sustainable behavior (Juárez-Nájera et al. 2010).

Issues such as the lack of a deep understanding of what sustainability is already have shown to be a major obstacle for managers in the process of implementing sustainability (Cebrián et al. 2015). Yet, this does not necessarily mean that individuals with more advanced educational levels more frequently present behaviors considered as sustainable (Kollmuss and Agyeman 2002).

In this perspective, it becomes important to also analyze the contribution of studies carried out by higher education institutions regarding the implementation of their sustainability programs, considering that education has proved to be an important antecessor of sustainable behavior. Thus, among the articles collected, 2 articles were highlighted due to the theme involved in each one. The first article (Pathways

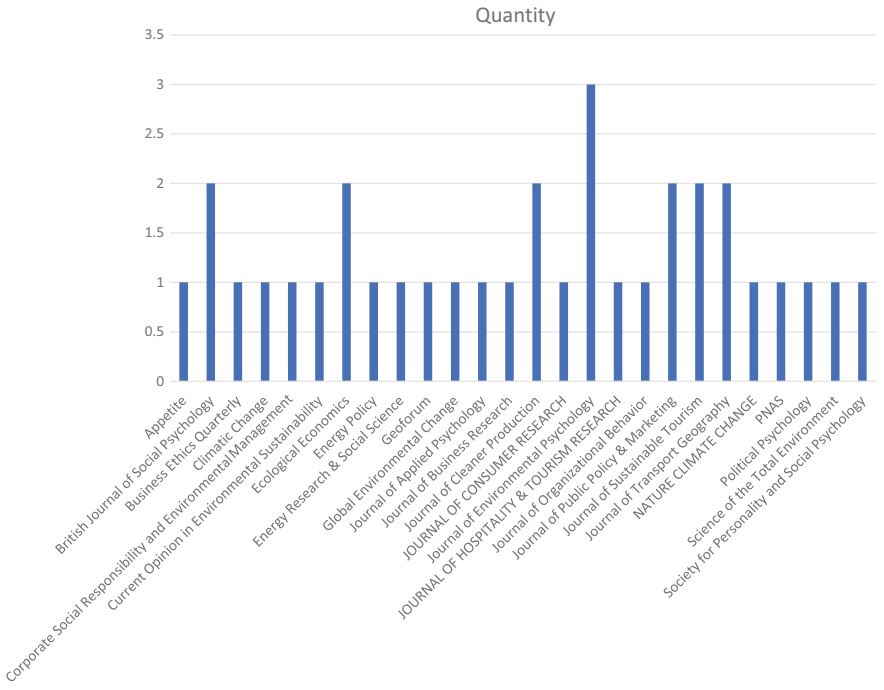

Fig. 1 Journals with articles used in this study. *Source* The author

to Cleaner Production in the Americas II: Application of a Competency Model to Experiential Learning for Sustainability Education) caught our attention for involving partnerships between American and Latin-American universities in the theme of sustainability (Mcpherson et al. 2016). The second article (Institutional and Societal Challenges in Sustainability Science and Explore the Potential of Uniting Education, Research and Societal Contributions to Form a Systematic and Integrated Response to the Sustainability Crisis) was deemed important due to linking sustainability within universities with the multidisciplinarity of various areas and subjects of study within universities (Yarime et al. 2012). The 2 articles were summarized with the purpose of synthesizing the main concepts and information relevant to the data collection.

The selected researches deal with sustainable behavior of individuals bringing the spotlight to antecessors and influences.

The level of analysis of the articles, in general, are summarized at: the subjective level (considering well-being and satisfaction with the past, flow and happiness in the present, and hope and optimism for the future); micro or individual level (that is, positive traits, such as love capacity, courage, aesthetic sensibility, perseverance, forgiveness, spirituality, high talent, and wisdom); and macro or institutional level (that is, positive civic virtues and institutions that help move individuals into better citizenship, such as responsibility, altruism, civility, moderation, tolerance, and a strong sense of work ethics).

Over time, the understanding that there is a positive relationship between positive feelings of employees and their performance became obvious. For this motive, although these studies do not specifically focus on the professional field, understanding how individual's sustainable behavior occurs can help organizations achieve their goals towards sustainability, what in turn has been motivating many researchers to work in this area. Such analyzes can help not only with the selection of employees who have the desirable personal characteristics and a positive attitude towards sustainable behavior, but also in the creation of programs that can capacitate these employees to gain this type of behavior.

According to these studies, 2 characteristics are intrinsically linked to sustainable behavior: self-efficacy and resilience. The definition of self-efficacy more often used is the one proposed by Bandura, which considers perceptual judgement of an individual in the belief of "how well they can execute courses of action necessary to deal with specific situations" (Bandura 1999, p. 122). Another broader definition states that: "self-efficacy refers to an individual's belief (or confidence) in their ability to mobilize motivation, cognitive resources, and the courses of action necessary to execute with success a specific task within a specific context" (Stajkovic and Luthans 1998, p. 66). Again, the key to definition is the specificity of task and context, as these interfere directly in the individual's perception about the difficulty of the proposed task. This characteristic exerts a great influence due to the individual's perception that sustainable objectives are difficult to achieve, and the perception that an individual's action will not make *the difference* in the final results.

In the case of resilience, understood as "the capacity of individuals to deal with success in face of significative changes, adversity, or risk, this capacity changes along time and is reinforced by protective factors, in the individual and the environment" (Stewart et al. 1997, p. 22). This characteristic, as a consequence of the perception of the difficulty in executing sustainable behavior is extremely important, as it can cause the individual to continue presenting the behavior even in face of the difficulties encountered throughout the process.

Griskevicius et al. (2012) understand sustainable behavior from an evolutionary perspective. In their study, the authors propose that many modern environmentalist tendencies and social problems are caused or exacerbated by 5 evolutionary tendencies: (1) propensity for genetic self-interest; (2) motivation for relative rather than absolute status, (3) propensity to unconsciously copy others, (4) a predisposition to myopia, and (5) propensity to disconsider impalpable concerns. An evolutionary approach suggests that, just as the forces of natural selection can mold morphological characteristics, such as the shape of our hands, the same forces can also shape psychological tendencies.

According to this conception, human beings evolved to reap more rewards for themselves, ultimately triggering the transfer of the inherent onus to others (Hawkes 1992). Natural selection does not care about survival of the species; what matters is the replication of someone's genes, which often comes at the expense of the survival of other genes (Dawkins and Krebs 1978). Although there is a variation in the transfer of the onus to others depending on the person (Van Lange et al. 1997), individuals are willing to make selfish choices in the face of social dilemmas, particularly when interacting with strangers in large groups.

Human beings have also evolved to cooperate with people who cannot return favors directly. The evolution of this type of aid is usually explained in the light of reciprocity theories (Nowak and Sigmund 2005). Indirect reciprocity postulates that organisms can develop the capacity to cooperate with non-reciprocal strangers because this may help establish a reputation as a good cooperator. Reputation concerns are particularly powerful when people strongly identify with a group and its members. For example, the strength of people's community identification predicts their willingness to help solve social dilemmas (Hardy and Van Vugt 2006), and this identification presupposes a willingness to punish cheaters and reward desirable behaviors in other members of the community (Brewer and Kramer 1986).

In addition, human beings have also evolved to copy and instinctively imitate the behavior of others. Psychologists have long recognized that human beings exhibit this tendency (Asch 1956), and it is believed that such behavior has brought them evolutionary benefits. Imitation is an underestimated contributor to environmental problems because many of these problems result from conflict between what people believe they should do versus what they actually see others doing (Cialdini et al. 1990). For example, although home residents say that their neghbors' behavior has little affect on their conservation behavior, studies show that neighbors' behavior is many times the strongest predictor of real energy savings (Nolan et al. 2008). In fact, the neighbors' behavior is many times a substantially stronger predictor than financial incentives (Nolan et al. 2008). When people notice that their neighbors

are not saving, they increase their own energy consumption, even when they were previously conserving energy (Schultz et al. 2007).

Many studies set out to understand sustainable behavior based on the standard consumption of individuals. The new findings in this field of study point out to a new important dimension in the study of sustainable goods, where the mental conception of the consumer must be studied (abstract versus concrete), as well as the benefits associated with sustainable products (economy versus self-transcendence). The main message of these studies consists in the demonstration of how mental representation plays a critical role in determining how consumers react to benefits resulting from pro-environmental and sustainable actions, which can help sustainability awareness programs, as one can propose actions with more concrete results.

3.4 Final Considerations

This study presents the findings, mapping and analysis of publications in the scientific databases *Web of Science* and *Scopus* on the theme of the sustainable behavior of individuals, considering antecedents for this behavior to occur. These findings include the analysis of 34 articles published in 26 journals with a JCR equal or higher than 1.3.

It was perceived that most studies are based on psychological perspective to understand the guiding lines of sustainable behavior, and that values, beliefs, and world-views are still perceived as the main influencers, from more recent perceptions based on the evolutionary perspective of human beings. These findings help, above all, to understand how this theme is evolving, and where the omissions still in need to be further addressed reside.

Many studies have analyzed the behavioral perspective of individuals in relation to specific issues of sustainability, such as: recycling, energy consumption, consumption in general, etc. However, the antecedents listed tend to influence sustainable behavior in general. In addition, the studies that have dealt with aspects that could influence the reduction of consumption on the part of individuals, defend the adoption of policies issued by governments and a closer watch of market trends, given that these are conflicting interests (market and society), where one tends to motivate the increase of consumption and the other to reduce it. Governments should then act as mediators in this process. Such scientific advances show that topics involving sustainability should not only be studied from the point of view of the individual as the sole responsible for actions that interfere in the environment. The individual is influenced all the time, and it is not always that psychological individual motivations can change this process, even if consumption is addressed individually.

The studies were carried out based on surveys, or using the theoretical test model. However, those researchers that considered empirical analyzes obtained data from cross-sections, with the exception of one only study. In general, the limitations of the researches carried out consist in the comprehensiveness of the same, since they

are restricted to certain locations, not taking into account the differences that can be found in different regions with respect to culture and other customs.

In addition, in some cases there was a low return of respondents, which raises the question as to the extent to which the findings of these studies can be generalized to entire populations. Another limitation found in these studies was the use of measurement of behavior based on self-reporting. Research based on self-reporting may present biases as to the trustworthiness of responses, once people tend to present response that is compatible with the research's intention, due to the individuals concern with people's judgement of their behavior.

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The Amerindian Good Living as a Sustainable Alternative to Latin American Development

Adriano Fabri and Dimas Floriani

Abstract The Amerindian Good Living (GL) appears in the 21st century as a sustainable alternative for development in Latin America. Based on the worldview, the ecological knowledge and the indigenous practice systems. Good living is a philosophy, a concept, a lifestyle of the original peoples, aimed at a life in harmony among all the people of the community, their ecosystems and their culture. In a dialogue of knowledge, between the millennial knowledge and the modern science and technology, promising initiatives arise when it comes to local and planetary sustainability. However, the autochthonous peoples who live the Good Living for thousands of years in their daily lives, satisfying their needs of life while respecting nature and preserving biodiversity, are under pressure and threatened by the unbridled expansion of the predatory development model that jeopardize their territories and ways of living. This paper examines philosophical and political aspects of the Latin American Good Living and how it manifests itself in Amerindian societies, impacting positively in the preservation of local ecosystems, in the perpetuation of indigenous cultures and, finally, in the opening of new possibilities in the search for sustainable alternatives for Latin American development.

Keywords Good living · Sustainable development · Latin America

1 Introduction

This paper is part of the reflections of the authors related to the search for an understanding of the complexity contained in the contemporary socio-environmental crisis. Such reflections were carried out during the postgraduate program in environment and development (PPGMADE—Class XII) of the Federal University of Paraná (UFPR-

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Brazil), in its research line on Environmental Epistemology. It is also inspired by the "global call for the construction of a sustainable future" carried out by the UN 2030 Agenda. In this way, the research seeks to analyze possible sustainable alternatives for development in Latin America, especially in the areas that still have great wealth of socio-biodiversity as in the case of the Amazon Rainforest.

Within this perspective, the theme chosen was Amerindian good living (GL), because it is a promising concept that has been arousing the interest of intellectuals, researchers, universities, the media and the public in general. As the GL is a category under construction that has various definitions, we clarify that the Amerindian GL dealt here is the one related to the lifestyle, the way of living employed by the various autochthonous peoples of Latin America, who mix in their daily lives the appropriated cosmovision to see the world, a traditional ecological knowledge to interpret nature and unique systems of practices to interact with the environment. In addition to reviewing aspects of the ethno-knowledge, the research seeks to verify its possible hybridizations with modern science and technology in the search for solutions related to the conservation of ecosystems and the perpetuation of local cultures.

This research is based on a post-modern and post-developmental critique, in which it considers that the socio-environmental crisis represented by climate change, global warming, pollution and scarcity of water, deterioration of soil, pollution of air and oceans, high rates of violence, poverty and deteriorating social that primarily affect the 'underdeveloped' countries, is engendered within the modern capitalist rationality that ended up creating the dichotomy between man and nature. This nature has passed from the condition of a sacred, revered being to the condition of a simple commodity that must be exploited to the very last consequences aiming at the wealth, the development and the countries' progress.

The environmental crisis that looms over the world is still perceived as a catastrophic premonition, not as a real ecological risk to the whole of humanity. In today's "risk society", global insecurity is more focused on widespread warfare and everyday violence than on the imminent danger of ecological collapse. The entropy limit law is very far from the common knowledge, the collective imagination and the experience to generate an awareness that effectively responds to ecological risk and redirects action to the construction of sustainable societies (Leff 2010).

In addition to the context of imaginary worlds generated by the discourse of sustainable development, the theories of sustainability, the thinking of complexity, the ecosofias of different imprints and the "environmental sciences", the research of sustainable alternatives to communities analyzes the imaginary of peoples, of culturally diverse communities in their ideologies, worldviews, and interests, able to generate a collective inclination to understand and act on the environmental crisis and climate change. "*This will lead us to explore cultural and social imaginaries, not only for the interest of knowing how people perceive ecological risk, but also from the perspective of their possible constitution as social actors and their strategies of reappropriation of the world from their ways of life*" (Leff 2010, p. 45, our translation).

As Castoriadis (1975) points out, social imaginaries are not only the representations of the world or the cosmovisions that give existential meaning and coherence

to certain practices. "*The imaginaries are rooted in the identities that form the cultural being; they affirm themselves as a principle of autonomy and singularity from which they not only resist the colonization of other dominant and hegemonic cultures, but also where they re-signify their identities. They are the roots from which worlds can be reinvented, they are the source from where the subjects of such imaginaries become social actors in the construction and reconstruction of their lifestyles*" (Leff 2010, p. 85, our translation).

Faced with the critique of hegemonic development unconcerned about the preservation of the environment and local cultures, the theories somehow post-modern as the environmental rationality, the epistemologies of the south, the environmental epistemology and the post-development point to alternatives that would have "one foot out and one foot within modernity". In other words, they would bring in its scope both science and modern technology, but they would not only operate with this rationality but also with a hybridization between modern reason and traditional ecological knowledge.

Aiming at taking advantage of all the expertise of indigenous and traditional peoples that handle nature in a balanced manner for thousands of years, but without giving up the use of science and technology in the monitoring and protection of their territories for example, or in the documentary record of their culture, we aim to analyze the GL as a sustainable alternative to Latin American development.

Thus, this article begins with an analysis of the philosophical, political and practical aspects of the good living. It finds connecting points between the proposal of the GL and the national documents and international conventions on sustainable development such as the UN 2030 Agenda, to seek for sustainable alternatives focused on the preservation of ecosystems and local cultures, from a critical analysis of the hegemonic development.

It ends with the records of practical cases of Amerindian GL experienced by peoples that from the dialogue of knowledge between ethno-knowledge and modern science and technology, who protect their territories, preserve their biodiversity, sustain their needs, preserve their customs and cultures and still set the example in the fight for the preservation of standing forests in the 21st century.

2 The Amerindian Good Living-Philosophical, Political, Practical Aspects and the Sustainability

The Amerindian GL is a way of life based on the experience and knowledge of the peoples from *Abya Ayla* (Latin America) in relation to the balanced and harmonious relationship between society and nature. Faced with the contemporary challenges related to climate change, preservation of biodiversity, water, soil, air, and protection of indigenous and traditional populations, the GL presents itself as an alternative to the markedly predatory hegemonic development of nature, which is deleterious to autochthonous populations.

The GL is a concept in construction that brings together ideas and antagonistic practices to the ideas disseminated by the conventional development, blindly aimed for the economic growth and mass consumption and that over time, ends up resulting in violence, social inequality and environmental degradation. The GL is also a critical reflection of Latin America and it is based mainly on ontologies and worldviews of the indigenous peoples from *Abya Ayla* (the name that replaces America, indicating that it is not just another name, but the presence of another subject as the discourse speaker, who until now has been silent and subalternized in political terms: the autochthonous peoples).

The GL is a concept in construction that can be adjusted to each locality and socio-environmental circumstance. For Alberto Acosta, the GL cannot be reduced to Western welfare, it must be supported by Indigenous cosmovisions in which material goods are not the only determinants (Acosta 2008). For David Choquehuanca, intellectual aymara, the GL means to "*recover the culture of life in complete harmony and mutual respect with nature, where everything is life and there is nothing separate*" (Choquehuanca 2010). For Gudynas, there are three plans to address the construction of the GL concept: the ideas (radical questioning of the conceptual bases of development), the discourses (the construction of other ways of speaking, writing or thinking about the world, people and nature) and the practices (concrete actions, political projects, governmental initiatives, regulatory frameworks) (Gudynas 2011).

From the imaginary of the GL, as it has settled itself in the life of the Andean and Amazonian peoples—the imaginary of a community life within an ecological community-derives another imaginary, that of the rights of nature. In the postulation of nature as a subject of law, the imaginary derived from phenomenology and existential ontology is expressed in the philosophical revolution that operates facing the rationalism of modernity (Leff 2010).

The GL has had one of its first formal appearances in 2008 in the new constitution of Ecuador as *Sumak Kawsai* (living and cohabiting—Quechua), where nature appears as the subject of law and in the new constitution of the Plurinational State of Bolivia of 2009, which offers ideas of good living as moral ethical principle according to several autochthonous peoples, such as the *suma qamaña* (*vivir bien*—Aymara) and *ñandereko* (harmonious life—Guarani).

For Huanacuni (2010) intellectual Aymara the GL cannot be equated with Western development because "*development is inappropriate and highly dangerous to apply in indigenous societies, as it is conceived in the Western world. The introduction of development among Indigenous Peoples slowly annihilates our own philosophy of good living, as it disintegrates the communal and cultural life of our communities by wiping out the foundations of both subsistence and our abilities and knowledge to satisfy our needs ourselves*" (Huanacuni 2010).

According to Torres (2001), GL is a well-being space where people, animals and crops coexist harmoniously, where there is no modern duality that separates society from nature, since one complements the other, so they are inseparable.

The manifestation of GL aims to show the world that "other ways of life are possible" and that they are intrinsic parts of their ways of being cultural, at a time when global problems (climate change) continue to be managed within the strategies gen-

erated in the context of reflexive modernization, that is to say, within the instrumental economic-technological and the geopolitics of sustainable development. Requiring the GL not only means a claim for historical justice against the subjugation of the ways of life of the peoples who suffered the imposition of modern rationality. The imaginary of the GL also proposes another understanding of the world and offers himself as a sample of how it could bind again to the human life with the natural order; it is a solution that goes beyond the scope of a reflexive modernity, the adjustments of the economy and of the potential of the technology to control the socio-environmental degradation and climate change (Leff 2010).

In addition to denying the conventional development and its negativities, the GL abandons the idea of progress and linear historical sequence, it defends another relationship with nature recognized as a subject of rights, it does not economize on social relations, it does not reduce everything to market goods and services, rethinks the quality of life independently of the possession of material goods by giving importance to the happiness, spirituality, and other sensitivities (Gudynas 2011). To find alternative paths to the development of the inner regions that lead to greater human wealth to more people, we must begin with a less arrogant view of the superiority of our world of gleaming hardware, a greater appreciation of the wisdom—and potential power—of the villagers who we teach, and guide (Keesing 1980 cited in Posey et al. 1984).

The socio-ecological devastation in Latin America that occurs today, mainly in its remnants of nature such as the Amazon rainforest, requires alternative strategies for Sustainable Development. The study of indigenous ecological knowledge (ethnoecology) provides the basis for these new strategies (Posey et al. 1984), when they are aligned with modern science and technology have great potential in the search for local and global sustainability.

This sustainability is currently threatened in Brazil and other countries of the world by the far right-wing governments that underestimate global warming and the socio-environmental crisis, avoiding taking action to lower their greenhouse gas emissions and encouraging deforestation and displacement of Indigenous and traditional communities. All this to clear the way for agribusiness, mining and large infrastructure projects that end up jeopardizing the livelihoods and way of life of traditional millennial peoples, as well as threatening the biodiversity, other riches and environmental services provided by what remains of forests standing in Brazil and other countries in Latin America.

3 The Good Living and National Laws, International Conventions and UN 2030 Agenda

The proposal of GL is related to several national and international documents that recommend the preservation of the original cultures and that relate them to the conservation and sustainable use of biodiversity. Documents such as:

The Brazilian constitution of 1988, which provides for the right to difference to Indigenous Peoples. This is what the caput of Article 231 of the Constitution reads: "*The Indigenous are recognized for their social organization, customs, languages, beliefs and traditions, and the original rights over the lands they traditionally occupy, and it is up to the Union to demarcate, protect and respect all their assets*" (CONSTITUTION 1988).

The Convention 169 of the International Labour Organisation—ILO on Indigenous and Tribal Peoples and its Article 7: "*Recognizing the aspirations of these peoples to exercise control over their own institutions, ways of life and economic development and to maintain and strengthen their identities, languages and religions, within the framework of the States in which they live*" (ILO 169).

The CBD-Convention on Biological Diversity, 1992: recommends in its Article 8 (Conservation in situ) and Article 10 (Sustainable use of components of Biological Diversity) the respect and preservation of traditional practices and knowledge that collaborate with the preservation of local biodiversity (CBD 2000).

The 2007 UN Declaration on the Rights of Indigenous Peoples sets out principles such as equal rights and prohibition of discrimination, the right to self-determination and the need to make consent and agreement of wills the benchmark of the whole relationship between indigenous peoples and States (ISA 2018a, b, c).

The Protocol of Nagoya: the effort of implementation of the third objective (Fair and Equitable Sharing of Benefits Arising from Use of Genetic Resources) of the CBD culminated in the adoption at its 10th Conference of the Parties, in 2010, of the text of the Protocol of Nagoya on Access to Genetic Resources and the Fair and Equitable Sharing of the Benefits Derived from its Use. The sharing of benefits derived from the use of genetic resources and associated traditional knowledge, which is at the heart of the Nagoya Protocol, is a development instrument (Gross 2013). Unfortunately, the regrettable attitude of the Brazilian government in not ratifying the accession to the Nagoya Protocol in 2018 leaves Brazil, one of the main historical mediators in the debate on the conservation and sustainable use of biodiversity, outside the decisions on the theme in the UN Convention. This attitude, among others, reflects a worrisome shift by the Brazilian government to move wildly on the remaining forests, especially the Amazon forest, to facilitate the deforestation for agricultural expansion, the promotion of major projects, oil extraction and mining. Such expansion will bring incalculable social and environmental risks for the region and its indigenous and traditional populations in addition to invaluable damages to the entire planet in times of global warming.

In view of the above and the objectives of the 2030 Agenda, which direct the action plan focused on people, the planet and prosperity, focused mainly on building a sustainable future on Earth, where poverty is eliminated in all its dimensions and nature is respected and preserved, GL appears as an alternative starting point in reading and interpreting the world and the relationship between men and nature and represents a strong ally in the collective construction of a world of peace with protected human and nature rights.

4 Amerindian Good Living as an Alternative to Latin American Development

Considering the worsening of the global socio-environmental crisis, which has its consequences widely spread (global warming, climate change, pollution, violence, misery…), it is necessary to search for other ideas that offer diversified points of view in relation to the development which is propagated to the four winds as the solution to all problems, but that does not always really match the expectations created in the population. This development, which carries with it assumptions contemplated in modernity such as economic growth, industrialization, historical linear progress and urbanization, fails in its basic promises to provide a higher quality of life for the populations of the so-called "underdeveloped" nations.

It is undeniable that we have achieved much in recent years in terms of economic growth, infrastructure, expansion of roads and ports to flow grain and ore production and the construction of large hydroelectric plants. We are connected to the internet and thereby we greatly increase the possibilities of personal and professional relationships. Finally we have a development along the lines of the "West" considering that most of these forms of expansion have been propagated from the West. But even with all that progress, most countries are still less economically developed than the countries that propagated the hegemonic development model, so the countries are still divided into developed and underdeveloped.

Faced with the issue of development in Latin America and mainly in regions with rich in biodiversity ecosystems and local cultures, as the case of the Brazilian Amazon, we search for alternatives to the hegemonic development model based on the traditional knowledge of indigenous peoples who still holds important points of their culture, but who do not give up the benefits of science and modern technology in the monitoring and protection of their territories for example.

Every study that tries to criticize the current model of development is exposed to the question: but then, what alternatives are available to the hegemonic development model?

It should be clear that there are no great alternatives that can be applied everywhere and in all situations. Thinking of the alternatives under the mode of sustainable development, for example, is to be located within the same model of thought that produces development and that sustains it. One must resist the desire to formulate alternatives at the macro and abstract level. The nature of alternatives as a problem of social research and practice can best be seen from its specific manifestations in concrete places. In a sense, "the alternative" has always been there. The deconstruction of development, along with local ethnographies can be key elements for a new kind of visibility and audibility of the forms of difference and cultural hybridization. The subalterns do speak, however, their audibility in the "Western" circles of discussion and theories is tenuous, not to say null (Escobar 2007).

For example, a group of Swedish anthropologists work on how the concepts of "development" and "modernity" are used, interpreted, and how they are questioned or reproduced in various social contexts from different parts of the world. This research

shows a complete constellation of uses, modes of operation and local effects associated with these concepts. It is a village in Papua New Guinea and some small villages of Kenya and Ethiopia, local versions of development and modernity are formulated by following complex processes that include traditional cultural practices, stories from the colonial past, and the contemporary location within the global economy of goods and symbols (Dahl and Rabo 1992). Escobar (2007) also advocates for a return to culture, particularly the local ones, in the critical analysis of development. The purpose of the analysis is to contribute to the liberation of the discursive field so that the task of imagining alternatives can begin (or so that researchers perceive from another perspective), and the local ethnographies already mentioned encompass useful elements for this.

These ethnographies on the circulation of discourses and practices of development and modernity give us a vision of the situation in which these communities are culturally in relation to development. "*This view can be taken as a basis to question the current practices in terms of their potential reach to articulate alternatives*" (Escobar 2007, p. 372).

Finally, there are subaltern groups in many places in the Third World who seem to be increasingly conscious of the contradictions imposed by the hegemonic model of development and that they resist through the defense of the place, as a prerequisite to link up with the global, the criticism of the situation itself, the stimulus of values and collective practices as a means of strengthening the identity, the opposition to modernizing development, the formulation of visions and concrete proposals, even with the limitations imposed. These are in a way the main elements for the collective construction of local alternatives (Escobar 2007).

The unprecedented socio-environmental crisis in "underdeveloped" countries requires new theories and research strategies. The crisis is considered as a conjunctural moment in the reconstruction of the connection between truth and reality, between words and things, which demands new practices of seeing, knowing and being (Escobar 2007). We identify the need to undo and unlearn the development propagated by the status quo, recognizing that the crucial elements to the search for alternatives are not in the academy, or in the institutions that promote development. They are rather in a rereading of traditional practices and in the reappropriation of the sociocultural production space present in the hybridized cultures re-signified by the dialectical relationship between development/modernity and tradition.

5 Examples of Amerindian Good Living Experiences

Two Amazonian ethnicities and one Andean were chosen as examples of GL experiences, which represent sustainable alternatives to the predatory development of socio-biodiverse patrimony in regions of Latin America that still have forests and biodiverse ecosystems. The three ethnic groups are now presented with their cosmovisions, knowledge and systems of practices rooted in their territories. They manage to develop hybridized experiences between local traditional knowledge and modern

science and technology in activities such as monitoring their territory and managing their socio-biodiverse patrimony, for example.

6 Ashaninka (Acre-Brazil)

The Ashaninka indigenous community of the Ammonia River is a people with a history of resistance since the time of the Inca Empire (from which they broke up and fled to the interior of the Amazon rainforest) and Spanish colonization. At the end of the 19th century some members of this Peruvian origin ethnicity were brought to the Brazilian lands by the rubber bosses (caucheiros) that kept them enslaved and exploited, in addition, they resisted the timber until the mid-1980s. After this sad period of its history and after the demarcation of the Indigenous Land and the connection with the organs of the Brazilian government, the state of Acre and national and international NGOs, this people has been transformed. They are giving a new meaning to their culture and today they are known as the Guardians of the Forest. It is outstanding how they have the ability to maintain their tradition while at the same time, they absorb the aspects of modernity and of development used for the protection of their territory and the preservation of their culture. These people are proud of their culture, they are moved by an acute feeling of freedom, ready to die to defend their territory, the Ashaninka are not mere objects of Western history. Their ability to reconcile traditional customs and values with ideas and practices in the white world, such as those linked to socio-environmental sustainability (ISA 2018a, b, c), is admirable. Projects such as the *Yorenka Ãtame Center* (Knowledge Forest), which is focused on the dialogue of knowledges, the management of yellow-spotted Amazon river turtles that returns thousands of specimen to the rivers every year, the agroforestry that produces food in abundance in the community, which helps the preservation of the ecosystem, the use of solar energy and satellite monitoring of the indigenous territory represent the capacity of intercultural dialogue (APIWTXA 2017).

In addition, they have manioc and rice groves and today they develop some of the best sustainable management projects in Acre, both in the forest area and in the areas of wild animals and bees. They have already reforested, with of diesel tree (copaiba), tonka beans (cumaru), tree stonecrop (balsamo) and mainly mahogany trees, more than 40 ha of areas that had been devastated by the white people that occupied the region before its demarcation as Indigenous land.

The natives have also planted more than five hectares near the central village with regional fruit trees, such as cupuaçu, graviola, sapoti, abiu, and mango. In addition, they chose large areas of forest for the repopulation of wild animals, which were disappearing from the region due to predatory hunting promoted by the white people prior to demarcation. In those areas, people are not going to hunt for a long time so that the animals multiply and repopulate the forest. Over 1600 coconut seedlings have also been planted throughout the villages. Large red footed tortoises are bred in captivity. In the middle of the Central Village, a small weir has already accumulated

more than 1700 small yellow-spotted Amazon river turtles, which in a very short time will multiply to be scattered in the Ammonia River along the indigenous land. There is also bee breeding around all the village houses.

"'*We are looking after our forest to make it richer from all the good that it offers us*', said Benke Pianco (Ashaninka leader), emphasizing that he has learned the sustainable management by pure intuition of knowing that when nature is well cared for, it produces all the good that men need" (ISA 2018a, b, c).

Finally it should be noted that these projects of socio-environmental sustainability are based on traditional knowledge passed from generation to generation that hybridize with the modern scientific and technological knowledge, thus formulating sustainable alternatives to the development of forests like the Amazon Rainforest.

7 Paiter Suruís (Rondônia-Brazil)

Since the official contact in 1969, the approach with non-Indigenous People has brought profound social changes among the Paíter. Of a warrior nature, the people struggle for the recognition and integrity of their territory, fighting as they can against adversities such as the incidence of irregular loggers and miners in their territory and the omission of governmental organs. Even so, the Paíter seek to maintain the vitality of their cultural traditions, in which society is understood from a division into halves, so that the segments of society, the productive activities and ritual life are expressions of the dualism between the village and the forest, the forest and the hunting, the work and the party—the festivals of exchange of offerings and the community work associated with them the highlights of the exchange and of the alternation between these halves (ISA 2018a, b, c).

The Paiter Suruí Parliament, created in 2010, is a forum for Democratic debate of ideas, reflections and deliberations. It represents the Paiter Suruí people in their decisions, demands, the implementation of internal policies and in the interface with government public policies. It is governed by a hierarchical organization, formed by *PAMATOT EY* (Council of Elders—superior body of wisdom), *LABIWAY EY* (parliamentarians elected by the population every 5 years) and *LABIWAY ESAGA* (major leader of the Paiter Suruí people). The Paiter Suruí people choose the representative leaders of the Parliament and comprise a population of approximately 1350 people, who live in 25 villages located on the border of 248,147 ha of the Sete de Setembro Indigenous Land in Rondônia.

The Matereilá Association of the Suruí Indigenous People, founded in 1989, acts in defense and preservation of cultural and territorial heritage, seeking to promote the guarantee of biodiversity and the formation of indigenous peoples and leaders in order to build and strengthen their autonomy in defense of territorial heritage. The PAMINE project is aimed at the reforestation of the degraded areas of the Sete de Setembro Indigenous Land (PAITER 2018).

The Suruí people, who live in Sete de Setembro territory, is a notable example of how mapping indigenous territories can help prevent deforestation and preserve

the culture. The leader Almir Surui first met Google Earth in 2007 and immediately realized its potential to preserve the heritage and traditions of his people. He proposed a partnership with Google to create an online map of Suruí cultural heritage, as well as a new system to monitor illegal logging and carbon stock using Android smartphones. This was the first project of deforestation and forest degradation mapping conducted by the indigenous community. Through this project, Suruís calculated the value of their forest in the voluntary carbon market—and became the first indigenous community to receive funds to preserve their forests. According to Almir Suruí "*the world can learn more about the forest and the history of each Indigenous community and recognize the role these lands play in the conservation of our planet*" (GOOGLE BLOG 2018).

8 Mapuche (Chile)

The Mapuche people originate in the central south zone of Chile and Argentina, with a history documented by archaeological records of around 4000 years of existence. (Bengoa 2007). In the 16th century, they had political, economic and social development in a vast territory with a population that surpassed one million inhabitants organized and with practices related to their natural environment. However, since the arrival of the Spanish, they have faced a process of loss of their natural and cultural environment. Under the military dictatorship, this process has continued and now repeats with the Chilean state and its different methods in the search for the reduction of the culture with the introduction of settlers and the fragmentation of communities and settlements (Díaz 2010).

The Mapuche people continue resisting the colonization of centuries with various methods and practices for the restitution of their ancestral territory, many by peaceful means and with international support and others with more aggressive methods, an unresolved conflict that has already suffered material and human losses (Pairican 2014).

According to Bengoa (1996, p. 27), in Arauco, "*the abundant nature of resources has allowed the development of a large-scale collecting system*", which reveals the high levels of biodiversity that existed prior to changes in the territory. Despite the vast population (more than one million inhabitants between the VII and X region), the way of life was appropriate according to the needs of its surroundings. However, this model changed in the period of the colony with intensive agriculture, being reflected in the present time as a model that is not so different, the forest monoculture.

The reflection of these changes in the Mapuche territory is a loss of their man-nature relationship, which is the reason of a high resistance in the process of recovery of the territory, once there is a link between the *Nehuen* (forces of the universe) and their symbolic way of life. In this approach, the balance between the natural and cultural environment is reduced by the irresponsible anthropization of the territory.

The contribution of the Mapuche people is in their intangible heritage which is their mode of occupation, the link with the natural environment, the responsibility

about the correct use of the surroundings through their farming systems, interventions of low impact on the landscape, conservation of the native forest to ensure the supply of basic services, the equitable distribution of its territory and the coexistence.

In relation to the experiences with traditional knowledge hybridized with modern science and technology we cite the example of the bilingual Radio Aukinko, which through the internet has been promoting for 9 years the dissemination and appreciation of the Mapuche language, the traditional music, the history of the people, as a 100% Mapuche cultural project.

9 Conclusions

The contemporary socio-environmental crisis in "underdeveloped" countries requires new theories and strategies of action. The crisis is considered as a conjunctural moment in the reconstruction of the connection between truth and reality, between words and things, which demands new practices of seeing, knowing and being. The need to undo and unlearn the development propagated by the status quo is identified in order to open the path to new ways of seeing and living the world (Escobar 2007). It was sought in this brief reflection on the complexity of the socio-environmental issue, about the development and about the GL as a sustainable alternative to the development of areas in the "underdeveloped" countries that still have an exuberant socio-biodiversity wealth, to think and give visibility to the experiences of the indigenous communities that live in harmony with the local ecological community, using in their daily lives both their traditional ecological knowledge and modern science and technology in the production of their subsistence, in the monitoring and preservation of their ecosystems and territories, among others.

Thus, the brief description of the three experiences of Amerindian GL lived by two Amazonian and one Andean community served to illustrate in practice the dialogue of knowledge between traditional knowledge and modern science and technology. They represent sustainable alternatives to the predatory development of Latin American socio-biodiversity as these indigenous peoples meet their material and cultural needs while respecting the standing forest with all its socio-biodiversity wealth. The GL thought and lived in *Abya Ayla* (Latin America) is the main critical platform to the predatory development of socio-environmental wealth. It is also a proponent of concrete actions based on the ontologies and cosmovisions of peoples originating in Latin America. Presently, the idea of development based on economic growth, modernization, industrialization, progress, linear history, among other assumptions of modernity continues to be chanted as a mantra all over the world, even though in many cases it does not meet several of the expectations generated in the populations of developing countries. Remaining for its critics the complicated task of the liberation of the discursive field so that other ways of seeing and living life and other imaginaries that can be identified, developed and articulated among them on the construction of new paths to freedom and to the construction of local and planetary sustainability.

This sustainability should be thought of in the great international conventions such as those of the United Nations, but it should also be planned, networked and mainly implemented through public policies and concrete projects created and implemented from the perceptions and needs of local populations. One should also use the millennial experience contained in the indigenous ecological knowledge without giving up modern science and technology, aiming at empowering indigenous communities who are directly responsible for the preservation and management of these ecosystems as providers of valuable environmental services and who are very rich in socio-biodiversity.

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Application of Information Entropy to Assessment Environmental Sanitation Sustainability Conditions: A Case Study at the River Grande Basin, Brazil

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Abstract Environmental sanitation is one of the main causing factors of water use conflicts at the Rio Grande Basin, Brazil. The precariousness of sanitation conditions in the area degrades water resources and affects the health and quality of life of the local population, as well as regional economic development. In this context, this study aims to assess the environmental sanitation sustainability condition in two Rio Grande Basin (BHRG) water management units. An evaluation index system grouped into three subsystems (economic, social and environmental) was applied to this end, carried out for the years of 2008, 2010, 2012 and 2014. The indicator and subsystem weights were based on the Entropy Information concept. The empirical results of this study indicated unacceptable environmental sanitation sustainability conditions for both assessed water management units. This study, thus, demonstrates the impacts of economic development and environmental quality on the human subsystem. In addition, it provides theoretical implications and practical approaches for assessing sanitation conditions under the sustainable development scenario, and may assist in planning actions and decision-making processes to meet the goals of Objective for Sustainable Development 6 stipulated for 2030 by the United Nations.

Keywords Sustainable development goals · Sustainability method analysis · Water resources management · Basic sanitation

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1 Introduction

Sustainable development requires meeting the needs of the present without compromising the ability of future generations to meet their own needs "(Brundtland 1987). Sustainability comprises three "pillars" or "subsystems", namely the environment, economy and society (Huang et al. 2015). In order to achieve sustainable development, the United Nations created "The 2030 Agenda for Sustainable Development", which consists of 17 sustainable development goals and 169 targets to be met by all countries by 2030. These objectives include "Ensuring the availability and sustainable management of water and sanitation for all" or the "Objective for Sustainable Development 6 (SDG 6)".

According to Brazilian Law nº. 11445/2007, which establishes national guidelines for basic sanitation, basic sanitation in Brazil is defined by a set of services, infrastructures and operational facilities, comprising:

(a) *Drinking water supply: constituted by the activities, infrastructures and facilities necessary for the public supply of drinking water, from capture to building connections and measuring instruments*;
(b) *Sanitary sewage: constituted by the activities, infrastructures and operational facilities for adequate collection, transportation, treatment and disposal of sanitary sewage, from the building connections to its final release into the environment*;
(c) *Urban cleaning and solid waste management: a set of activities, infrastructures and operational facilities for collection, transportation, transshipment, treatment and final destination of household waste and garbage originating from the sweeping and cleaning of public places and streets*;
(d) *Drainage and management of urban storm water: a set of activities, infrastructure and operational facilities for urban drainage of rainwater, transportation, holding or retention for damping of flood flows, treatment and final disposal of rainwater drained in urban areas* (Brasil 2007).

Law nº. 11445/2007 is guided by five principles: (1) Universalization—access to all goods and services produced by society, (2) Equity—overcoming avoidable, unnecessary and unfair differences, (3) Integrality—components of each of the various basic sanitation services, providing the population with access to the conformity of their needs and maximizing the effectiveness of actions and results, (4) Intersectoriality—linking analyses, plans, programs, decisions and actions to territories, and (5) Sustainability—integration of environmental, economic, social and governance variables that interfere with the sanitation sector.

In order to achieve the effectiveness of Law nº. 11445/2007 based on its guiding principles and achieve the sustainable development goal six (SDG6) by 2030 (ONU BR 2018), it is fundamental to apply sustainability analysis methods or tools to advise planning actions and decision-making. In this scenario, indicators are excellent tools for assessing progress towards sustainable development. In addition, working with indicators is recommended by researchers, decision-makers, and international institutions. However, sustainability is an approach that requires integration between

ecosystem conservation and social, economic, institutional and environmental subsystems into a single system (Ni et al. 2012). In this context, hydrographic basins are a natural unit or unique system that allow for this integration (Tundisi 2008; Guidolini et al. 2018a).

Some global assessment methods use subjective weights to calculate subsystem weights, such as the AHAS—Analytic Hierarchy Process (Saaty 2013), ARAS—Additive Ratio Assessment (Zavadskas et al. 2010) and ANP—Analytic Network Process (Carlucci 2010), among others. These methods present certain drawbacks, such as a non-standardized rating system and results that may be inconsistent with actual data due to subjective weights. On the other hand, so-called objective methods disregard the preferences of the decision-maker from statistical models and are based on the inherent amount of information provided by the indicators (Toumi et al. 2017).

Among objective methods, the entropic weight method is highlighted in several types of analyses, such as water resource allocation (Sun et al. 2013); water resource transport capacity (Ma et al. 2012); efficiency phosphorus evaluation use (Laner et al. 2017); environmental vulnerability assessments (Zhao et al. 2018); sustainable sport development level assessments (Liu and Cui 2008) and sustainability assessments for Latin American countries (Toumi et al. 2017). This method is based on Shannon's entropy coefficient (1948), which comprises a number of desirable properties and allows for weight determination solely on the basis of the amount of statistical information provided by the indicators (Toumi et al. 2017).

In this context, the present study aimed to assess the environmental sanitation sustainability condition of two water management units in the Rio Grande Basin (BHRG): GD1 (Alto Rio Grande) and GD8 (Baixo Rio Grande), Brazil, considering water supply, sewage disposal, and solid waste disposal. The results of this study display the potential to contribute to action-planning and decision-making to reach the SDG 6 up to 2030.

2 Methodology

2.1 Study Area

The River Grande Basin (BHRG) is located in southeastern Brazil. The river basin contribution area is of 144,689.54 km^2, divided between the states of Minas Gerais (MG)—60% of the total basin area and São Paulo (SP)—40% of the total basin area. The BHRG comprises 393 municipalities, totally or partially inserted in the basin, housing 8.6 million people, corresponding to 4.5% of the Brazilian population in 2010 (ANA 2016). Inserted in the Paraná Hydrographic Region, one of the most important hydrographic regions in Brazil, the river basin is subdivided into 14 water management units (UGHs). UGHs are administered by state river basin committees and are given different names in MG and SP. In MG, the eight UGHs affluent to the Rio Grande are called UPGRHs—Water Resource Planning and Management

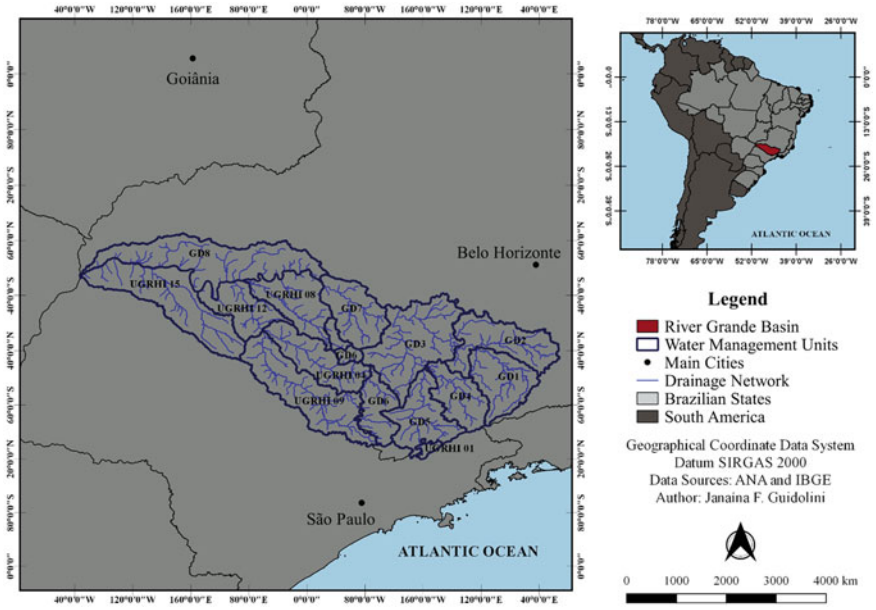

Fig. 1 River Grande Basin and its respective Water Management Units (UGHs)

Units, coded "GDs". In SP, the six UGHs affluent to the Rio Grande are known as "UGRHIs"—Water Resource Management Units (IPT 2008) (Fig. 1). Most of recorded water use conflicts at the River Grande Basin relate to environmental sanitation (sewage and solid waste), diffuse pollution due to agricultural activities and soil erosion (Guidolini et al. 2018a).

This study selected two water management units in MG, GD1 (Alto Rio Grande) and GD8 (Baixo Rio Grande). The selection was based on the analysis carried out by Guidolini et al. (2018b), who characterized Rio Grande Basin water management units. GD1 presents the lowest Municipal Human Development Index (MHDI) and the lowest proportion of agricultural area of the Rio Grande Basin. In contrast to GD1, GD8 presents the highest HDI among MG water management units and the highest proportion of agricultural area of the basin. In addition, GD8 is highly industrialized and urbanized. GD1 is the least economically exploited and comprises the smallest population among the Rio Grande Basin water management units in MG.

2.2 Selection of the Evaluation Indicator System

The sustainable development indicators used herein were selected considering important variables for monitoring Law nº. 11445/2007, the scientific literature and to reach the aforementioned sustainable development goal SDG 6 (to ensure the availability

and sustainable management of water and sanitation for all). Indicator selection was also limited to data availability and frequency.

Despite their limitations, the selected indicators allow for sanitation sustainability condition of the and can aid in the planning and fulfillment of both the PLANSAB and SDG6 stated goals for GD1 and GD8.

It is important to note that data were used at the municipal scale. Subsequently, the average between the GD1 and GD8 municipalities was calculated to obtain the final value for each indicator and for each water management unit. In addition, data from the Brazilian Atlas of Human Development are only available for 1991, 2000 and 2010. Therefore, the data for the unavailable periods were estimated by applying linear regression equations. The indicator system and data source definitions are presented in Table 1.

Table 1 Indicators and data source definitions

Indicators	Measure	Resources	Desirable trend
Social subsystem			
S1	Water Supply Public Network (no. families)	Basic Attention information System/SIAB (2008–2014)	+
S2	Garbage Collection (no. families)	Basic Attention Information System/SIAB (2008–2014)	+
S3	Sewage Collection (no. families)	Basic Attention Information System/SIAB (2008–2014)	+
S4	Complete Elementary School (≥18 years old) (%)	Brazilian Human Development Atlas (1991/2000/2010)	+
S5	Untreated Water (no. families)	Basic Attention Information System/SIAB (2008–2014)	–
S6	Child Mortality (%)	Brazilian Human Development Atlas (1991/2000/2010)	–
S7	People Hospitalized with Waterborne Diseases (no.)[a]	Basic Attention Information System/SIAB (2008–2014)	–
Economic Subsystem			
E1	Gross Domestic Product (R$ 1.00)	Brazilian Institute of Geography and Statistics/IBGE (2008–2014)	+
E2	Per Capita Income (R$)	Brazilian Human Development Atlas (1991/2000/2010)	+

(continued)

Table 1 (continued)

Indicators	Measure	Resources	Desirable trend
E3	Activity Rate (≥18 years old)-%	Brazilian Human Development Atlas (1991/2000/2010)	+
E4	Hospitalization Average Cost (R$)	Basic Attention Information System/SIAB (2008–2014)	–
E5	GINI Index (dimensionless)	Brazilian Human Development Atlas (1991/2000/2010)	–
Environmental Subsystem			
ENV1	Dissolved Oxygen ($mg.L^{-1}$)	National Water Agency/ANA (2008–2014)	+
ENV2	Total Coliforms (NMP[b]/100 mL)	National Water Agency/ANA (2008–2014)	–
ENV3	Biochemical Oxygen Demand ($mg.L^{-1}$)	National Water Agency/ANA (2008–2014)	–
ENV4	Total Phosphorus ($mg.L^{-1}$)	National Water Agency/ANA (2008–2014)	–
ENV5	Nitrate ($mg.L^{-1}$)	National Water Agency/ANA (2008–2014)	–
ENV6	Ammoniacal nitrogen ($mg.L^{-1}$)	National Water Agency/ANA (2008–2014)	–

[a]Cholera, Typhoid and Paratyphoid Fevers, Shiguelosis, Amebiasis, Diarrhea and Presumed Gastroenteritis Infectious, and Schistosomiasis
[b]Most Probable Number

2.3 Entropy Weight Method for the Assessment of Environmental Sanitation Sustainability Conditions

The entropic weight method for weighting indicators and subsystems is explained by Toumi et al. (2017). The methodological steps for calculating the Environmental Sanitation Sustainability Conditions Index (CSS) are presented in Fig. 2. This overall indicator allows for the definition of a 5-grade evaluation criteria of the overall sustainable development level referring to the evaluation criteria of sustainable development level resources. This coefficient reflects the development situation and trend for the GD1 and GD8 water management units at the River Grande Basin. These grades are displayed in Table 2.

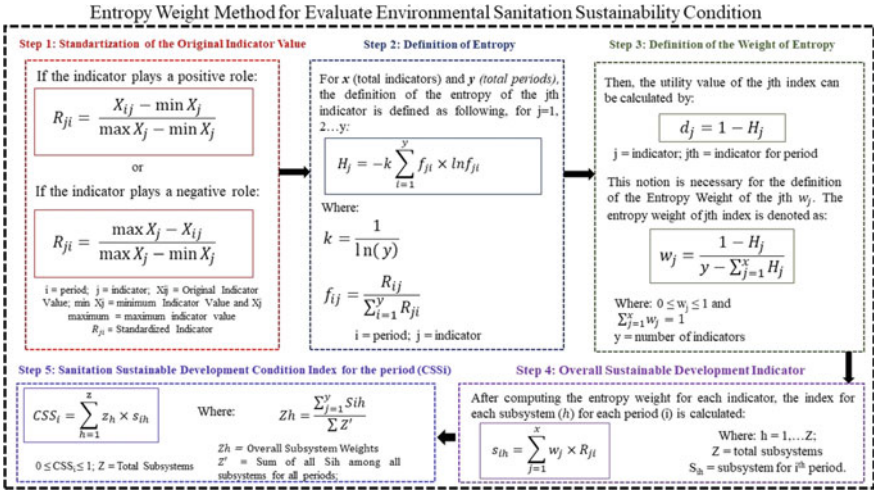

Fig. 2 Methodological steps for calculating the Environmental Sanitation Sustainability Condition Index (CSSi)

Table 2 Overall sustainable development classification

Level	[0;0.2]	[0.2;0.4]	[0.4;0.6]	[0.6;0.8]	[0.8;1]
State	No sustainable development	Weak sustainable development	Basic sustainable development	Sustainable development	Strong sustainable development

Adapted from Toumi et al. (2017)

3 Results

3.1 Entropy and Information Weights of the Selected Indicators

The information weight of the selected indicators is presented in Table 3.

GD1: The social subsystem highlighted the following indicators: S6 (Child Mortality-%) and S7 (People Hospitalized with Waterborne Diseases—no.) with lower entropies and higher information weights. For S6, entropy was 90.31% and information weight was 0.4080. The results were similar for S7, at 90.30% entropy and 0.4086 information weight. The indicators highlighted in the social subsystem represented 81.66% of the total information weight for this subsystem.

The economic subsystem highlighted indicators E5 (Gini Index—dimensionless) with entropy of 25.87% and information weight of 0.2895, and E2 (Income per capita—R$), at 38.19% entropy and 0.2414 information weight. The indicators

Table 3 Indicator weights in each of the sustainable development subsystems

Indicators	GD1 (Alto Rio Grande)	GD8 (Baixo Rio Grande
Social indicators		
S1	0.0360	0.1215
S2	0.0054	0.1073
S3	0.0059	0.1508
S4	0.0235	0.0147
S5	0.4080	0.2913
S6	0.4086	0.2534
S7	0.1450	0.0580
Economic indicators		
E1	0.1388	0.1944
E2	0.2414	0.0099
E3	0.1387	0.0094
E4	0.1916	0.2234
E5	0.2895	0.5629
Environmental indicators		
ENV1	0.1293	0.2241
ENV2	0.2132	0.1805
ENV3	0.1245	0.1642
ENV4	0.1920	0.1545
ENV5	0.2073	0.1403
ENV6	0.1337	0.1363

highlighted in the economic subsystem represented 53.09% of the total information weight for this subsystem.

For the environmental subsystem, indicators ENV2 (Total Coliforms—NMP/100 mL), ENV5 (Nitrate—mg.L^{-1}) and ENV4 (Total Phosphorus—mg.L^{-1}) presented lower entropy and higher information weights, at 60.71%/0.2032; 61.78%/0.2073 and 64.61/0.1920, respectively. The indicators highlighted in the environmental subsystem represented 61.25% of the total information weight for this subsystem.

GD8: The social subsystem highlighted indicators S5 (Untreated Water—no. families) and S6 (Child Mortality-%) with lower entropies and higher information weights. For S5, entropy was calculated at 73.09% and information weight was of 0.2913. For S6, an entropy value of 76.59% and 0.2534 information weight were observed. The indicators highlighted in the social subsystem represented 54.47% of the total information weight for this subsystem.

The economic subsystem highlighted indicator E5 (Gini—dimensionless index) with entropy of 79.08% and information weight of 0.5629, thus representing 56.26% of the total information weight for this subsystem.

For the environmental subsystem, the ENV1 (Dissolved Oxygen—mg/L) indicator presented the lowest entropy (64.73%) and higher information weight (0.2241), followed by ENV2 (Total Coliforms—NMP/100 mL), at 71.58% entropy and 0.1805 weight information. These indicators represented 40.46% of the total information weight for this subsystem.

3.2 Subsystem Weighting

The subsystem weights (*Zh*) are presented in Table 4. The subsystems displayed similar weights for both study areas. At GD1, the social subsystem presented 0.2446 weight, the economic subsystem, 0.3964 and the environmental subsystem, 0.3590.

Table 4 Environmental Sanitation Sustainability Condition (CSS) indicators at GD1 and GD8

Period	GD1 (Alto Rio Grande)	GD8 (Baixo Rio Grande)
Social indicators of sustainable development		
Zh	0.2446	0.2539
2008	0.5444	0.3507
2010	0.3541	0.5897
2012	0.2750	0.2614
2014	0.1379	0.1117
Economic indicators of sustainable development		
Zh	0.3964	0.3935
2008	0.3929	0.6617
2010	0.2265	0.1353
2012	0.5805	0.6586
2014	0.9252	0.5780
Environmental indicators of sustainable development		
Zh	0.3590	0.3526
2008	0.2316	0.5041
2010	0.3800	0.5198
2012	0.5708	0.5041
2014	0.7423	0.2952
Environmental Sanitation Sustainability Condition Index (CSS)		
2008	0.3721	0.5271
2010	0.3128	0.3861
2012	0.5023	0.5033
2014	0.6070	0.3603

At GD8, the social subsystem presented 0.2539 weight, the economic subsystem, 0.3935 and the environmental subsystem, 03526.

Thus, the economic and environmental subsystems at the two Rio Grande Basin water management units are noted as presenting great responsibility in achieving sustainable sanitation conditions, corresponding to approximately 74% of the total weight.

3.3 Sanitation Sustainability Condition Index (CSS) at GD1 and GD8 During the Analyzed Study Periods

The Sanitation Sustainability Condition Index (CSS) at GD1 and GD8 are presented in Table 4 for each analyzed period. At GD1, the sanitation sustainability condition, in general, evolved from 2008 to 2014. In 2008, this unit reached a CSS of 0.3721, decreasing to 0.3128 in 2010, increasing again to 0.5023 in 2012 and ending 2014 with a CSS of 0.6670. Thus, between 2010 and 2012, GD1 was characterized by a weak stage of sustainable development concerning sanitation, evolving to the basic stage of sustainable development for sanitation between 2012 and 2014.

On the other hand, GD8 regressed sanitation sustainability conditions between 2008 and 2014. In 2008, this unit reached a CSS of 0.5271, decreasing to 0.3861. In 2012, an increase to 0.5033 was observed, but another decrease was again noted in 2014, to 0.3603. Thus, in 2014, GD8 was characterized as at a weak sanitation sustainable development stage.

4 Discussion

The application of the Entropy Weight Method allows for the measurement of the amount of useful information provided by the sustainability indicator. When the magnitude of the value among the evaluation objects for the same indicator is high, entropy is low (Zhi-Hong et al. 2006). Therefore, the indicator will provide more useful information, and its weight will be higher. The indicators with the highest weight and the lowest entropy for the GD1 and GD8 social subsystems were S6/S7 (Infant Mortality and Number of Hospitalizations for Waterborne Diseases) and S5/S6 (Untreated Water and Infant Mortality), respectively. These indicators adequately reflect the sanitation situation in the assessed water management units. Despite the notable advance of the sanitation sector throughout the study period, a significant distance to sanitation service universalization is still noted. In addition, advance occurs very unevenly.

In 2013, GD1 comprised a population of approximately 363 thousand people. The treated sewage collection rate was of only 12.8%, while GD8 presented a sewage collection rate of 43% during the same period and housed a population of approximately

536.3 thousand people (ANA 2016). It is noteworthy that 5221 families defecated in the open-air at GD1 in 2013. At GD8, 343 families were in the same situation (SIAB 2013).

The number of households without access to treated water was of 19.54% at GD1 and 28.55% at GD8 in 2013. During the same period, water distribution losses from the supply networks reached 19.2% and 30.3% at GD1 and GD8, respectively (ANA 2016).

Concerning garbage collection, 14% and 6% of the households did not have their garbage collected at GD1 and GD8 in 2013, respectively. Improvements in water quality, basic sanitation and hygiene conditions can reduce diseases, especially in the most vulnerable age groups, such as children and the elderly (Paiva and Souza 2018). High infant mortality rates are yet another consequence of inadequate sanitation conditions. Despite decreasing over the years, infant mortality rates are still high at both water management units.

The Brazilian sanitation sector displays serious shortcomings, as most institutions in this sector are unequal and fragmented, due to a decentralized regulatory model (ABES 2018). In addition, discrepancies between sanitation infrastructures are also noted. GD8 clearly presents a better infrastructure in relation to GD1, which may have influenced the information weight of S6 and S7 social subsystem indicators, which were significantly higher at GD1.

The economic subsystem at GD1 highlighted indicators E2 (Income per capita) and E5 (Gini index), which measure the degree of inequality in the income distribution of a population, with higher information weights and lower entropy. The GD8 economic subsystem also highlighted indicator E5. Per capita income increased slightly over the years, although inequality in income distribution at the two water management units did not occur linearly throughout the study periods. In 2010, both GD1 and GD8 achieved the lowest Gini Index or lower inequality in the income distribution of the population for the analyzed period. The per capita income of the poorest 10% grew 69% between 2001 and 2009, while the gain was of 12.58% among the richest 10%. The average per capita income of Brazilians in this period rose 23.7% in real terms (Neri 2011).

Income distribution is directly related to educational level. Higher incomes per capita and GDP (Gross Domestic Product) are observed at GD8 when compared to GD1. The schooling rate (complete elementary school) among people aged 18 years and over is higher in GD8. Salvato et al. (2010) concluded that the higher the income percentile considered, the greater the contribution of differences in schooling to differences in income. Moreover, the income dispersion of the poorest regions increases when the education level of the richest regions is provided, maintaining the salary profile of the region.

In 2009, hospitalization costs for gastrointestinal infections in the Unified Health System (SUS) were of about R$ 350 (national average). This led to public expenditures of R$ 161 million in the same year in treating infected people in the hospital (Instituto Trata Brasil 2018). At GD1, the cost of hospital admissions for waterborne diseases between 2008 and 2014 was of R$ 83,928.59. At GD8, this expense

was of R$ 161,482.10. These expenditures could have been avoided by investing in sanitation service infrastructure, quality, universalization, and fairness (SIAB 2013).

Finally, the environmental subsystem was represented by the main water quality parameters. The environmental subsystem at GD1 highlighted indicators ENV2 (Total Coliforms), ENV4 (Total Phosphorus) and ENV5 (Nitrate) as presenting lower entropy and higher information weights. GD8 highlighted the AMB1 (Dissolved Oxygen) and AMB2 (Total Coliforms) indicators as presenting lower entropies and higher information weights. In general, water quality parameters were within the limits established by current Brazilian state and federal legislations, namely Joint Legislative Resolution COPAM/CERH-MG nº. 1 of May 1st 2008, and Conama Resolution nº. 357, dated March 17th 2005, which provide water body classifications and environmental guidelines for their setting and establish the conditions and standards for effluent discharges and other measures.

However, high concentrations of total coliforms were observed for both GD1 (18612 NMP/100 mL) and GD8 (49147 NMP/100 mL) from 2012 to 2014, with the limit being up to 5000 NMP/100 mL. Considering the significant number of families that defecate in the open air, high total coliform values were expected. Bacteria from the coliform group are present in the gut of warm-blooded animals and humans, and are eliminated in high numbers in feces (10^6 g/ 10^8 g). The coliform group includes bacteria that are not exclusively fecal and can occur naturally in soil, water and plants. In addition, coliforms display the capacity to multiply in water, especially in tropical climates (OMS 1995).

Although the ENV4 and ENV5 indicators were within the allowed limits at GD1 throughout the analyzed period, attention must be paid to the fact that these indicators tend to increase over time and can cause water eutrophication, as well as undermine population health.

At GD8, the ENV4 indicator was above the limit established in the legislation (up to 0.05 mg/L in lotic environments) (COPAM 2008), reaching 0.45 mg/L from 2012 to 2014 at GD8. In addition, it is necessary to take into account the low dissolved oxygen value (6.12 mg/L) and high biochemical oxygen demand (3.72 mg/L) and ammoniacal nitrogen (1.62 mg/L) values at GD8. The statutory limits for these parameters are $\geq$6 mg/L (CONAMA 2005), up to 5 mg/L and up to 3.7 mg/L, respectively.

In view of this, the economic and environmental subsystems presented the highest information weights, as they relate to (1) access to sanitation services and the quality of life of the population and (2) environmental quality, especially water quality, which directly affects public health. Thus, the results for the social subsystem in this study reflect the impacts of economic development and environmental quality on the local populations. In addition, the imbalance between the social, economic and environmental subsystems within and between the assessed water management units was also evidenced.

When analyzing the data collected by the entropic weight method, the low sustainability stages of GD1 and GD8 sanitary conditions were expected and emphasize the need for attention to this sector.

Concerning economy, sanitation is considered a strategic sector in a country's development perspective as investment expansion would promote improved population health and environmental quality, as well as create job openings. Investments in sanitation, from a social perspective, are essential to reduce poverty. However, from an economic development perspective, they also add value to a number of other activities, such as real estate production and tourism. From an economic and financial point of view, the importance of the sanitation sector to Brazil is characterized by the expressive volume of resources handled both by companies directly responsible for the provision of sanitation services and by those linked to the industrial sector that produce equipment and services for the sanitation sector (Britto and Bessa 2009).

Thus, the sanitation sector, both at GD1 and GD8, still displays many challenges to be faced in the coming years concerning universal, equitable and comprehensive access to sanitation services and compliance with the SDG 6 to occur up to 2030. The scarcity of non-burdensome resources due to the current fiscal crisis (from 2014 to the present day) and the end of the disqualification due to the PAC (Growth Acceleration Program) are some of the greatest current challenges is the search for investment resource sources. Another important challenge to be overcome is the significant fragmentation between environmental policies and social and economic development policies (intersectionality), which require integration in search of transdisciplinarity, aiming at knowledge unification.

The entropic weight method presented results compatible with the real GD1 and GD8 situations. However, this method displays some limitations, and the results presented herein are restricted to its methodology. Thus, generalizations for different periods, other work scales and different indicators are not possible.

The present study is useful for future research, especially those aimed at compliance with the SDG 6 in Brazil, and provides appropriate theoretical and practical implications of the evaluated indicators for assessing sanitation conditions under the sustainable development scenario.

5 Conclusions

From 2008 to 2014, sanitation at GD1 showed improvements (especially from 2012 to 2014), from a "weak stage of sustainable development", with a CSS of 0.3721 to "basic or intermediate stage of sustainable development, with a CSS of 0.6670. However, GD8 presented worsening conditions from 2010 2014 compared to 2008. The sustainability condition of GD8 sanitation in 2010 was at a "basic or intermediate stage of sustainable development" with a CSS of 0.5271, decreasing to a "weak stage of sustainable development", with a CSS of 0.3603, in 2014.

The economic and environmental subsystems corresponded to approximately 74% of the total weight for both GD1 and GD8, with significant responsibility in the sanitation sustainability condition of both water management units during the analyzed period. The impacts of economic development and environmental quality on the human subsystem also became evident in this study.

The most noteworthy indicators presenting less entropy and higher information weights were, for GD1: Human Subsystem (S6 and S7); Economic Subsystem (E2 and E5) and Environmental Subsystem (ENV2, ENV4, and ENV5) and for GD8: Human Subsystem (S5 and S6); Economic Subsystem (E5) and Environmental Subsystem (ENV1 and ENV2).

The entropic weight method displays limitations, and the results presented herein are restricted to its methodology. Thus, generalizations for different periods, other work scales and different indicators are not possible. However, this method presents results more compatible with the real situation of the study areas.

Sustainability assessment studies are critical to assist decision-making in meeting the United Nations sustainable development goals set for 2030. Despite the limitations of the applied method, this approach is useful for future research, especially those aiming at meeting the SDG 6 in Brazil, and provides theoretical and practical indicator implications concerning sanitation condition assessments under the sustainable development scenario.

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Sustainability in the Decision Making Process: A Systematic Review of Literature

Rafael Felix da Silva and Edelvino Razzolini Filho

Abstract The concept of corporate sustainability, based on three essential pillars—economic, social and environmental—represents the evolution of a continuous process of paradigms break. In this evolution, the focus of the business management changes from a one-dimensional view—ruled, exclusively, by profit-driven—to a perspective that also considers social and ecological aspects, in the decision-making processes. This conception was established as a strategic approach and an innovative way to promote the sustainable development. Therefore, the aim of this article consists of investigating how the publications in national and international journals approach the relationship between sustainability and decision-making process between 2008 and 2017. For this purpose, an exploratory study is held, supported by Systematic Literature Review (SLR), for which the search and analysis procedure will take place in four database (Capes Journals Portal, Scopus, Science Direct and Scielo), using the SLR Roadmap as reference. Thus, this study seeks to clarify aspects related to the way the issue has been researched, as well as providing analyses that can contribute to the goals achievement proposed by United Nations (UN) in the document "Transforming our world: the 2030 Agenda for Sustainable Development". It is possible to conclude that there are academic studies that relate corporate sustainability to decision making. This subject matter gained greater prominence in the academic field in the last few years. The concept of sustainable development proposed by the United Nations advocates three dimensions of sustainability although, in the studies investigated the environmental dimension was predominant.

Keywords Sustainable development · Business management · Academic production

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1 Introduction

The Sustainable Development, as defended in the Report of Our Common Future of the World Commission on Environment and Development (WCED) (1988) advocates meeting the needs and aspirations of the present generation without compromising the ability of future generations to do the same.

Elkington (2011) ratifies this understanding by proposing the Triple Bottom Line (TBL), a concept based on three essential pillars (PPP-Profit, People and Planet), interpreting sustainability through integration of economic, social and ecological perspectives.

TBL presents itself as a tool to support decision makers (Maia and Pires 2011), enabling the elaboration of parameters and measurement of corporate performance, based on perceptions, procedures, and precepts formulated in order to reduce the resulting negative impacts of organizational activity and generate value to its stakeholders (Petrini 2006).

However, the adoption of a decision-making process based on sustainable principles is still considered a challenge (Martínez and Bringas 2014), since it requires the decision maker to deal with unstructured problems, composed by subjective and contrasting variables, simultaneously (Guerry et al. 2015).

Whereas supporting organizations to make decisions in a sustainable way can help the world to develop in a fairer and more harmonious way, and the academy has the relevant instruments to provide such aid, it is proposed as an objective to investigate how publications in national and international journals, addressed the relationship between corporate sustainability and decision making in the period between 2008 and 2017.

It is noticed that the analysis of this theme presents contributions of academic and practical nature, since a theoretical framework will be generated for future studies, as well as a current and reliable picture of the main scientific discoveries in this area, subsidizing the organizations in the implementation of actions that stabilize the various dimensions of sustainability.

The present study is structured in five sections: the first, introductory; the second presents the theoretical foundations that underpin the research; the third describes the methodology used; the fourth analyzes and discusses the results found; and the fifth presents the conclusions and suggestions for future studies.

2 Theoretical Grounding

In the continuation, the essential concepts that support the present work are presented, firstly outlining the Sustainable Development, to next address the Business Sustainability, finishing this foundation with an explanation about Sustainable Decision Making.

2.1 Sustainable Development

The massive expansion of economic activity initiated after the Industrial Revolution produced a context of significant transformations, both in the environment and in society (Maddison 2007), causing a significant increase in the average standard of living in financially wealthy countries at the same time in which the emergence of diverse problems around the world, among them the climatic changes, the disorderly population growth and the elevation of the indices of misery in underdeveloped regions (Intergovernmental Panel on Climate Change 2014; National Climate Assessment 2014; Risk Business Project 2014; Steffen et al. 2015).

The search for an understanding of the factors that permeate these transformations motivated the United Nations (UN) to establish a debate agenda marked by the holding of world conferences, such as Stockholm in 1972, and Nairobi, 1982 (Feil et al. 2013) that would culminate in the elaboration of a concept of sustainable development, proposed in 1988 in the Report Our Common Future and widely disseminated in the Rio 92 Conference.

According to the World Commission on Environment and Development (1988), "sustainable development seeks to meet the needs and aspirations of the present without compromising the possibility of serving them in the future."

Sustainable development, according to this definition, reveals itself as a new paradigm, as it seeks to break with exploration and consumption patterns, focused exclusively on profit making, aiming at a more comprehensive perception of sustainability, composed of multiple dimensions (Lemos 2010).

It is important to note that, although widely accepted, this conception is also criticized, and it is considered by some authors as "vague" (Clifton and Amran 2011), "static" (Raatzsch 2012) and excessively focused on "needs" human capacities (Sen 2011).

In the present study, the concept defended by CMMAD is accepted, understanding that sustainable development is not a science or technique, but rather, according to (Martinez and Bringas 2014) a normative-guiding principle that, in order to be operationalized, needs political, social and organizational engagement.

Clarifying what is sustainable development, it is necessary to understand this issue in the business sphere, about what is discussed below.

2.2 Business Sustainability

The business activity was directly related to sustainable development, through the Triple Bottom Line (Ciegis et al. 2009), a proposal of corporate sustainability outlined by Elkington (2011) structured in the same dimensions of sustainability as those employed by CMMAD.

The TBL aims to integrate the economic, social and ecological perspectives of the companies, directing the decisions and actions related to the organizational man-

agement, associating the ideals of corporate social responsibility and sustainability (Maia and Pires 2011).

Thus, corporate sustainability emerges as a way of guiding the actions of entities, in an environment that has required increasingly agile responses and decisions, in order to reconcile concerns such as expansion of profit margin, competitiveness and cost reduction, to values and ethical goals (Raynard and Forstarter 2002).

Business sustainability is intended to help companies act responsibly, balancing the interests of a broad group of stakeholders, and strategically managing not only the potential impacts occasioned by their activities, but also effectively collaborating for social development and preservation of the Environment (Brazilian Institute of Corporate Governance 2018).

However, it is noteworthy that organizational changes directed towards sustainability are still very difficult to achieve by companies (Passeti et al. 2014).

In this sense, Whiteman et al. (2013) argue that organizations must accept the existence of a "safe operating space" for their actions, capable of improving living conditions on the planet, without prejudice to their activities or new business opportunities.

Understanding that many socio-environmental problems are caused by business decisions, taken in simple and fragmented processes, aiming only the attendance of economic issues, makes urgent the debate regarding the improvement of a decision-making process that considers all the complexity related to the sustainable approach (Schaltegger et al. 2013; Munda 2006).

Once the importance of sustainability for organizations is established, it is necessary to understand how decision-making processes occur in this context.

2.3 Sustainable Decision Making

In the organizational context, it is possible to conceptualize decisions as being the "result of choices", solutions that minimize uncertainties or reduce ambiguities (Peterson and Blomberg 1999). Consequently, decision making would be the cognitive process that results in the selection of an option or a course of action among several possible alternatives (Schultz et al. 2015).

The decision-making process, theoretically, should be composed of a "rational process" in which decisions would be based on well defined criteria and strategies (Goldman et al. 2012). However, reality shows that decision-making, often, occurs in "nebulous", fragmented and subject to diverse interference (National Ecosystem Assessment 2011).

It should be pointed out that an objective increasingly pursued by organizations is "to make informed decisions on information and knowledge". However, it can be observed that more subjective factors such as ideologies, values, norms, interests, power relations, institutional context, among others, have the potential to greatly influence decision makers (Folke et al. 2002; Goldman 2012).

This seems to be the case of corporate sustainability, characterized by divergent values and norms among decision makers. The high uncertainty about causes, solutions and risks implies the decision maker to choose alternatives that refer to personal experiences and interests (Maia and Pires 2011).

According to Guerry et al. (2015), corporate sustainability would only become a concept that can be implemented in an organization as a whole, based on its systematic insertion in decision-making processes. Christen and Schmidt (2011) believe that corporate sustainability must be seen as a decision-making strategy, allowing them to transform their "action guiding" power into a decision strategy.

We can conclude that organizations face the challenge of "changing their priorities" (Jamali 2006), countering social and environmental concerns with economic results (Cintra and Carter 2012). However, there is still a long way to go so that shared concern and discourse about corporate sustainability can achieve the real implementation of its principles (Intergovernmental Platform on Biodiversity and Ecosystem Services 2012).

These being the essence concepts for the purpose of this work, in the continuation one talks about the methodological routing adopted for the same one.

3 Methodological Routing

In order to investigate the way publications in national and international journals have addressed the relationship between corporate sustainability and decision-making processes, an exploratory research based on a Systematic Bibliographic Review (RBS) has been developed.

RBS is a technique used to search and analyze productions of a given field of knowledge (Conforto et al. 2011), according to Kitchenham (2004) with the purpose of identifying, evaluating and interpreting published papers, adherent to a question or phenomenon of interest.

The selection of RBS to solve the proposed problem occurred because it enables the careful and reliable verification of research already performed within a specific theme (Bereton et al. 2007), allowing the explanation of existing contributions, gaps and trends in a domain or area of science.

In addition, RBS allows, by means of statistical procedures, to make evaluations and inferences, only possible, based on the meeting of different perspectives in the work investigated (Tranfield et al. 2003).

During this exploration, the steps in the Systematic Bibliographical Review (RBS), proposed by Conforto et al. (2011), were noted, with reference to the RBS Roadmap. It consists of 3 phases, namely: Entrance, Processing and Exit.

3.1 Conduct of Systematic Bibliographic Review

Following the above-mentioned roadmap, RBS was approached to look for answers to the problem "how publications in national and international journals addressed the relationship between corporate sustainability and decision-making in the period 2008–2017?", object of this research.

The search strategy—strings—was elaborated based on a review of preliminary bibliography, in which the recurrent use of some terms was verified. These, after a process of verification, adjustments and tests of word combinations and Boolean operators, resulted in the following search strategy: "Decision Making" the main term, along with "Corporate Sustainability", "Sustainable Development" and "Triple Bottom Line."

It was decided to use the terms in English, considering that it would broaden the scope of the research, since, regardless of the language in which the articles were originally written, the indexes: title, abstract and keywords are also marked in that language.

It was considered, as a criterion for inclusion of the retrieved publications, the context in which the subjects investigated were inserted. Thus, articles dealing with sustainability and decision making in a scenario other than the business environment, would be discarded, because they did not meet the objective of this research.

It was chosen, the joint approach of the researched subjects as qualification criterion, that is, studies that relate business sustainability and decision-making processes. It should be emphasized that the investigated universe comprises the period between 2008 and 2017, a temporal window that could present an updated panorama of the main ideas that permeate the subject matter.

The selected strings were applied in four databases: Capes Periodicals Portal, Scopus, Science Direct and Scielo. These databases are online platforms that allow access to scientific publications from various countries and areas of knowledge.

Initially, it was conceived the accomplishment of the searches of the strings in the titles, abstracts and keywords of the publications, that happened in the bases Science Direct and Scopus. As the other bases did not provide this option, it was necessary to adapt the searches in the Capes Newspapers Portal (in the subject) and Scielo (all indices). Due to this adaptation, the number of articles, recovered and later excluded, in these two platforms was superior to the others (Table 1).

The application of the keywords, in the four bases selected, resulted in the recovery of 3653 jobs. It should be noted that the number of publications found in Capes Portal represents approximately 68% of the total. This fact can be explained by two reasons. The scope of the search in this base was greater (subjects) than the others (title, abstract and keywords), and apparently the system of this base has disregarded the logical operator Boolean "and", which requests the retrieval of publications that present both themes surveyed together, returning articles that contained at least one of the themes, which configures the logical operator "or".

The above circumstance motivated an additional procedure in the papers returned in Capes Portal. These were submitted to an investigation that sought to verify the

Table 1 Research results in databases according to search strategy

Search strategy						
		Capes portal	Scopus	Science direct	Scielo	Total
Keywords	"*Decision Making*" and "*Corporate Sustainability*"	36	12	3	2	53
	"*Decision Making*" And "*Sustainable Development*"	2430	963	101	60	3554
	"*Decision Making*" And "*Sustainable Development*"	17	19	7	3	46
	Total found articles (nofilter)	**2433**	**994**	**111**	**65**	**3653**
Filters	Verification of atendance of the search strategy (Capes Portal and Sclelo—less 2.277 articles)	235	994	111	36	1376
	1st Filter (Reading of the title, abstracts andkeywords—less 1.233 articles)	63	75	13	27	93
	2nd Filter (Exclusion of Duplicities—less 35articles)	22	21	5	10	53
	3rd "Filter (Reading of the introduction and conclusion—less 41 articles)	10	5	1	1	17
Total of publications adhering to the scope of the research		**10**	**5**	**1**	**1**	**17**

Source Prepared by the authors (2018)

occurrence of the strings in the title, abstract and keywords, excluding articles that did not fit the search strategy used. This filter was also applied to articles obtained in the Scielo database, since the search in this platform was performed in "all indices".

It should be noted that the terms "Decision Making" and "Sustainable Development" have returned a number of papers that are much higher than the others, this can be better understood after the first filter, which demonstrated the realization of several studies that deal with sustainable development in several contexts other than the enterprise, unlike the other strings that had application closer to the purpose of this analysis.

The first filter consisted of thorough reading of titles, abstracts, and keywords. The publications that were apparently aligned with the survey objective were selected for the next filter and the remaining 1283 papers were disregarded for this review. It should be noted that due to the brevity of some abstracts, the first filter was not enough to prove that the publication met the objectives and inclusion criteria. Hence, it was decided to submit the remaining articles to other filters.

It was verified the occurrence of duplicate articles recovering, since four bases and three types of strings were used, in this way the 2nd filter consisted of the verification, and later exclusion of 35 repeated papers.

The remaining 58 articles went through the application of the 3rd filter (reading of the introduction and conclusion of the papers), which resulted in the permanence of 17 articles that fit the scope of this analysis.

For the analysis of these papers a script was established, including: the temporality of the publications, the authors' nationality, the number of journals, the use of keywords, types and methodologies of research, main research findings, and mainly, business sustainability to decision making.

4 Analysis and Discussion

When considering the 17 publications selected for this review, it was possible to carry out analyzes, segmented in two perspectives. The first one will present a detailing of elements that compose the productions. While the second, will discuss the forms of relationship found in the revised papers, as will be seen below.

4.1 Detailing of Papers

In this section we will describe some elements that compose the articles researched, in order to provide a better understanding of the investigated problem, such as journals in which the research was published, the researchers' country of origin and the number of productions per period.

Table 2 Publications by magazine

Magazine	Number of Publications
Integrated Environmental Assessment and Management	1
International Journal of Sustainability in Higher Education	1
Journal of Cleaner Production	5
Journal of Global Responsibility	1
PNAS	1
RAM-Revista de Adm. Mackenzie	1
Springer Science	1
Supply Chain Management: An International Journal	1
Sustainability Journal	2
The British Accounting Review	1

Source The authors (2018)

4.1.1 Newspapers

This review consisted of 17 articles, of which 15 were published in scientific journals, while 2 were reported in international events. It should be noted that the aforementioned events addressed sustainability in the area of Production Engineering.

The remaining articles were published in 10 journals, and 5 of them, approximately 30%, were published in the same journal, the Journal of Cleaner Production—JCP.

The JCP is an international journal, transdisciplinary, focused on the research and practice of clean, environmental and sustainable production, according to the information on its own website, with an impact factor of 5651, in the year 2017.

The following is a table containing the journals in which the investigated articles were published, as well as the number of publications related to each one.

It is now timely to point out that among the journals that make up Table 2, there is only one Brazilian, RAM, Mackenzie's Journal of Management, "whose mission is to contribute to the excellence of academic activities in the area of business management knowledge via the dissemination of scientific papers" (Mackenzie Journal of Management 2018).

4.1.2 Authors

Regarding the authors of the reviewed articles, it is possible to infer a tendency to carry out collaborative papers, due to the partition of 44 authors in the preparation of the 17 studies, and in only 4 cases the papers presented a single author.

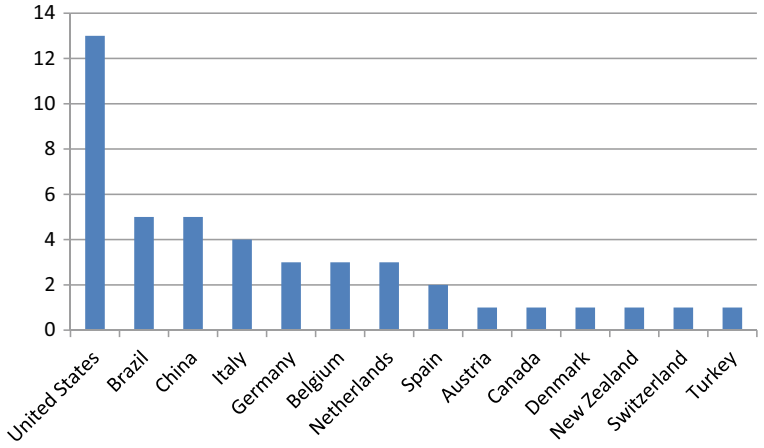


Fig. 1 Authors by country. *Source* The authors (2018)

Still regarding the researchers, chart 1, below, highlights the distribution of the authors by country, where it is noted, predominance of North American authors 13, followed by Brazilians and Chinese, 5 each.

It is worth noting the absence of scholars of African origin, the only continent not represented in the chart (Fig. 1).

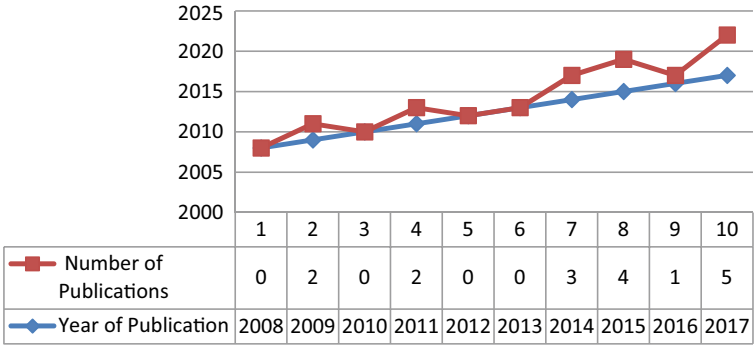
One of the probable reasons for the significant number of Brazilian authors is the use of two national databases—CAPES and Scielo Periodical Portal—to carry out the initial survey, which may have contributed to a larger number of Brazilian productions recovered.

4.1.3 Publications Per Year

Regarding the number of productions occurred in each year under investigation, it can be verified, according to Fig. 2, that the thematic has changed from a stable situation, between the years of 2008 and 2013, when few papers were published, for an increase, with high propensity, initiated in 2014, reaching its highest level (5 publications) in 2017.

4.2 Relationship Between Corporate Sustainability and Decision Making

At this moment, questions will be analyzed and debated regarding how the investigated publications related Corporate Sustainability and Decision Making. Atlas TI. software was used for this analysis and techniques of Content Analysis, a method



	1	2	3	4	5	6	7	8	9	10
Number of Publications	0	2	0	2	0	0	3	4	1	5
Year of Publication	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017

Fig. 2 Publications per year. *Source* The authors (2018)

that, according to Bardin (2009), allows analyzing several forms of communication, through systematic procedures and objectives to describe the studied content.

4.2.1 Keyword Categories

The investigated articles has defined 88 keywords, terms that serve to condense the main information contained in the text, facilitating the retrieval of papers that refer to the thematic sought.

It was verified, among the keywords used, the repetition of some patterns that gave opportunity to their categorization. Thus, 8 categories were created, as shown in Fig. 3.

It is possible to verify that most of the used terms related to sustainability (33) revealed that the surveyed studies have given greater emphasis to this theme.

In addition, the third category "Virtues" presents adjectives such as "ethics" and "responsibility", terms that are usually associated with sustainable themes, as well as the category "metrics", composed of words such as "indicators" criteria or dimen-

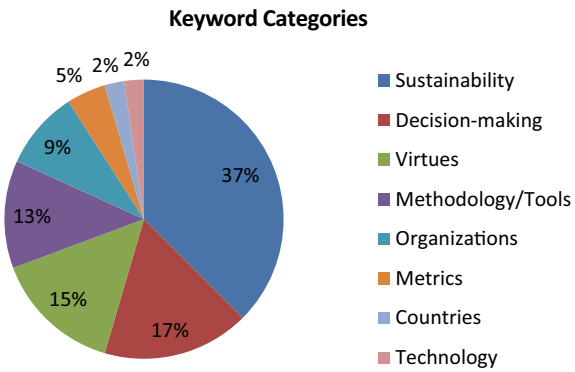


Fig. 3 Keyword Categories. *Source* The authors (2018)

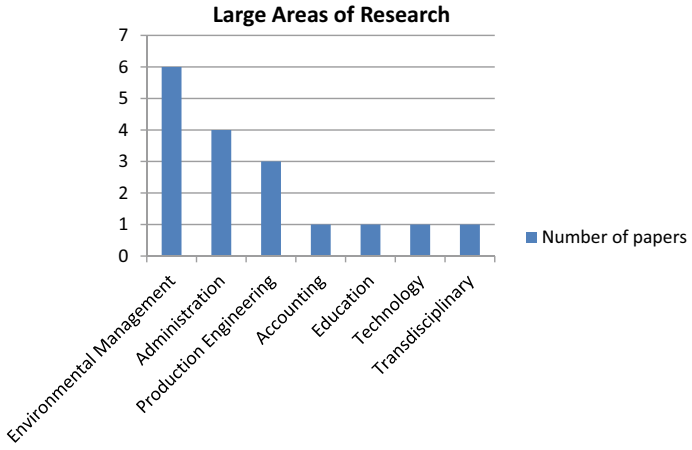


Fig. 4 Research Areas. *Source* The authors (2018)

sions of sustainability, which confirms the propensity of these studies to a sustainable bias.

It should be noted that 10 of the 15 surveyed publications in periodicals have taken place in journals that are specialized in environmental sustainability research, which helps to explain such prominence.

4.2.2 Large Research Areas

The collected publications were carried out in 7 different areas of knowledge, demonstrating a plurality of approaches, which corroborates the relevance in carrying out studies aimed at understanding the ways in which the researchers related two such urgent themes to contemporaneity.

As shown in Fig. 4, the Environmental Management area overlapped the others, indicating that, despite sustainability, at the corporate level, cares about the social and economic dimensions, at least, among the studies investigated, concerns in the ecological dimension prevail.

It should be noted that other areas have sought to contribute to the debate about corporate sustainability through decision-making processes. Of particular note are the Administration and Production Engineering, responsible for undertaking 4 and 3 studies, respectively.

4.2.3 Relationship Between Themes

All the articles reviewed jointly addressed the two subjects of this investigation. However, the analysis of practiced content has identified 5 ways in which the papers

have related Business Sustainability to Decision Making, being: Sustainability Measurement; Sustainability Dimensions; Flows and Administrative Processes; Decision Theory; and Business Management.

It is observed that these categories summarize the main perspectives addressed in the investigated publications. In this way, the Sustainability Measurement seeks to translate aspects such as sustainability indicators, environmental impact evaluations and product life cycles under the influence of decision making.

Sustainability Dimensions include issues such as TBL, stakeholders and environmental services, elements that make up the different approaches to sustainability proposed by Elkington (2011), treated from the perspective of business decisions.

The categories Flows and Administrative Processes; Decision Theory; and Business Management, represent studies with more administrative bias, in which business decisions were treated as parameters for the achievement of corporate sustainability. These categories are based on the items: decision complexity, decision theory, business growth, administrative tools and techniques.

5 Final Considerations

This study sought to find ways in which national and international publications related Business Sustainability to Decision Making.

It was verified that the two subjects are widely investigated separately, given the number of productions initially returned from the searches performed in the selected databases.

The situation is different when we talk about the joint approach of the two themes, with only 17 articles being identified, with such a characteristic, in a temporal universe of 10 years.

Nevertheless, the research proved to be fruitful, since it made it possible to verify the existence of studies that correlate the subjects in question, demonstrating a tendency of growth in this field of research.

Five categories were identified for which the subjects were related, and two of them—Sustainability Measurement and Sustainability Dimensions—place greater emphasis on sustainability issues, using decision making as a way to achieve it.

The other categories—Flows and Administrative Processes; Decision Theory; and Business Management—on the contrary, have in decision making their central point, treating sustainability as administrative demand or management strategy.

It is suggested, finally, carrying out further studies to broaden and deepen the understanding of the subject investigated, such as the mapping of the decision flows and processes known sustainable businesses, and how the corporate sustainability can be inserted in these processes.

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Governance, Risk and Compliance: Concerns in Sustainability Research Agendas

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Abstract It is increasingly evident that mechanisms and integrated structures of governance, risk management and compliance are valued as an approach to improve an organization's sensitivity to uncertainties. These mechanisms and structures are also key to better define internal processes and controls, resulting in the creation of value and differentiation of a company in the market. However, sustainability research agendas that integrate such themes are still unclear. The plurality of concepts and directions in the scientific community causes a certain disparity in the understanding and structuring of an effectively integrated management. Through field mapping, this paper intends to identify the main thematic areas on this topic. A systematic review technique was used, following the planning based on a research protocol. Given its holistic contribution, the research also presents potential to support the development of new studies, defining paths and opening other research opportunities, resulting in theoretical and practical contributions from this field of study.

Keywords Integrated management · Sustainability regulations · GRC

1 Introduction

The accelerated pace of corporate change brings new challenges to the organizational environment. These challenges include requirements related to the need for greater information security, monitoring and management of corporate risks, entry of new

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players, access to capital, ethical and responsible behavior, the maintenance of market relations and compliance with economic, social and environmental regulations.

The integrated management of corporate commitments leads to an emerging field called "Governance, Risk and Compliance (GRC)". In recent years, although still incipient, a growing body of literature concerning studies related to the acronym GRC has been observed. The predominant understanding of GRC is based on a structure that integrates several organizational areas with the purpose of implementing business strategies in accordance with governance, risk management, legal compliance and internal controls.

It is demonstrated that the GRC field is not sufficiently explored in the scientific community, and when related to sustainability-oriented research agendas, it is even more deficient (Doyle et al. 2019). Therefore, links with the areas in question are rarely carried out, losing out a potential field of exploitation.

On the other hand, international norms, such as Sarbanes-Oxley, started to show GRC as part of sustainability research agendas (Doyle et al. 2019). In order to understand this emerging movement, the objective of this study is to map all the scientific studies of Governance, Risks and Compliance and analyze possible links with the field of sustainability, through the process of literature mapping. Through systematic review and analyses of the integration of these themes, a reflection of the perspective of sustainability and a discussion about what still needs to be studied in the area is provided, in addition to recommendations for future studies.

The proposed theme and the applied methodological approach can be considered of great relevance for the area of strategic administration and sustainability, so that the central themes concerning the acronym GRC and Sustainability can be raised, analyzed and integrated.

2 Governance, Risk and Compliance

Financial scandals at the beginning of the twenty-first century, such as the fall of Enron in 2001 (Clarke 2005), and the ones involving WorldCom, Parmalat and the Lehman Brothers (subprime crisis in 2008), amongst others, promoted new discussions about the structuring of Corporate Governance from the global perspective and imparted new concerns and institutional positions. Over the last few years, research on Corporate Governance (CG) under different perspectives has generated considerable demand among academics and professionals.

Centered on the prevalence of control and organizational management systems, corporate governance has been meaningfully inserted in the entities of most different structures. The role of Corporate Governance is to mitigate the agency problem that may arise from the separation of ownership and control.

Effective corporate governance implies structuring mechanisms that ensure that executives respect the rights and interests of stakeholders, as well as those responsible for the generation and distribution of wealth invested in the company, the shareholders (Aguilera et al. 2015). For Bajpai and Mehta (2014), corporate governance is a set of systems, processes and principles that ensure an appropriate company administration aiming at the best interest of all stakeholders.

With respect to Compliance, the implications are not limited to the internal organizational scope. Implications are also extended to the selection and analysis of suppliers and business partners, which justifies the need for criteria of best practices on how to build partnerships. Furthermore, the adoption of internal mechanisms and procedures for integrity, honesty, and more transparent practices are important recommendations to prevent illicit acts (Delbufalo and Bastl 2018). Such a position, besides reducing risks, avoids the applicability of punishments, ensures image preservation, organizational reputation and respective market permanence.

3 Sustainability

Sustainability is a relatively recent issue in the organizational environment. Its inception focused on major environmental disasters that occurred between 1950 and 1990, such as the Chernobyl nuclear accident, the Great Smog of London and the contamination of Minamata Bay in Japan. These events encouraged a global discussion on the subject of environmental policy, drawing attention to the need for measures to ensure sustainable development.

Two main milestones concerning the devastating effects of disorderly growth are the Stockholm Conference, which gave rise to the discussion of "Development and Environment", a concept of "ecodevelopment", and the Conference on Environment and Development (UNCED, Rio/92). The latter is certainly one of the most important movements, which promoted the development of Agenda 21, an important step towards the development of the concept of sustainability, primarily in the business context.

However, it was prior to these events that the concept of sustainable development was brought up. In 1987, the Brundtland Commission Report, a document from the World Commission on Environment and Development (WCED), defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, p. 8). The World Business Council for Sustainable Development is a coalition of international companies committed to the three pillars of sustainability: social, economic and environmental.

From the Brundtland Report, other concepts of sustainability have emerged (Munisamy and Arabi 2015), however, in the scientific field the definition that is currently most widespread and used as a model is the composition of sustainability

established by Elkington (2012), called the triple bottom line (TBL) or tripod of sustainability, constituted by the economic, social and environmental pillars.

The economic pillar is related to the organizational financial expectation, in order to align responsibly the operations and activities of the company and their respective generation of wealth. The social aspect implies that the company has responsibilities with society and these go beyond its economic and legal liabilities (Carroll 1979). Finally, the environmental pillar, is directly related to the reduction of environmental impacts, adequate management and conservation of natural resources (Lorenzetti et al. 2008).

Since the dissemination of the concept of sustainability, it has been used within multiple fields of research and action; that is, the same denomination comprises different concepts and practices (Claro et al. 2008). However, according to the authors, all definitions carry the notion that sustainable development is composed of the three dimensions mentioned above.

In this way, the three pillars of sustainability became part of the companies' communication and transparency reports to the market, as well as their interrelationships dynamics (Isenmann et al. 2007). In addition to the discussions and structuring of sustainability, Elkington (2012) explores the pillars in an interesting way. The author explains their interconnections, stating that when working in a connected way, the social and environmental pillar results in social and environmental justice; the economic and social pillars result in business ethics; and the interaction between the economic and environmental aspects generates eco-efficiency, which is the subject of the present investigation. Figure 1 illustrates in a synthesized way the exploration of the triple bottom line.

It should be noted that sustainability has become a field of knowledge that is considerably sought after and investigated in the context of scientific research, in light of the increasing demands and immediate solutions to solve the problems inherent to environmental impacts and the need for human survival. The main thrust of global political discussions is to reconcile economic growth without compromising

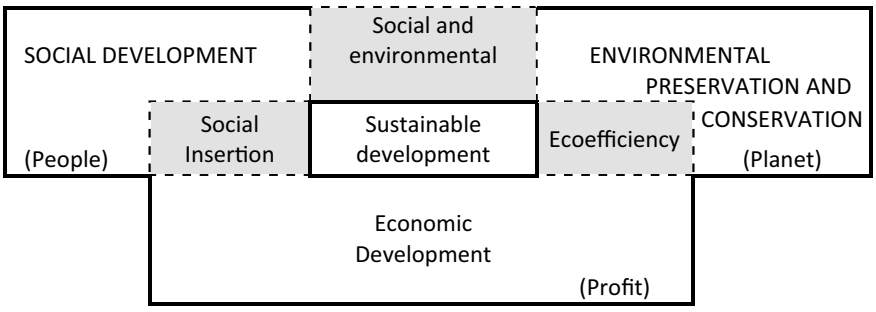

Fig. 1 Elements of sustainability. *Source* Savitz and Weber (2007)

or depleting irreplaceable natural resources, preserving natural wealth and ecological systems, and promoting the reduction of social inequalities (De Simone and Popoff 2000), which is a challenge that requires new tools and new approaches (Hoffren and Apajalahti 2009).

4 Methods

The methodological approach followed a rigorous and systematic procedure. The most appropriate method to meet the research objective was the Systematic Review technique, since it uses systematically designed procedures to search and evaluate studies, in order to bring the content consolidation and main evidence of the researched field. A research protocol was developed in which data collection, data processing and results analysis were systematized using a sequential structure, based on the propositions of Biolchini, Mian, Genc-Nayebi and Abran (2017), Tranfield et al. (2003), as detailed in Fig. 2:

Step 1—Planning: preliminary review of the literature in order to clarify the researchers' understanding for the development of the following stages, enabling the formulation of the question and respective research objective, within the context of Governance, Risks and Compliance and integration with Sustainability.

Research question: What is the state of the art on the scientific studies of Governance, Risks and Compliance, from the sustainability perspective?

Purpose of the research: Carry out the mapping of all scientific studies of Governance, Risk and Compliance and the connection with the field of sustainability.

Step 2—Processing: consists of conducting the systematic review, with inclusion and exclusion criteria:

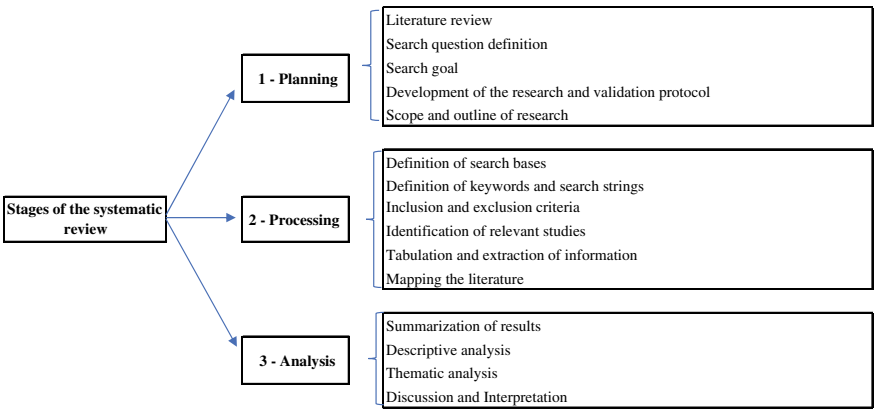

Fig. 2 Stages of the systematic review. *Source* Adapted by the authors from Biolchini et al. (2007), Genc-Nayebi and Abran (2017), Tranfield et al. (2003)

(a) Determination of expression strings in search engines. The definition of the terms was supported by other studies in the same topic, consisting of: ("GRC" or "Governance, Risk and Compliance" and "Social and Environmental Responsibility").
(b) Web of Science was the selected database. This choice is based on the multidisciplinary studies and references at the international level.
(c) The filters applied in the database represented the following criteria: publication type (scientific articles), English language, field (topic—title, abstract and keywords), and research area (Business, Management and Accounting).
(d) Time frame: All available years.

From the criteria established above, the results consisted of 41 articles for analysis. In the sequence, the phase of integral analysis took place aiming at the categorization of its content, so that all the information is tabulated and checked. Finally, the last stage of the systematic review was the exclusion of articles that were not consistent with the topic in their integral analysis and had no specific contributions to the field, resulting in 7 studies suitable for the analysis, allowing the indexation of the articles that met the research focus.

Step 3—Analysis: The perspectives and contexts of the studies were explored, summarizing the results and mapping the field with the presentation of the thematic lines, discussions and interpretations.

5 Results

Through the systematic analyses of the results, three thematic axes were identified among the 7 studies. It should be pointed out that for the definition of the thematic axes, readings of several sections of the articles were carried out for the categorization of their content and they were grouped according to their similar approaches. Thus, the studies that presented the greatest meaning and connection between GRC and Sustainability were analyzed for the composition of their thematic axis.

Table 1 presents the conceptual framework with the definition of each thematic axis, as well as the criteria for inclusion of the studies.

The thematic axis lead to the fields that are in formation in the studied area. Since this research topic is in its early stages, more studies are needed to increase the development and deepening of investigations.

The related thematic lines were determined from the associations proposed by the authors of the 7 analyzed articles. The process included the review of the keywords and sections of each analyzed article. The topics were then determined by content analysis using the criterion of joint thematic similarity for the establishment of categories of analysis.

Table 1 Conceptual framework

Thematic axis	Inclusion criteria	Main approaches
Sustainable strategic innovation	Approaches that comprise GRC mechanisms geared towards sustainable innovation	In the scope of innovation, when researching the resources for the development of innovative projects, studies have been focused on the investigation of the relation of sustainability and the business strategy based on GRC. In addition, it reveals the central role of GRC knowledge integration as the basis of competitive advantage, revealing strategic business opportunities
Social and environmental management structure	Approaches that demonstrate the effectiveness of corporate sustainability in the GRC structure	It demonstrates internal controls in the practice of environmental risk management, and governance and compliance mechanisms
Implementation of integrated good practices	Approaches related to the practical implementation of GRC mechanisms working in tandem with the sustainability mechanisms in an integrated way	The implementation should be carried out according to the characteristics of each company and their respective need for advances related to organizational strategies

Source Authors

The determination of the thematic axes related to a field of study is essential for its better mapping because it allows the understanding of the basic theory that sustains each field and the authors' reflections in relation to the variables proposed in their studies. The investigated academic literature points to the formation of 3 thematic axes that make up the field of GRC study. The themes "**Sustainable Strategic Innovation**", "**Social and environmental Management Structure**" and "**Implementation of integrated good practices**" are the main focus of studies in the articles investigated.

Advances in innovations driven by market competitiveness, differentiation and cost reduction are mitigating the challenges faced by the business context. In this regard, the thematic axis "**Sustainable Strategic Innovation**" focuses on the relationship between sustainability and GRC's business strategy. The studies on this axis address the importance of integrating GRC and Sustainability as basis for competitive advantage and for revealing innovative strategic business opportunities. Based on solidified governance practices, mapped and controlled risks, and an effectively implemented compliance program, sustainability actions are consequences of integrated management. The innovative process is then properly aligned with the com-

bination of processes and implemented structures, in order to achieve organizational goals.

The "**Social and Environmental Management Structure**" axis reveals the importance of internal controls in the practice of environmental risk management, including but not limited to: Governance, control environment, commitment to ethics, segregation of duties, review and information and communication. Effective sustainability is also presented in financial reports of quality, compliance, commitment to ethical values and consistency in pursuit of strategic and operational objectives based on good corporate governance.

On the other hand, the thematic axis "**Implementation of good integrated practices**" is directed to the preventive role in the planning and orientation of responsible environmental conduct, highlighting the uniqueness of each organization and characterizing the implementation in a specific and effective way. This axis shows that the investment in new practices of GRC and Sustainability is configured as an effective trade-off, in addition to establishing confidence for market players.

After the mapping of the thematic axes, the main years that reflect the development of research in the area in question were analyzed, as shown in Fig. 3.

It is clear that the field is still in formation and in its early years. Based on the review carried out in the present research, the first study that integrates GRC and Sustainability issues was launched in 2011. This assertion can be justified, precisely because of the period in which financial scandals occurred at the beginning of the twenty-first century, which promoted new discussions about the structuring of Corporate Governance, Risk Management and Compliance from a global perspective, imparting new concerns and organizational positions.

This period is also marked by the new requirements of mechanisms that provide for the prediction of possible conflicts of interest, the adhesion of the main actors,

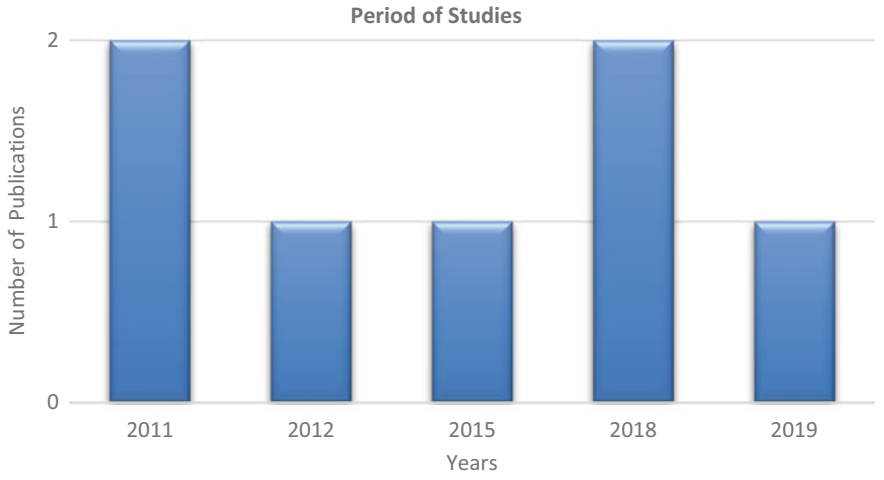

Fig. 3 Period of studies. *Source* Authors

Fig. 4 Regions with scientific production. *Source* Authors

agreements and codes agreed upon, economic efficiency and the maximization of value for stakeholders (shareholders, employees, the surrounding community, among others).

However, research in this area is still underexploited and deserves important attention. In order to enrich and bring some more contributions to this research, the countries of the main authors who produced the majority of papers were also identified. China stands out as the main region of academic production. Australia also stands out with 2 authors. It is also observed that research in this approach was initiated in Germany, Ireland, Malaysia and Thailand (Fig. 4).

6 Conclusions

The GRC and Sustainability themes comprise several definitions in the scientific literature. As it does not have a single definition, GRC is subject to several interpretations, leading to many discussions and divergences in the field. The central focus of this study was to investigate the academic production in the field that refers to GRC and Sustainability. A systematic review was carried out, allowing a better understanding of the investigated field, its relational variables (thematic axes) and their respective mapping. With this scenario, it is possible to determine directions for new research that may advance in this field of study.

After indexing 41 articles that refer to the parameters defined in the methodology of this study, a total of 7 articles were considered valid for analysis, divided into 3 categories that constitute the thematic axes that make up the GRC and Sustainability study field. The main thematic axes related to the investigations are “Sustainable Strategic Innovation”, “Social and-environmental Management Structure” and “Implementation of integrated good practices”. It is evident that the evolution of the

corporate universe in the integration of best practices is related to the disposition of the improvement of the procedures and conduction of the business, as a driving force of GRC and Sustainability.

The efforts made in this study aim to contribute towards the national and international literature on the subject. In addition to the aforementioned themes, it is recommended to increase production both in national and international studies regarding the GRC approach in academia, since the application of this approach in practice begins with the knowledge produced in educational institutions and their verification.

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A Search for the Spiritual Roots of Sustainable Development—Justice, Peace and the Integrity of Creation

Lars Rydén

Abstract The concept of sustainable development (SD) refers to a development within the physical capacity of our planet to provide material resources, but already from its beginning it is clear that researchers and others concerned with SD also saw it as an existential issue and referred to its spiritual content and roots. In this paper I will investigate in which way this has been manifested in the conferences of the World Council of Churches and its agendas, especially *Justice, Peace and the Integrity of Creation*, as well as by the orthodox and catholic churches. In the environmental movement the spiritual character of SD has always been present and clearly expressed by the International Union for the Conservation of Nature, IUCN, and its ethics working group and the 1991 conservation strategy, *Caring for the Earth—A Strategy for Sustainable Living*. Similarly the spiritual character of SD has been in focus in several civil society initiatives, in particular the *Earth Charter* and more recently in the so-called *Spiritual ecology* movement.

Keywords Sustainable development · Spiritual roots · World council of churches · Integrity of creation · Environmental ethics · Spiritual ecology

1 Sustainable Development Is a Global Concern

The first traces of the concept of sustainable development (SD) takes us back to the early eighteenth century (Grober 1990) and the insight that the ongoing use of forest resources was too drastic and would undermine the long term availability of those resources. The modern discourse may, however, be more properly connected to the understanding that the increasing demands of a growing human population will in the end overrun the capacity of the Earth to provide, and that this exploitation constitute a continuous degradation of the environment, is of global reach and includes the whole width of services that Nature provides.

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These approaches were manifested in both dramatic and concrete manners in 1972. In March that year the publication of the *Limits to Growth*, a research report from the Massachusetts Institute of Technology under Prof. Dennis Meadows (Meadows et al. 1972) under the commission of the Club of Rome, clearly demonstrated the ongoing degradation of the global ecosystems would lead to its eventual collapse, provided that no change of directions would be done. In June 1972 the first United Nations conference on the Global Environment[1] was organized in Stockholm, as a Swedish initiative. The conference dealt with environmental issues, and the understanding that environmental degradation did not stop at national borders, and had to be addressed in international cooperation. But many of the delegates fully understood that it was not only about the environment. Social and economic issues were tightly coupled to environmental degradation, as expressed most clearly by The Indian Prime Minister Indira Gandhi and the Swedish Prime Minister Olof Palme.

The global approach to the destiny of the Earth was later that year dramatically demonstrated by the photo of our planet from space, *The Blue Marble*, taken by the Apollo 17 mission. The message was clear: The Planet is one and we have to address its future development together. We are all in it together. It was most succinctly expressed by Russell Schweighart, astronaut on Apollo 9: "We are not passengers on space ship Earth. We are the crew."

It is clear that the origin of SD was management, management of natural resources. This remains true for every person, organisation or larger system which have adopted SD as a main concern. But for some of these it is clear that it is not only, even not mainly, a question of management. It is much deeper and is connected to existential values and our identity as humans and our role on planet Earth. For example Donella Meadows, the main author of Limits to Growth expressed this very clearly. I refer to this as the spiritual roots of sustainable development and have searched for it in religion, in ethics, in biology and in different forms of civils society organisations.

2 The Role of the Churches—World Council of Churches

The World Council of Churches (WCC), formed in 1948, is an ecumenical community of (presently) 349 Christian churches. It is a main actor in the global agenda on the role of religion in society. The Catholic Church is not a member but has worked closely with the Council and has always been an observer at the meetings of World Council of Churches.[2] It is also relevant to point out that the United Nations, also formed at a similar time after WWII, had close connections to the WCC from its formation. WCC main office is found in Geneva, next to the UN main building and thus the influence these two organisations for global development have had on each

[1]The United Nations Conference on the Human Environment. https://sustainabledevelopment.un.org/milestones/humanenvironment; http://www.un-documents.net/aconf48-14r1.pdf.

[2]World Council of Churches. http://www.oikoumene.org/en/.

other is significant, and individuals working in each of the two organisations met and meet regularly in a variety of informal ways.[3]

We may expect that the spiritual roots of SD are to be found among the churches. In the community of churches, however, the understanding and awareness of sustainable development began with *development* and followed its engagement in and concern for the developing countries, then referred to as the third world. The churches had since long been connected to development issues through its missionaries in poor countries, where they often provided all healthcare and education that existed. In the 1960s the accelerated pace of decolonisation and improved knowledge of the situation in poor countries formed the background to a large increase in the focus on *justice and peace*. These words became key concepts at the 4th World Council of Churches (WCC) General Assembly 1968 in Uppsala, Sweden (Jonsson 2013).

The activities of WCC includes two main directions, a more traditional theological called *Faith and Order* and a second *Life and Work* more often referred to as *Church and Society.* Both existed before the formation of WCC, and express the two approaches to ecumenism: Dialogue and Action. The Church and Society branch has its origins in the activities initiated by the Swedish Archbishop Nathan Söderblom in Uppsala, a forerunner in Ecumenism, already in the 1930s. It is in this branch that the interest for peace and international justice took its beginning in the late 1960s.

The events of 1972, however, had an influence on the WCC. When a special conference of WCC on *Science and Technology for Human Development* met in Bucharest, Romania in 1974, the Report from the Stockholm Conference on the global environment and the Limits to Growth publication of 1972 was one point on the agenda. The final declaration from Bucharest included a call for a "sustainable and just society", said to be the first time that sustainability was applied to society in relation to the environment.[4]

The discussion on sustainable development became the main concern at the fifth General Assembly of the World Council of Churches in Nairobi, the following year 1975. The Programme for the Conference was a *Just, Participatory and Sustainable Society* (JPSS). There was a general understanding that the resources of the world needed to be distributed in a just way, but also that these resources were limited and that humanity already balanced on the border to what the planet could provide (Brander 2002). The representatives from the churches in the poor countries asked for justice and development opportunities, while the rich countries were concerned with controlling the environmental impact and ecological safety. The process was very similar to what later was seen in the Brundtland Commission (Rydén and Sundström 2003).

From that time on Sustainability has been a topic in the WCC agenda. A WCC meeting in 1976 agreed that the "Search for a Just, Participatory and Sustainable Society" would be a major emphasis for the future work of the Council. This in turn

[3]Bishop Emeritus Jonas Jonsson, Strängnäs, Sweden, personal information. Bishop Jonsson took part in all main conferences and several special conferences of WCC.

[4]World Conference on Science and Technology for Human Development in Bucharest. www.environmentandsociety.org/tools/keywords/conference-technology-human-development.

led to a 1979 conference on "Faith, Science and the Future" at the Massachusetts Institute of Technology in Cambridge, in the United States.

The focus on sustainability has been more intense in the 1990s and later. The WCC has been a participant at all UN conferences on SD and both influenced the outcome of these conferences and itself being influenced by them, from the 1992 Rio conference on environment and development, UNCED, where WCC was one of the participants, up to the Paris 2015 COP 21 of the UNFCCC. The main agenda was however from the 1980s and later Peace and International Justice, and the situation of the so-called 3rd world countries. In the long term it was thus the fight for social justice which dominated WCC.

3 The Orthodox and Catholic Churches

There is a clear difference in tradition between the Roman Catholic and Lutheran Churches on one side and the Orthodox Churches on the other, going back to their origins. While in the "western" Roman Catholic tradition, and even more so the Lutheran churches, focus is on *action*, in the "eastern" or orthodox theology focus is on *being*. Human is seen as being present in the world or being part of Nature and the world. The Orthodox Church is there to bear witness on man's presence in Nature (Brander 2002).

This has great consequences for how the two Churches relate to the environmental crisis which became imminent in the 1950s and 1960s. In the Word Council of Churches it was in particular the Indian theologian Paulos Gregorios who introduced and developed the understanding of the ecological crisis as a spiritual crisis, a break in our connection to Earth and our environment.

> There is a binding unity and continuity that we share with all of God's creation. In recent years, we have been reminded of this truth with flora and fauna extinction, with soil and forest clearance, and with noise, air and water pollution. Concern for the environment is not an expression of superficial or sentimental love. It is a way of honoring and dignifying our creation by the hand and word of God. (Chryssavgis 2007)

Since the 1990s the Ecumenical Patriarch Bartholomew in Istanbul has contributed in very decisive ways to the responsibility of the Orthodox religion for the environmental crisis. He earned the title "Green Patriarch" as a religious leader addressing alarming environmental issues over at least two decades "defining environmentalism as spiritual responsibility" (Ejdersten 2016).

The Ecumenical Patriarch's initiatives to protect the environment, derives from the ancient values of the Orthodox Church. He declares that environmental abuse is sin:

> To commit a crime against the natural world is a sin. For human beings to cause species to become extinct and to destroy the biological diversity of God's creation; for human beings to degrade the integrity of the earth by causing changes in its climate, by stripping the earth of its natural forests, or by destroying its wetlands; for human beings to injure other human

> beings with disease by contaminating the earth's waters, its land, its air, and its life, with poisonous substances—all of these are sins. (Chryssavgis 2012)

The environment is not only a political or a technological issue; it is, as Patriarch Bartholomew likes to underline, primarily a religious and spiritual issue (Ejdersten 2016). Environmental protection is intimately connected to and dependent on numerous other social issues of our times, including war and peace, justice and human rights, poverty and unemployment. We have, in recent years, become increasingly aware of the effects of environmental degradation on people, and especially the poor. The term 'eco-justice' has been used in religious circles to describe this interconnection.

Also in the Catholic Church a concern for the environment and sustainable development has risen to a main position. In his encyclical *Laudato Si* ("Praised Be") from 2015[5] Pope Francis strives to "enter into dialogue with all people about our common home." The encyclical has the subtitle "On Care For Our Common Home". In the text the Pope criticizes consumerism and irresponsible development, environmental degradation and global warming, and argues that these are the result of the developed world's indifference to the destruction of the planet in its pursuit of short-term economic gains, and calls all people of the world to take "swift and unified global action".

Pope Francis sees the warming of the planet as a symptom of a greater problem: that humans no longer see God as the Creator but rather consider "other living beings as mere objects subjected to arbitrary human domination".

Also in the Catholic Faith one may trace the roots of concern about Nature and the environment back to Biblical times.[6] Francis argues that "caring for creation is as old as Genesis, as clear as the Sermon on the Mount, as transformative as St. Francis" (of Assisi of the thirteenth century). His pledge for a moral and spiritual transformation in our connection to Earth's ecosystems is not new. In our times Popes John Paul II and Benedict both spoke frequently about the Christian requirement to tend the garden and protect the poorest. Caring for the creation is one of the seven tenants of Catholic Social Teaching.

Pope Francis had an education as chemist before becoming a priest, and probably understands the situation more than most religious leaders. He knows that all life depends on clean air and water, and a stable and reliable climate and that the poor suffer the most from economic and environmental injustice. He knows that climate change is the greatest threat life our Earth has ever seen and that it is caused by humans. Still he emphasize that the ecological crisis is a spiritual one. An important focus of the encyclical is "the relationship between global poverty, catastrophic inequality, and worship of the golden calf of consumerism that leads to environmental destruction." (see footnote 6).

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[5]Encyclical Letter *Laudato Si*' ("Praised Be") of the holy father Francis on the care for our common home. http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html.

[6]Earth Ministry. http://earthministry.org/advocacy/pope-francis-encyclical-on-the-environment/.

4 Justice, Peace and the Integrity of Creation

When the 6th General Assembly of the World Council of Churches gathered in Vancouver in 1983 the participants reported a general feeling of the severity or seriousness of the situation, as if life itself was at stake. It is not surprising considering the world situation at the time. The two large powers of the Cold War, NATO and the Soviet Union, were in the process of deploying intermediate range nuclear missiles, the SS 20 and the Pershing, close to each other's borders. This so–called double zero decision was aggressively protested against by many groups in civil society, including many with a Christian background, by demonstrations and even occupation of missile deployment sites. The smallest mistake could lead to nuclear annihilation as the time from a nuclear alert to attack had shrinked to some 6 min.

During the meeting the phrase *Integrity of Creation* was added to the previous goals of *Peace and Justice*. It is unclear from where the expression originated. It may rather be understood as a reaction to the feeling at the meeting and the sense of imminent threat to society (Brander 2002).

At the meeting thus the *Justice, Peace and Integrity of Creation* (JPIC) was added to the other agendas of the WCC. It was not intended to constitute a new program but rather a way for the two main directions of the WCC, Faith and Order and Life and Work, to meet and develop a statement common for all Christian Churches to gather around. This should be accomplished through a "conciliar process of mutual commitment (covenant)" (Brander 2002; Hall 1989).

In the following years several interesting inputs to the process were done. Theologian Douglas John Hall described how integrity of creation could be understood as threefold (1) how external form and internal reality are in harmony; (2) how the components of creation are connected and in balance; and (3) as describing an internal value of its own (Hall 1989). The British chemist James Lovelock, famous for his Gaia hypothesis, contributed with the description of how all systems on Earth were interconnected and had the capacity to adapt to new situations and thus keep the system of the planet in balance, thus contributing to the meaning of integrity (Lovelock 1995). A similar understanding of integrity also comes from basic ecology, introduced originally by Eugen and Howard Odum in the 1950s. Although their systems were not worldwide, as Lovelocks, it included both biotic and abiotic components, and certainly also humans (Odum 1975). Carl Friedrich von Weizäcker in Germany underlined that the three parts in the JPIC were dependent on each other: There is no peace without Justice; there is no Justice without safeguarding the Integrity of Creation, and no Integrity of Creation without Peace, etc. (von Weizäcker 1986).

At the 7th General Assembly in Canberra there were four sections. The first, called *Giver of life—sustain your creation*, was where the process of the consultation was intended to be reported. The report was however thin. It had not been possible to reach a common understanding between the partners of the process. Rather the divide between the Western Churches, focusing of Justice and Peace and stewardship (see below) as before, and the Eastern Orthodox Churches focusing on Integrity of Creation, remained (Brander 2002).

The continued process was continued in a section of WCC called Justice Peace and Creation, which later was renamed Theology of Life. It was part of the UNCED conference in Rio in 1992, but later lost in importance.

The concept of Integrity of Creation has however been adopted by numerous other churches and remains a vital concept for very many around the world. The understanding is very simple: just as a person's integrity can be violated so can the integrity of creation be violated. It is what is happening now with all environmental impacts, overuse of resources, climate change and, not the least, large scale loss of biodiversity. It is at the centre of sustainable development that this processes come to an end and the respect of the creation is restored. The concept lives on in e.g. societies of catholic women, such as Society of the Sacred Heart,[7] the Society of the Holy Child Jesus[8] and the International Union of Superiors General.[9] The Franciscans emphasise the role of ecology.[10]

5 Stewardship and the Integrity of Creation

When the 6th General Assembly of the World Council of Churches gathered in Vancouver in 1983 an import approach to the new concept of the integrity of creation was the concept of *steward and stewardship*, strongly emphasised by Douglas John Hall during the meeting (Hall 1989). It was done with the background of a strong position of stewardship and stewards established in western Christianity, especially the Lutheran churches, since the nineteenth century, with roots back to first Luther himself and his Catechism and further down to the New Testament (Brander 2002).

Stewardship in its nineteenth century understanding, strongly established in the Lutheran World Federation (LWF), was referring to how the priest was taking care of his congregation, that is, his work to support individual members of the congregation to fulfil their human potential, both economically and in the capacity of humans and Christians. The original Greek understanding of stewardship was more referring to the household and the duties of the master of the household. An important part of the concept was economic management (Brander 2002).

During the discussion at the WCC Assembly several new approaches to the concept of stewardship helped to widen the concept and making it relevant for adopting the concept of integrity of creation. One is that stewardship also had a spiritual meaning since it included taking care of the communion and its use in the congregation. A second widening which became increasingly important after the Vancouver meeting

[7] Society of the Sacred Heart. https://rscj.org/.

[8] The Society of the Holy Child Jesus. http://www.shcj.org/.

[9] UISG (International Union of Superiors General). http://www.internationalunionsuperiorsgeneral.org/.

[10] Irish Franciscan Province *Caring for the Integrity of Creation through Ecology*. http://www.franciscans.ie/caring-for-the-integrity-of-creation-through-ecology/.

was that stewardship was not only referring to the congregation but a much wider context, nature and, in the end, the whole of creation.

In the years which followed up to the Canberra General Assembly it was clear that, as mentioned, the divide between western and eastern churches remained. Stewardship stayed an important part of the western churches approach, and was thus rather action-oriented. The concept became, however, more inclusive and referred to as the responsibility of wise management of the environment (Brander 2002).

An important part of the debate was about the difference between "rule or govern" the environment versus "manage or administer" the environment. The first approach could easily develop into exploitation while the second more to taking care of or supporting. The origin of this divide can be traced back to at least Francis Bacon of seventeenth Century England. His main opus *Novum Organum* (Bacon 1620) introduced the understanding of science as a systematic means to control and dominate the resources which Nature provides. Many of his recommendations were sound, such as collecting and systematising the results of scientific work, and was a crucial contribution to the establishment of academies of sciences, the Royal Society in London being the first. But it changed dramatically the approach to Nature. From having been *divine* it became a *resource*. From having been the creation with an integrity, it became a resource to be used. Thereby the integrity of creation could be violated. One may compare to a human whose integrity is violated if the person is only seen as a resource to be used—in the extreme slavery—that is, an operational attitude, rather than an individual with a value in itself, a person to be respected. The respect, *nota bene*, does not hinder the person from contributing to the society and others and thus being operational. In the same way the environment or Nature may contribute to society and others, that is, being harvested, even if it is respected for its own sake.

6 The Environmental Movement—The International Union for the Conservation of Nature

Through its participation in the 1972 Stockholm conference the environmental movement had from the beginning been part of the process that led up to the establishment of sustainable development as a global concern. It was in particular fuelled by Rachel Carson's Silent Spring (Carson 1962) and what followed from this. It took a long period, however, before the environmentalist in general were prepared to include a wider perspective and see its concern for the environment as part of the general development process. A reason is that environmentalists most often focused on pollution; the protection of nature and biodiversity, even if part of it, was not in the centre. It is perhaps best illustrated by the process which took place in the International Union for the Conservation of Nature, IUCN.

The International Union for the Conservation of Nature, IUCN,[11] founded by UNESCO in 1946–48, is an organisation with several hundred member organisations,

[11] International Union for the Conservation of Nature, IUCN. https://www.iucn.org/.

both governments and NGOs, for the protection of biodiversity. Its headquarters is in Gland, just outside Geneva. Since its establishment IUCN has become the global authority on the status of the natural world and the measures needed to safeguard it.

In 1980 IUCN, published its *World Conservation Strategy* in which the concept of sustainable development was given currency. It was well understood that their work was based on a value of respect for nature, bio-ethics. In 1984 Ronald Engel, then Professor at Meadville/Lombard Theological School at the University of Chicago, was asked to address the IUCN General Assembly in Madrid, Spain on the subject of environmental ethics, and to form "an inter-commissional working group to advise the Director General of IUCN on how IUCN can play a more effective role in promoting the ethical dimensions of the World Conservation Strategy". The result was the IUCN Ethics Working Group, EWG.[12]

EWG eventually enrolled some 500 participants from 50 countries, many of them theologians. Ethics was, on this base, included as an important element in IUCN:s second conservation strategy published in 1991 as *Caring for the Earth—A Strategy for Sustainable Living*, that deals with how to implement sustainable development. Its Chap. 2 on "Respecting and caring for the community of life" covers the topic of ethics. A global workshop on the theme, held in 1993 between 17 organisations, was reported in *Advancing Ethics for Living Sustainably* (Engel and Denny-Hughes 1994). Much of the thoughts in this group have been summarised by its chairman Ronald Engel (Engel and Engel 1990).

It is noted that the request was to establish an environmental ethics, not biocentric ethics. The ethics introduced in Caring for the Earth Chap. 2 is mainly anthropocentric, human centred. Its statements of "Elements of a world ethics for living sustainably" begins with "Every human being is part of the community of life, made up of all living creatures. This community links all human societies, present and future generations, and humanity and the rest of nature." and continues further down "Every human being has the same fundamental and equal rights, including: the right to life, liberty and security of person …". It is only later that we can read "Every life form warrants respect independently of its worth to people. Human development should not threaten the integrity of nature or the survival of other species". In spite of the fact that the organisation is made to protect Nature it seems that its ethics is very much a question of protecting people!

The religious dimension of the ethics of protection of biodiversity was included later when IUCN, UNESCO and UNEP partners were invited to prepare recommendations for the Global Biodiversity Programme. The EWG then created a special working group involving 80 persons from 23 countries which wrote the proposal "The Role of Ethics, Culture and Religion in Conserving Biodiversity: A Blueprint for Research and Action". It became the basis for Action 82 of the *Global Biodiversity Strategy* (1992) (Hamilton 1993).

The protection of biodiversity is a key component of sustainable development; since long it is one of the most threatened components of sustainability. The rate of

[12]History of the Ethics Group. https://ethicsspecialistgroup.wordpress.com/history-of-the-ethics-group/.

extinction of species is estimated to be from 100 to 1000 times larger than before human society (Mace et al. 2014). It is also deeply connected to the spiritual side of SD as each species being destroyed is an impact on and reduction of the Creation. Many individuals feel very strongly about this. SD is not only for us humans. It is also for all species on the planet. We do not have the right to deny them their existence.

7 The Peace Movement and the United Nations System

We may also look for spiritual roots of sustainability in the United Nations, the organization which embodies more than anyone else the strife for peace-making and development. UN has through its much wider agenda, including environmental concerns through UNEP and social and economic concerns through i.a. UNDP and ECOSOC, been a leader in the development of Sustainability. In 2015 UN made public its SD Goals.

It is obvious that the UN charter and many of the activities of the UN have promoted the *peace and justice* cause of the WCC. As mentioned the UN system offered the WCC to be included in its rank at its conception, and was prepared to offer venues for the secretariat of the WCC in the UN building in Geneva. Even if WCC then decided to be formally independent of UN, the ties have continued to be close.

Is there a spiritual background to this leading role of UN in sustainable development? To answer this question one needs to look not at the official bodies of the UN system but rather to the individuals who have been shaping these bodies. The role of Dag Hammarskjöld, the 2nd Secretary General of the UN in office 1953–1961, is of special significance here. Dag Hammarskjöld died on duty in Congo in 1961. After his death a manuscript covering some 600 notes, reflections, some in poetic forms, was discovered. This was published as *Vägmärken* (*Markings*) in 1963 (Hammarskjöld 1964). In a covering letter to his literary executor he calls it "a sort of White Book concerning my negotiations with myself—and with God." It is highly regarded as a classic of contemporary spiritual literature (Van Dusen and Henry 1967).

Many of the entries in *Markings* describe Hammarskjöld's struggles to view his professional duty as a spiritual responsibility. It is very personal, not in immediate terms covering his work. Hammarskjöld was however very much connected to Nature and its protection. He had a leading role in the Swedish Society for Nature Conservation and valued highly the few moments ha had to himself in the Swedish high mountains (fjäll) also touched on in Vägmärken.

Much less is known about other leading personalities in the UN system or to what extent Hammarskjöld was able to influence his immediate coworkers.

8 Civil Society Initiatives—The Earth Charter

The Brundtland Commission, and not the least Gro Harlem Brundtland herself, repeatedly said that the Sustainable development entirely depends on the acceptance of a new ethics. The report from the Commission *Our Common Future* says: "We have attempted to demonstrate how human survival and well-being may be dependent on our capacity to successfully transform the principles behind sustainable development into global ethics" (World Commission on Environment and Development (WCED) 1987). Mrs. Gro Harlem Brundtland, expressed herself in a similar way when opening the World Conference on the Changing Atmosphere in 1988: to come to grips with the environmental dilemma requires that "we develop… a new holistic ethics in which economic growth and environmental protection go hand in hand around the world" (Usher 1989).

This is formalized in the *Earth Charter initiative*. In 1994, Maurice Strong, Secretary-General of the Rio Summit, and former head of state of the Soviet Union Mikhail Gorbachev, working through organizations they each founded, Earth Council and Green Cross International respectively, initiated the development of an *Earth Charter* as a civil society initiative. The drafting process, from 1997 managed by an Earth Charter commission, drew on hundreds of international documents and consultations, came to consensus on the Earth Charter in March 2000 at a meeting held at UNESCO headquarters in Paris. The Earth Charter was formally launched in The Peace Palace in The Hague later that year.[13]

In the period up to 2005 the Earth Charter campaign recruited thousands of organizations representing millions of people, and finally also the global institutions UNESCO and IUCN. Important strongholds in the development are found in e.g. Boston, USA, Moscow and Buenos Aires. Their website http://www.earthcharter.org is an important meeting place.

Efforts to have the Earth Charter formally recognized at the World Summit on Sustainable Development in Johannesburg, 2002, came very close to success, resulting in numerous public statements of support from world leaders and heads of state.

The Earth Charter played a role as a global consensus statement on the meaning of sustainability, the challenge and vision of sustainable development, and the principles by which sustainable development is to be achieved. Today it has in many ways been replaced by the Sustainable Development Goals of 2015. Its role as an ethical statement, however, remains. It is seen as an ethical foundation for sustainable development, and could be understood as an enlargement of the Declaration of Human Rights, or a basic document for a global environmental ethics. In the Earth Charter the ethics of UN conventions is enlarged to include also Nature.[14]

[13] Earth Charter Initiative. http://earthcharter.org/.

[14] Earth Charter. http://earthcharter.org/discover/the-earth-charter/.

9 Civil Society Initiatives—Spiritual Ecology

Spiritual ecology is an emerging field recognizing that there is a spiritual side of all issues related to conservation, environmentalism, and earth stewardship. Spiritual Ecology ask for contemporary conservation work to include spiritual elements and for contemporary religion and spirituality to include awareness of ecological issues.

Spiritual ecology is foremost established in the USA. Among the first organizations supporting this movement was the *Lindisfarne association*, established by William Irwin Thompson in New York in 1973.[15] He was inspired by a long list of spiritual and esoteric traditions, as well as by the philosophies of Alfred North Whitehead and by Teilhard de Chardin.

Another of the supporting organizations is the *Kalliopeia Foundation,* based in San Rafael in California.[16] It is "responding to a call—a global challenge—to take spiritual as well as physical responsibility for our common home with projects which support contemporary issues at their root, with the understanding that ecological, cultural, and spiritual renewal are interdependent." It strives to embody the following core principles: "Life is sacred; Ecology, culture, and spirituality are inextricably interdependent; Generate creative ideas and outcomes through simple, meaningful engagement with others and the Earth; Embracing an ethic of care—the essential and natural aspiration to respond to needs beyond our own." It works by supporting "young leaders and innovators who recognize the need to create a future that is not driven by materialism and greed, but rooted in the spiritual values of reverence for nature, interconnectedness, stewardship, compassion and service."

Spiritual ecology maintains that ecological renewal and sustainability necessarily depends upon spiritual awareness and an attitude of responsibility. Spiritual ecologists thus ask for both the recognition of creation as sacred and behaviors that honor that sacredness.

10 Conclusions

The spiritual character of sustainable development has been recognized from its very beginning in the 1970s. It has been discussed and expressed in a more systematic manner in religious contexts, especially the World Council of Churches and its agenda for Justice, Peace and the Integrity of Creation. In the environmental movement it has been firstly dealt with as the foundation for environmental ethics and later in its own right in the Earth Charter and the so-called Spiritual ecology movement.

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[15] Lindisfarne association. http://www.lindisfarne-association.org/.

[16] Kalliopeia Foundation. http://kalliopeia.org/.

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Sustainability Practices at Hotels and BnB Establishments on the Island of Gotland in Sweden

Anette Oxenswärdh

Abstract Tourism, one of the major industries in the world, has seen a constant increase in the past decades in Sweden and in particular on the island of Gotland. Among the different types of accommodation for visitors, Bed and breakfast, (BnB) facilities in Gotland are becoming more popular, in particular among independent guests. These facilities are often family owned, holding a few rooms, and have strong seasonal dependence. Research shows that there is a genuine willingness among BnB organizers to offer sustainable accommodations within the BnB industry. Many of the hosts can be defined as part-time lifestylers, that is, small entrepreneurs who often have a clear orientation towards non-economic motives. Their services, solutions, products, and world views can be seen as a venue for the creation of values of sustainability. However, this informal sector of housing recruitment is growing, which means that a large proportion of providers are outside municipal supervision but also support. Hotel's sustainability work, on the other side, is controlled by authorities and owners. Laws and directives regulate the work towards sustainability at the hotels. It is, though, hotel managers who has to push forward the questions of sustainability in their accommodations. But how do the hotels and BnB accommodations work and manage to implement sustainability issues in practice? This study aims to investigate both BnB establishments and hotels and their daily, practical work towards sustainability. The theoretical background consists of processes of co-creation, assignment and responsibility understanding as well as leadership towards sustainability. The results show that there is a difference between these types of housing as regards the way in which knowledge is shared. In addition, there is a clear difference in the way in which sustainability is expressed in practice: the accountability is largely attributable to the hotels, but BnB entrepreneurs convey responsibility. Hosts at BnBs seem to play a more active role in the mediation of sustainability issues than is the case with the hotel managers. It seems, moreover, that anonymity between hotel guests and staff does not encourage dialogue that in turn seems to be a prerequisite for knowl-

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edge exchange. Skills of dialogue can be considered as important tools in creating both extrinsic and intrinsic motivations for all parties in the work for sustainability.

Keywords Co-creation of values · Leadership · Responsibility · Sustainability · Tourist accommodation

1 Introduction

Tourism is a dynamic global industry which has grown and changed dramatically over the past twenty years (WTO 2010). The growth of travel has led to the concern shown for the environment and quality acquiring great importance (Gray et al. 2000; Gustafsson et al. 2003; Antony et al. 2004). Sustainability demands has further been connected to organizations with the term 'Corporate Social Responsibility' (CSR) since the 1990s and has more recently entailed a more holistic perspective, including all actors in society. Research has shown both various and changing definitions of sustainability/CSR (Carroll 1999). CSR has also been argued to entail a win-win situation where CSR initiatives are seen as a vehicle for efficiency and business success, rather than being in conflict with this (Porter and Kramer 2011; Furusten et al. 2012). Tourism is one of the largest resource consuming industries in the world. It is also the fastest growing and important industry in terms of the number of employees and its potential for the social, economic and environmental impacts (Holjevac 2003). Over the last decade, the implementation of different standard management systems, covering, among others, sustainability issues, have become apparent (Ayuso 2007). Moreover, according to voluntary management systems could have the potential to lead companies to a more sustainable development and would help hotels to be more competitive. Within the growing hotel industry, a number of initiatives to implement sustainable strategies have been undertaken on an international scale. Since the announcement of the Declaration of the Hague on Tourism, in 1989; 2003 Publication of the Djerba Declaration on Tourism and Climate Change 2007, Celebration of the II International Conference on Tourism and Climate Change in Davos, producing the Davos Declaration (Riquel 2010); a wide range of legislation e.g. protecting the environment has been passed in the light of corporate performance in the field of tourism. Many international and national environmental standards have been created, which can be implemented on their own or jointly with other international standards e.g. ISO 14001 and EMAS, EU Eco-Management and Audit Scheme (Ayuso 2007). The tourism industry on the island of Gotland in Sweden, has been an important economic factor for more than 150 years (Scholz and Wegener Friis 2013; Ronström 2008). As a constantly growing industry, tourism has increasing importance for employment on the island.

The main challenge for tourism development in the future, in the whole world is, however, sustainable development. In the 1990s, an intense debate on how to define sustainable tourism emerged (Muller 1994; Butler 1999; Hunter 2002; Hind and Mitchell 2004) however, a generally accepted definition of sustainable tourism

(Tao and Wall 2009) has not yet been agreed upon, even though the concept itself is well known (Garrod and Fyall 1998). The maximisation of benefits of tourism has also limits. It is not possible to increase tourism exponentially since there is a limit in terms of carrying capacity. Tourism should be kept at a level that allows both social and environmental sustainability rather than merely economic sustainability with maximisation of profit (Swarbrooke 2002). In the past decades, a new wave of tourism research has emerged that calls for the co-creation of sustainable values and solutions through the direct engagement of local stakeholders and communities (Richards and Hall 2000; Li and Hunter 2015). Within this perspective, Bed and Breakfast (BnB) and hotel accommodations are interesting research platforms that can potentially lead to an improved understanding of the sharing economy accommodation sector, and its impact on the environment and society in particular. The BnB phenomenon has seen a global increase over the past forty years, also thanks to technological advancements such as the internet and the rise of major room rental companies within the shared economy. It has literally exploded in Gotland in the last five years, particularly through the online platforms.

Research shows that there is a genuine willingness among BnB organizers to offer sustainable accommodations within the BnB industry (Oxenswärdh 2016, 2017). Many of the hosts can be defined as part-time life-stylers, that is, small entrepreneurs who often have a clear orientation towards non-economic motives. Their services, solutions, products, and world views can be seen as a venue for the creation of values of sustainability (Griggio and Oxenswärdh 2018). However, this informal sector of housing recruitment is growing, which means that a large proportion of providers are outside municipal supervision but also support. Hotel business has also been expanding on the island of Gotland due to increasing number of visitors over the past decade. Hotel's sustainability work, on the other hand and in general in Sweden, is controlled by authorities and owners. Laws and directives regulate the work towards sustainability at the hotels. But how do the hotels and BnB establishments work and manage to implement sustainability issues in practice? This study aims to investigate BnB establishments and hotels and their daily, practical work towards sustainability in Sweden, on the island of Gotland. This exploratory study discusses how BnB entrepreneurs and hotel managers on the island of Gotland reflect on issues of sustainability, what kind of solutions they implement in their establishments, and what the potential policy impacts could be. This study focusses on two distinct parts: (1) owners' and managers' motivations and choices for sustainable practices at their accommodations, and (2) the factors that hinders to realize their sustainability goals.

2 Theoretical Background

The concept of shared economy has become popular since the publication of Botsman and Rogers' book (2010) on collaborative consumption or economy (a term first coined by Felson and Spaeth in 1978) and has entered public discourse between 2011 and 2012 following the global success of Uber and Airbnb (Martin 2016).

Collaborative economy denotes "the use of internet technologies to connect distributed groups of people to make better use of skills, goods and other useful things" (in Dredge and Gyimothy 2015: 293). Within collaborative economy, shared economy can specifically be defined as "citizens freely sharing skills and knowledge in collaborative online endeavours, such as Wikipedia and open source software development" (Martin 2016: 151). Botsman and Rogers (2010) as well as Heinrichs (2013: 3) believe that collaborative consumption in the sharing economy has the potential to create "new pathways of sustainability", by promoting sustainable consumption practices, and by connecting consumers and enabling "them to make more efficient use of underutilized assets" (Martin 2016:149).

Within postmodern social theory, postmodern society is increasingly being defined by collaborative consumption and sharing economy, as part of a moral economy (see Germann Molz 2013). In tourism and hospitality studies in particular, novel frameworks are being developed in which collaborative consumption and production typologies (Munoz and Cohen 2017), and strategies (e.g. collaboration between the private and public sphere so that government can integrate new, developing collaborative consumption strategies such as a major room rental company into existing systems, see Cohen and Kietzmann 2014) can achieve sustainability. At the center of this theoretical framework lies the idea of human capital. As we know, the sharing economy is based on network effects in which consumers-peers (both hosts and guests) not only exchange goods and services (a room in a BnB/hotel) but also act upon each other's knowledge, experiences, and social and cultural capital to create a valuable product.

Thus, inspired by the Bordieuan forms of capital (1986), human capital in the sharing economy encompasses both cultural capital, that is, a person's cultural assets (education, personal predispositions etc.) that confers social status and power within a stratified society and social capital, that is, "the aggregate of the actual or potential resources which are linked to possession of a durable network" (Bourdieu 1986: 51). An individual's network of connections is thus essential part of the societal structure. Here, human capital creates a social-relational bridge between consumption and production, making both the guest and the host active makers in creating potentially more sustainable tourist experiences and strategies.

All this, described above, has challenged hotel business under the late decades. Human capital is also important for the hotel management. A committed leader can conduct sustainability work that is powerful and well thought out. Business enterprises have discovered that competitive advantages may be captured by measuring success in term of triple bottom line (TBL): social equity, ecological integrity, and financial profitability (Adriate and Fink 2008).

3 Consumers as Co-creators

The relationship between consumption and production has been questioned in the research. The two are no longer viewed as two separate processes (Firat and Venkatesh 1995). Today the consumer is seen as a participant in the process and one that creates a sense of the product. The consumer is thus a "co-producer" of his consumption, as consumption is seen as an identification marker. The co-creating act gives a sense of the product. Through its co-creation role becomes customers' active participants in the experience of the product. Through the co-creation role, the costumer becomes an active participant. At the same time, consumers are co-creators of values. This new role for the consumer is significantly different from the passive mass-market consumer in post-war consumption (Bergman and Klefsjö 2008, 2012; Cohen 2004; Vargo and Lusch 2006). This division of production and consumption, along with changing consumer roles and co-creation of value is shown most clearly in relation to the experience of consumption. Emotions arise inside consumers' heads through a complex interaction between the stimuli outside the individual and the person's personality, past experiences, etc. Experience Consumption is co-hijacked and consumers themselves clearly play an important role as contributors to the value of the product.

Co-creation is a term that has been discussed in various contexts and has held somewhat different connotations. Customer Participation has been defined as the degree to which the customer is involved in producing and supplying a service (Dabholkar 1990). Co-creation and customer engagement have also been noted as important for innovation and product (Thrift 2006; Matthing et al. 2004).

The emphasis in the early literature was the co-production as a source of productivity gains (Lovelock and Young 1979; Mills et al. 1983). Today the focus is on the customer's participation in the construction of goods and services, and it is suggested that customers can participate in the production and delivery through self-service (e.g., self-service grocery stores and gas stations). However, according to Prahalad and Ramaswamy (2004a, b), the creative process cannot only be seen as a tool to reduce production costs, but should be seen in relation to value creation. They use the term co-creation in the sense that customers go from being passive audience to become active co-creator of experiences. Co-creation is described in the experience economy as an environment, in which the supplier constructs context and the consumer is part of it (e.g. Disneyland). Bendapudi and Leone (2003) argues that the co-production may extend even further and is not only about customers' involvement and participation in a physical sense, but may also include psychological aspects.

Values are usually divided into subjective and objective values. This dichotomy arises when we see values based on consumption (value-in-use) compared to the value of trade (value in exchange). Value in Exchange values often expressed as the price of a commodity. Values of products and services can also be divided into utilitarian (benefit, e.g. such as fixing a car) and hedonistic (perceived feeling, e.g. such as to experience a concert) (Strahilevitz and Myers 1998) and the so-called novelties (novelty value, it is desirable for the moment.)

4 Sustainability as a Value and Quality Marker

Sustainability is based on the verb sustain meaning "to maintain, nourish, or encourage a phenomenon, and/or strengthen or improve it" (Sumner 2007, p. 77). The most widely accepted definitions of sustainability focus on improving the quality of human life without harming the environment and the capability of natural systems (Brundtland 1987; IUCN/UNEP/WWF 1991). The sustainability approach helps organizations work toward the goals of economic, social, and environmental sustainability and equally emphasize three pillars, which are triple-bottom line on an organization (Perez and del Bosque 2014; Wilson 2003).

Scholars who attempted to explain corporate sustainability at the organizational level stressed that people inside and stakeholders outside the organization should be considered and treated ethically, and in a responsible manner while working toward three dimensions of sustainability (Dyllick and Hockerts 2002; Wilson 2003). According to their definitions, corporate sustainability can comprise all corporate activities related to the pursuit of economic, social, and environmental health with the aim of raising standards of living for shareholders, employees, customers, pressure groups, and communities (Dyllick and Hockerts 2002; Van Marrewijk 2003).

Since WWII tourism, and mass tourism in particular has developed into an industry, and governments and developers have commonly responded with a range of neoliberal industry policy measures. In the past twenty years, however, growing concerns over resource depletion, climate change, increasing poverty, and global displacement have prompted new, alternative socio-political models of tourism guided by social, environmental, and economic sustainability ideas and practices (Dredge and Gyimothy 2015: 294). In the shared economy, the human capital is the asset already existing but not being used according to its potential. In this way, the collaborative economy offers a way of overcoming barriers to innovation, investment and product diversity by making hosts and guest interacting and investing their human capital in the creation of value-loaded and sustainable products.

5 Intrinsic and Extrinsic Motivations

Intrinsic motivation is defined as the doing of an activity for its inherent satisfactions rather than for some separable consequence. Although, in one sense, intrinsic motivation exists within individuals, in another sense intrinsic motivation exists in the relation between individuals and activities. Extrinsically motivated behaviours, those that are executed because they are instrumental to some separable consequence, can vary in the extent to which they represent self-determination (Ryan and Deci 2000). Internalization is the process of taking in a value or regulation, and integration is the process by which individuals more fully transform the regulation into their own so that it will emanate from their sense of self. Thought of as a continuum, the concept of internalization describes how one's motivation for behaviour can range from a moti-

vation or unwillingness, to passive compliance, to active personal commitment. With increasing internalization (and its associated sense of personal commitment) come greater persistence, more positive self-perceptions, and better quality of engagement.

A more autonomous, or self-determined, form of extrinsic motivation is regulation through *identification*. Here, the person has identified with the personal importance of a behaviour and has thus accepted its regulation as his or her own. Internalization and integration are the processes through which extrinsically motivated behaviours become more self-determined. Ryan and Deci (2000) points out that the facilitation of more self-determined behaviour requires conditions that allow satisfaction of these three basic human needs: to feel connected, effective, and agentic as one is exposed to new ideas and exercises new skills (Ryan and Deci 2000).

6 Lifestyle Entrepreneurs

There is a new style of entrepreneurship emerging in the tourism sector that aims to develop products that brings together the pillars of sustainability (social/cultural, environmental, and economic), and in so doing can create a better society. This conceptual and practical framework is well encompassed in the concept of sustainable livelihood, as introduced by Scoones (1998: 5): "the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base". Lifestyle entrepreneurs are part of this new trend.

Peer-to-peer online platforms such as Airbnb have partly englobed niche forms of tourism such as cultural and natural tourism. Airbnb, in fact, is not just an urban platform for the tourist accommodation sector but has also become economically and socially relevant in rural environments. Martin's research (2016: 154) has shown that the sharing economy in the form of Airbnb accommodations "identifies the environmental and social impacts of unsustainable consumer behaviour within capitalist economies as the problem to be addressed. Hence, the sharing economy is heralded as a new and sustainable form of consumption based on individuals accessing rather owning resources." Interestingly, his research also shows that the same actors within the sharing economy of Airbnb also acknowledge that many of its current forms (Airbnb has developed into a corporate co-option of the sharing economy) tend to reinforce the neoliberal economic paradigm, making economic, social, and environmental sustainability harder to achieve. In the past thirty years there has been a growing recognition of the importance of small-scale and lifestyle entrepreneurship in the tourism industry (Shaw 2004), but research on BnBs, despite the recent global growth of BnB establishments in developing and developed countries due to Airbnb (Guttentag 2015; Visser et al. 2017), has not developed accordingly.

Tourism entrepreneurship and lifestyle entrepreneurs such as BnB owners is still quite a neglected area of research (Ioannides and Petersen 2003; Thomas 2004; Li 2008; Ateljevic and Page 2009; Ateljevic and Doorne 2000; Burns 2001). There

are numerous definitions of lifestyle entrepreneurs (for a brief literature review of definitions used for lifestyle entrepreneurs see Gomez-Velasco and Saleilles 2007). According to Burns (2001), lifestyle entrepreneurs are primarily motivated by their will to undertake an activity they enjoy and provides adequate income. Morrison complicates the conceptualization of various forms of entrepreneurship by formulating three main features of entrepreneurship, that is, social, economic, and psychological, followed by the description of main entrepreneurial manners. Her results show that in the case of lifestyle entrepreneurs, the main motivation for starting a business are oriented towards non-economic motives (Morrison 2006). These results are confirmed by other researchers worldwide. Ateljevic and Doorne (2000), for instance, have shown in their research on adventure tourism small enterprises in New Zealand, that economic factors are not the driving forces for those entrepreneurs they studied.

For them, lifestyle values were central, making them operate within an ideological fence in which "their business success might be best measured in terms of a continuing ability to perpetuate their chosen lifestyle" (Ateljevic and Doorne 2000: 380–381). These findings highlight the importance of human capital in the creation of lifestyle businesses such as the BnB in this research.

It is important to highlight that lifestyle entrepreneurship within the booming sharing economy in the tourism industry can be a highly creative and innovative activity because, as Ateljevic and Doorne argue (2000: 381 in Shaw 2004: 126) the "rejection of an overly profit-driven orientation does not necessarily result in financial suicide or development stagnation, but rather provides opportunities to engage with 'niche' market consumers". Research shows that within the tourism industry, lifestyle entrepreneurs such as BnB owners can be important stakeholders in the creation of new tourism products as well as in the conservation and promotion of local natural and cultural heritage (Ateljevic and Doorne 2000), making them important platforms for understanding sustainable tourism development.

7 Hotel Entrepreneurs/Managers

Leadership is the art of influencing others. Communication is the primary task of any executive, and communication with employees regarding their concerns, problems, ideas, and suggestions about the organization is a critical skill of managing (Henderson 2004). The hotel managers require competency in terms of motivation and interpersonal skills. These skills are needed to inspire and motivate others, delegate work, and allow others to lead under the appropriate circumstances. Effectiveness of the ability to work with a variety of people influences the success of the managers (Kakabadse and Margerison 1988). A concern for community competency is considered as another leadership competency needed for managers. Hotel managers can promote the ideas of creating positive publicity for the hotel and placing a premium on social skills for the community (Zaccaro et al. 1991). This requires flexibility in dealing with others and in adjusting plans opportunistically as dictated by the demands of a changing social environment.

The importance of sustainability in the hotel industry has increased over the last decades, and sustainability is expected to be the defining issue for the industry in near future (Deloitte 2010). Sustainable innovation is a critical attribute in modern hotel management, as is widely recognized by experts and hotel managers alike. Hotels have also adapted to the risks associated with litigation and regulation as well as to the need of sustain profitability and market growth (Smerecnik and Andersen 2011).

Sustainable hotels are claimed to be perceived positively by hotel guests even though researchers have also identified contradiction between what customers state and how they act in reality. Customers seem to be reluctant in choosing sustainable hotels by making their choices depending on other attributes such as price, location or consumer trends (Han et al. 2009; Tilikidou et al. 2014). There are still barriers to the wider adoption of sustainable development principles by hotel managers. In order to implement sustainable management systems is believed to be expensive, there is insufficient information about the outcomes, hotel managers lack knowledge and skills and the market demand is limited (Hsiao et al. 2014). Sustainability certification has either not had positive effect on hotel bookings and revenues because it has been experienced as a conflict with quality expectations (ibid).

8 Accountability—Responsibility

Responsibility is a word and a concept that is increasingly being mentioned in our society, not at least in discussions about sustainability. It is pointed out how important it is, in any organizational context, to develop co-workers into responsible actors. In the scientific sense, the concept of responsibility is first and foremost a philosophical question. Philosophy and responsibility are interconnected on the one hand in the general question of what responsibility possibly is and on the other side of the normative question: what responsibility should be? (Kernell 2002). According Wildavsky (1986) responsibility is so integral part of human relationship that in its various meanings and shadings it serves as a synonym for almost every important political word. Responsibility is one of the major political concepts alongside freedom, equality and solidarity, etc. that are easily to use but the more precise meaning often remains vague (Wildavsky 1986). In practice meets the talk of responsibility often an approach that has been called Sunday concept. This means that everyone uses the word only in rhetorical sense as referring to responsibilities seems generally acceptable and it causes no harm. Bovens (1998) points out, however, that responsibility is a real concept that is even known by everyone. It is hard to imagine that anyone would deny or ignore their responsibility or deliberately behave irresponsibly. At the same time the term is used as a spiritual or emergency solution, e.g. within the party and government programs. In fact, responsibility as a concept is understood in many ways and used for many different purposes: responsibility changes depending on the time, venue and speakers (Bovens 1998). As a legal term the concept of responsibility is describing personal or financial penalties. In law and political science implies responsibilities consequences of an act or not acting.

A person who commits a crime must take her responsibility through paying fines or imprisonment. She is forced to face the consequences of her action. The law has been developed from the basic idea that one is free by choosing action alternatives, because otherwise it would be just as meaningless to ask people to be accountable as it is to punish machines (Mackie 1990; Permer and Permer 1994). In political science are the terms political responsibility and civic responsibility presented. To take active responsibility is an opportunity to free us from being held responsible/accountable.

Be assigned responsibility, to be accountable, does not automatically result taking or acting responsibly. An assigned responsibility is a passive form of responsibility. Taking responsibility is an active action, based on the subject's own free will? To be liable, however is based on future requirements. But to be held responsible for an act, must include that the actor has understood the responsibilities that the task/mission contains. Additionally, must the one who is held accountable had had the opportunity and own the ability to perform the task.

The responsibility is a complicated concept, according to Ingarden (1970, 1983); it commits us to study its different dimensions together. Lucas (1995) claims that, before we can form us a clear idea of what the real responsibility includes, we must also consider the circumstances in which we are not responsible.

9 Understanding the Assignment and Responsibilities

There is a certain dynamic between individuals, groups and organizations. Broadly speaking, responsibility in any organizational context can be described as a relationship between the commissioner and the actor. Relations of responsibility constitute the arena where both the exaction and the assumption of responsibility can take place. Responsibility/accountability is a crucial question in all organizations working towards sustainability. Issues of accountability consequently have a direct relationship to professional development in organizations. An essential part of the organization's assignment is to assume responsibility.

Different actors can understand both, the assignment and the responsibility, in different ways. This can be described in terms of the understanding of assignment and responsibility. The actors' understanding and interpretation of the assignment is significant for the way in which they assume responsibility for fulfilling what they are commissioned to do. The understanding includes the cognitive and psychological processes and shows in turn how the assumption of responsibility can be shaped (Abrahamsson and Andersen 2005; Oxenswärdh 2011).

When the understanding of responsibility describes what happens to the professionals and in turn leads to heightened competence, the concept of responsibility can also be viewed as a pedagogical concept. The understanding of assignment and responsibility can thus be regarded as a learning process, which is in turn essential for active assumption of responsibility. This learning process is deemed to be an important part of the organization staff's competence development and professional

development. These processes of understanding can be seen as a part of process of Collective learning (Oxenswärdh 2011).

Process of understanding one's responsibility is, however, a more unexplored concept—unlike understanding the mission—and it has to do with operator's own approach in question the nature of the professional obligation to consider themselves obliged on assignment.

To illustrate the difference between the terms, it would be quite possible finding cases where assignments understanding of a co-worker is high, i.e. it is a clear picture of the tasks they believe the decision maker expects be implemented. Despite this understanding, responsibility taking can be low, i.e. a number of different—e.g. moral/ethical/cultural—causes, may hamper actor's accountability to really carry out the assignment. One way to express the distinction between mission understanding and the responsibility of understanding is to assume that the former rests on the legal and the latter on legitimate grounds. Concepts of legality and legitimacy disclose relations between justice and morality. Legality focuses on social actions in a formal sense and is sanctioned by the state, e.g. by orders and rules of law. Legitimacy is more unspoken value system that has nothing to do with the formal legal system but in stead rests on ethical foundations (Bertilsson 1987; Oxenswärdh 2011). At the core of mission understanding exists seemingly even understanding of responsibility. Responsibility understanding is formed in the core of actor's competences. Thus, it is further emphasized that actors' responsibilities also include understanding of the approach to change and development.

10 CSR, Corporate Social Responsibility

In recent years there has been significant discussion in the business, academic, and popular press about "corporate sustainability." This term is often used in conjunction with, and in some cases as a synonym for, other terms such as "sustainable development" and "corporate social responsibility." According to Wilson (2003) the concept of corporate sustainability borrows elements from four more established concepts: (1) sustainable development, (2) corporate social responsibility, (3) stakeholder theory, and (4) corporate accountability theory. Sustainable development sets out the performance areas that companies should focus on, and also contributes the vision and societal goals that the corporation should work toward, namely environmental protection, social justice and equity, and economic development. Corporate social responsibility contributes ethical arguments and stakeholder theory provides business arguments as to why corporations should work towards these goals. Corporate accountability provides the rationale as to why companies should report to society on their performance in these areas.

Bergman and Klefsjö (2012) state that CSR is about creating a clear picture internally of how the organization today affects its stakeholders and other actors, and develop routines and approaches that strive to minimize any negative effect from the organization's processes and products on these groups and their environment.

There is currently no clear definition of what CSR really means and there are several different approaches. There are indications that there is a correlation between CSR and the company's profitability. Several large companies testify to this positive correlation. At the same time, there are also organizations that primarily exercise social responsibility for other reasons. In the hotel industry, in recent years, such entrepreneurs have been highlighted who would like to emphasize the importance of social engagement, not least in matters of sustainability (Bergman and Klefsjö 2012).

Not all companies currently subscribe to the principles of corporate sustainability, and it is unlikely that all will, at least not voluntarily. However, a significant number of companies have made public commitments to environmental protection, social justice and equity, and economic development. Their number continues to grow. This trend will be reinforced if shareholders and other stakeholders support and reward companies that conduct their operations in the spirit of sustainability.

11 Leadership and Responsibility

Because of the sustainable issues have become critical and not at least competitive issues in the hotels, there had been a need of recognition the vital role of leadership emphasizing the importance of leadership in developing and implementing sustainability strategies as well as in communicating corporate sustainability with internal and external stakeholders (Banerjee et al. 2003; Epstein and Buhovac 2014; Metcalf and Benn 2013).

In leadership literature, responsible leadership has been proposed to improve the company's social or environmental performance (Voegtlin et al. 2012). Responsible leadership has been defined as 'the art and ability involved in building, cultivating and sustaining trustful relationships to different stakeholders, both inside and outside the corporation, and in coordinating responsible action to achieve a meaningful, commonly shared business vision" (Maak 2007, p. 334). Therefore, environmentally responsible leadership can be defined as the art or ability to mobilize stakeholders inside and outside the organization to achieve business goals related to environmental sustainability (Maak 2007).

Environmentally responsible leadership is, thus, associated with the ability to engage with internal and external stakeholders. Environmentally responsible leaders are expected to consider the consequences of their actions for all stakeholders outside the organization, listen to the interests of their claims, and engage with them in formulating a strategy (Epstein and Buhovac 2014; Voegtlin et al. 2012). Moreover, environmentally responsible leaders should be able to convince their employees that environmental sustainability is an organization's core value and communicate its importance, allowing them to recognize such issues as part of their daily practice and to become more engaged in environmental actions (Banerjee et al. 2003).

12 Methodology

12.1 Case Area

The island of Gotland is situated in the middle of the Baltic Sea. Around 58,000 people live permanently in Gotland. Visby is the island's capital and only city where the principal administration, education, and health services and the most hotels are found. As in many other parts of the country, centralization is strong in Gotland.

Approximately 24,000 people live in Visby, close to 40% of the island's permanent inhabitants. About as many live in the countryside, however, rapid depopulation and loss of public services "has been rapid and is still going on, except during a couple of months in summer, when the population in some places multiplies 20 times or more" (Ronström 2003: 2). The inscription of Visby into the World Heritage List in 2005 has propelled the medieval town and the island into the global circuit of tourism. Improved transportation to and from the island as well as complete digitalization of the island (completed in 2017) has added to its competitive and attractiveness as a place to work and live. This has certainly enabled the town of Visby as well as rural Gotland to more easily and efficiently enter the global digital platforms and booking systems, and thus develop new forms of entrepreneurship. The enhanced number of visitors to the island has also demanded increased hotel room capacity. Even hotel business has benefited from digitization through the many different booking sites on the internet. Recently, the inauguration of the new cruise pier in Visby in April 2018 has opened up new opportunities and fears for tourism development in the city, and probably, on the whole island.

12.2 Data Collection

Primary data collection for this study took place between June 2017 and October 2018 as well as Jan–Feb 2019 on the island of Gotland in Southern Sweden. Twenty qualitative semi-structured interviews (Bernard 2006)—one hour each—were conducted with ten BnB owners in rural Gotland and with managers on ten hotels in the city of Visby. Interviews were based on an open-ended questionnaire developed by the author. All interviews were conducted in Swedish, except for one, in English. The questionnaire was composed of four sections, each containing related questions: (1) Introduction (owner's/manager's age, background etc.…), (2) On the business's establishment (when and why the owner started the BnB, accommodation's features/started working at the hotel etc.…), (3) Questions about sustainability (general questions about sustainability and how owners/managers implement sustainable solutions in their accommodations), (4) Sustainability and the future (what owners/managers wish to develop in the future in regard to sustainability in their accommodation, sustainability and tourism on the island etc.…).

Hotel managers were chosen from among the variety of hotels concerning the structure and size of their businesses. All ten hotels are situated in the main city of Gotland, Visby, five of them are part of the bigger, international hotel chains and five others are independent, private owned facilities. The selected hotels in this study has number of rooms, between 30 and 149. The interviewed hotel managers had responsibility over the issues of sustainability at the hotel. The average age of managers was between 30 and 40 years, most of them had university degree in economics or management and were fluent in at least two languages. Three of the managers originated from the island of Gotland and seven were from different part of mainland Sweden.

The amount of personal in the hotels varied strongly seasonally, and could be all from 16 in low season, up to 100 in high season.

The criteria used for the BnB selection were: BnB providers had to be residents of the island, owners of the BnB, and currently in business. Of all the BnB owners interviewed, one is run by one person and nine couples. The average age of participants was 50 and above, most of them had a college education, and were fluent in at least one foreign language (mostly English). Three participants, all female, were returning Gotlanders, meaning that they moved back to Gotland where they family originated and established their BnB in their family home. Four participants were foreigners who recently moved to Gotland and purchased a house. One participant was Swede but with no familial tides to Gotland.

The amount of personal varied even among BnB owners within seasons between 1 and 4 persons, but in the seven of ten accommodations did consist only the owners, usually a married couple. The number rooms varied between one to 30 rooms.

13 Analysis

This exploratory study discusses how BnB entrepreneurs and hotel managers on the island of Gotland reflect on issues of sustainability, what kind of solutions they implement in their establishments, and what the potential policy impacts could be. More specifically this study focusses on two distinct parts: (1) owners' and managers' motivations and choices for sustainable practices at their accommodations, and (2) the factors that hinders to realize their sustainability goals. Below, the most salient findings of this research are presented and analysed. In the following, in Table 1, the results of interviews with both BnB hosts and hotel managers are presented dealing with their awareness of sustainability in their businesses. The statements have been analysed against and by using the four sustainability aspects: economic, ecological, social and cultural sustainability.

Table 1 Actors awareness of sustainability issues

BnB owner and awareness on sustainability issues	Hotel managers and awareness on sustainability issues
Sustainable issues are important because the planet is our home! Cultural events are recommended, farms with good animal attitude. Artists who live on the island etc. Historical facts and sights are recommended Think about what you eat and what you do Being sustainable is idealistic! But it can be realized in practice. The guests are asking for sustainable products and living A balance is needed between the ecological, cultural, economic and social sustainability elements We live sustainable lives. Uses local products Better quality and good conscience Gotland is a little island with an easy access to beaches and cultural sites Easy to book via internet. Beautiful nature Perfect area for bicycle rides	Technology is developing all the time and new knowledge is added, sustainability is a continuous work, the water issue, biodiversity, waste, cultural brochures, proximity to the guests enables the dissemination of sustainability issues Balance important in communication—there has been a change within the guests' attitudes—sustainability is now expected and has become a value

14 BnB Owners' and Hotel Managers' Motivations and Choices

See Table 1.

15 BnB Providers

Lifestyle entrepreneurs are driven by ideals, innovation, and the will to change the world around them through their 'disruptive' economic activities to realize "a pathway to a decentralized, equitable and sustainable economy" (Martin 2016: 153) and develop sustainable livelihood strategies for them and the society they inhabit. The research shows that, although all participants have some sort of economic motives for starting their BnB, profit is not their main goal. This confirm recent studies that show how the sharing economy (Ateljevic and Dooren 2000) and lifestyle entrepreneurs (Morrison 2006) are best understood by reference to the cultural, economic, and social settings in which they are embedded (Oxenswärdh 2018).

All participants want to earn some extra money and supplement either their pension or other activities through the BnB: six out of ten interviewees want to use the money they earn to renovate their home, whereas some of them wish to invest and develop larger establishments as their main source of income. Thus, profit per se is not the driving motive for running a BnB in rural Gotland for participants. The

two strongest motives for opening their BnB were: meeting different people from around the world and live a different, better, more sustainable life. The findings are in line with recent research. Schaper and Calsen (2004) as well as Tzschentke et al. (2008b), for instance, point out in their research that personal values and beliefs are crucial in small hospitality firms for the implementation of sustainable initiatives and measures. For instance, one of the owners wanted to live a more sustainable and less stressed life, whereas another, after decades of living in a crowded city, needed to find a good place where he could live a safe and stable life and realize all his long-term sustainable plans. All participants in this study have one characteristic in common: before they started their BnB, they all spent time either abroad or in other parts of Sweden either for work (9 out of 10) or for study and work. During this period, participants have acquired skills and knowledge that are necessary to run a BnB: language skills, a different perspective on their own and/or other cultures, travelling and staying at similar establishments etc. Two of the ten informants are foreigners who have lived abroad for many years, speak several languages, and bring their own working experiences to their venture.

One of the owners, who just started his home-based BnB just outside Visby, would like to use his knowledge and long-term experience in the marketing sector to develop the market of rural BnB on the island:

> We need to understand the market in Sweden. I have the statistics, but what to do with it? I don't get it. Why don't BnB here do like in other countries? Joint marketing, for example. Charter flights that can go from the UK to Gotland or from Germany or maybe long-weekend packages for the winter?

A lady runs her BnB in her family home in the countryside. She has been working in the design industry for many years. She has the experience, the knowledge, the contacts and wishes for better branding for the accommodation sector in Gotland. A couple run a campground/farm with a diversified set of accommodations, from BnB to cottages and offer a wide range of activities for their guests year-round. Another lady tells that they are doing fine financially, even though the work is never-ending because they do everything themselves. It is not easy, particularly because their main goal with their establishment is to be sustainable: they have their own solar panel system and produce their own power, they have their own recycle centre, their own rules for serving food, as to optimize distribution and reduce waste. The couple has been educating themselves on sustainable strategies and solutions for years, attending courses on the island and on the mainland, collaborating with Uppsala University and Region Gotland. They share their knowledge with locals, islanders, the university, they are even on documentaries.

In order to achieve their goals, their cultural capital (Bourdieu 1986) appears to be one of their most valuable assets. These lifestyle entrepreneurs bring to the table a diverse range of awareness, motivation, knowledge, and skills that have the potential to develop a more sustainable rural accommodation on the island. Sharing and connecting with their guests seem to be one of the main motives for opening a BnB. These cultural encounters are part of alternative forms of tourism that privilege the authenticity of the encounter and of the experience, where visitors, and in this

case hosts too, long for what Krippendorf called "emotional recreation" (1987: 74), that is, activities and experiences that are not part of the everyday life and that provide people with "intellectual, physical, and even spiritual stimulation" (Harrison 2003: 27). These experiences are only possible when those who provide them have similar cultural assets (education, skills, life experiences) than those who want to enjoy them. Here the tourist consumption of the BnB experience and holiday in Gotland becomes valuable and enriching for both parties, the host and the guest, because of the shared contents.

To realize their visions of a better life, in which their knowledge, skills, and ideals are shared with their guests to create a valuable and memorable experience, participants engage their guests during their visits. Pine and Gilmore (1999) "observed that a memorable experience must engage consumers across dimensions through active participation in which all senses are involved" (Griggio 2015: 254). This perspective can also be expanded to hosts. One of the most salient ways participants engage their guests staying at their BnB is through strategies of sustainability. One interesting aspect of this research concerns participants ideas and practices of sustainability. When asked to define what sustainability is for them, all participants said that sustainability for them was: recycling, using the car less, and buying local produces—food and crafts and giving hints on different cultural/historical objects to visit. One lady for instance, has taken the decision not to fly anymore in order to reduce her carbon footprint.

To sum up this part of the analysis it seems that BnB owners, through their statements, can be seen as persons aware of all the four pillars of sustainability. One of the hotel managers can be seen as a lifestyle entrepreneur. Her small privately-owned establishment is run by sustainable thinking throughout. Her goal in future is to become the most sustainable hotel in the island.

16 Hotel Managers

Hotel managers, interviewed in this study, are pointing out the importance of strategies for sustainability in their hotels but not all have started to work for or have even goals drawn up for this work. They do not talk about value-creation, importance of it for themselves or their staff in understanding sustainability goals. Five of the managers are working in the bigger international hotel chains and have both education and engagement on sustainability issues. They seem to be aware of the global issues of sustainability and express their worries over the planet. But most of them seem to follow the market logic within their statements by telling that customers now are demanding some sustainable solutions. Still, majority of the managers doesn't even touch this topic in their statements. It can be understood as lack of knowledge on sustainability issues or that managers took sustainability issues as granted. Managers are clearly connecting the issues of sustainability to their assignment and not into their personal life.

17 Goals and Actions Toward Sustainability in Accommodations

Interview statements were further divided into questions on what goals and actions both BnB owners and hotel managers have for their sustainability work. Here below, in Table 2, are some of the statements presented.

18 BnB Owners

When asked how they 'translate' their ideas of sustainability into their BnB business, there were few in congruences between theory and practice. Almost all of the respondents claim that they want to live a more sustainable life and run her BnB the same way. BnB entrepreneurs show that they really live as they learn. They seem to take a responsibility for their actions. They grow their vegetables or use organic and locally-grown goods in their accommodations. Many of them have already switched to a more energy-saving system in terms of heating, lighting and transportation. They seem to have a dialogue with their guests about sustainability and the desirable measures towards these goals in their homes. Furthermore, there are information in the form of brochures and various signs that remind and inform the guests of the importance of saving energy and thinking sustainably. Through dialogue with the guests where even their experiences are exchanged, the value creation of sustainability takes place. As far as the financial investments on sustainable measures are concerned, it seems that BnB owners are not primarily interested in the measures generating money, but investing for the sake of more ideological reasons.

19 Hotel Managers About the Goals and Actions

The responses from hotel managers testify how the organizational form influences the measures and goals set for sustainability. In a larger, profit driven businesses, the emphasis seems to lie on economic premises and regulations. There are few entrepreneurs who go further than this, but there are also some of that kind. In this study they can be found among the smaller, privately owned options. It is these managers who also engage their staff and train them on sustainability issues in a conscious manner. Larger hotels tend to implement more strategic environmental management practices, while the personal values and beliefs of managers in small hotel operations have been found to be predictors of sustainability adoption (Tzschentke et al. 2008a).

A significant difference has been observed between chain-owned hotels and independent hotels; the latter rely on managers to introduce sustainability, while the former has more strategic environmental policies and values.

Table 2 Goals and actions towards sustainable accommodations

Goals and actions in BnBs	Goals and actions in hotels
Our goal is to become an energy center on the island Re-cycled interior and construction materials. Folder in the room talks about sustainability measures. Ecological sheets We rent out bicycles to our guests Being self-reliance—producing my own vegetables using sustainable cultivation methods, installing solar panels, insulate the house to reduce energy usage Solar panels. Led lighting. We drive electric car Certified breakfast buffet. Ecological products. Local suppliers Geothermal heating. Waste sorting We buy wind power, drive gas car. Don't buy stuff, borrow machines instead. We have installed timers for use of hot water Inform of local excursions, events and local craftsman. We have info brochures on the wall	We want to be the leading hotel within sustainability thinking. The guests are to put their garbage in a vessel—we then sort in 17 different sections Save water, signs on towel use, waste sorting, energy efficient (no heating in the rooms when no guests are present) The food is from Gotlandic suppliers, retailers, info boards are placed in the restaurants for the guests about this Consumption should go down e.g. sheets should not be changed so often. Leftover food goes to biofuel. We compost or the municipality does it We have signs on sustainability measures in all the rooms, at the pool on the water use and the reuse of the towels We hire an eco-labelled laundry. The pool is heated with recycled heat More waste sorting, we donate goods that are left behind to aid organizations Signing lists are available and applied for the staff in order to check up sustainable measures No internal training takes place within environmental issues due to short employment contracts We developed our own technology—took away all chemicals—more money remains in the cashier, do not release toxins into the sewer, staff feel better We have won several awards for our environmental work The people, planet, profit—important to consider Two days of introductory course for all staff. In the case of new recruits, we will address issues of sustainability. Staff meeting every month—once a year we have an environmental meeting Save a pike—an environmental campaign for the guests made that the environmental issues aroused

In order to control their staff, the hotels use different types of signing lists instead of investing in more education to their personnel, in order to increase their understanding of sustainability issues. This can create a type of instrumentalism, in which, responsibility is expressed through the duty and becomes very fragmented (Oxenswärdh 2011). Information over the sustainability work at some of these ten hotels were communicated by hotels' homepages and via different info boards, but were not discussed directly with the guests, expect in one hotel. However, all managers expressed their willingness to do more in the future for sustainability at their facilities; but they addressed some external obstacles in this work, the topic that will be discussed in the following paragraph.

20 Factors Hindering Sustainability Solutions

For all participants, indistinctly, sustainability is a big issue, one they are attempting to solve by living more sustainably, as shown in the above section. Part of the strategy is also to educate themselves and their staff about sustainable strategies and solutions. Still, all of them complain that it is very hard to reach their wished potential. Why is it so? What is slowing them down, according to their point of view? (Table 3).

21 Hinders at BnB Accommodations

When asked what the main barriers toward a more sustainable product are, e.g. an accommodation business that is mostly self-reliant and does not deplete the island's resources, nine out of ten participants listed lack of communication, information, and complex bureaucracy at regional level. Participants were not shy to talk about their frustrations with Region Gotland. There were two main points participants particularly cared about. Despite their efforts to run a more sustainable establishment, they feel that Gotland is not doing enough to become a more sustainable island, hence hindering their own efforts and damaging their business. Some of the respondents highlights problems related to the environment that Region Gotland ought to address quickly and more aggressively not only to improve tourism, but also to improve the life of those who live on the island. One current very 'hot potato' in the sustainability and business panorama of Gotland, is the new cruise pier. Respondents are concerned about how sustainable it is to support cruise tourism.

Despite these difficulties, ideologies of sustainability and a certain confidence in their own cultural and social capital keep participants running. They think that what they are doing is important for the future. This is confirmed by several studies, as pointed out by van Haastert and De Grosbois (2010: 181): "it is common for small hospitality firms to remain unprofitable, to struggle with long-term survival and face difficulties with major capital investments. This context is very important to understanding the level of commitment and concerns that small hospitality owners

Table 3 The factors that hinders implementation of sustainability goals

BnB accommodations and hinders	Hotels and hinders
One serious issue concerns the un sustainability of the global food chain. It is the production and transportation of food which is not sustainable anymore Water shortage but also the fishery situation in the Baltic region is a hinder The cement industry on the island uses too much water and then municipality want us citizens to save water I don't think this island is sustainable…we must import much of what we consume Gotland is not really a sustainable island, but it's trying…farmers should use less chemicals in the ground, and the region should help achieve these goals also with the help of a better regional transport system The island is only partly sustainable. But there is still much left to do…I wonder how sustainable is, for example, the cruise pier? We are throwing away our garbage, there is mining, and many differences in the island, strange Problem with the public transportation Tax rules for the BnB owners are complicated Frustrations with Region Gotland Lack of communication, clear rules, and heavy bureaucracy within Region Gotland Region Gotland should simplify bureaucracy. There are different guys that don't talk to each other, they should know more about the rules and each other, take time to help and to just control, inform not just about our obligations but also how they can help us with our rights There should be simpler regulations, better counselling…it's difficult to get a person to talk to, there is the need for preventive work, same with fire protection China shops, not many local products for sale. About the countryside: guests think that countryside people are nice but it is difficult to find good food outside Visby. People from the continent want to have nice restaurants even in the countryside	We at the hotel industry on the island are not following the development; not planting trees, not having ecological and environmentally certified coffee etc. The certification body we have been with for several years does not give us feedback. I contacted them and now we have together developed a program for monitoring sustainability work at the hotels in Sweden The poor public transportation system is a hinder for our guests getting around the island. Energy consumption—high in the hotels—how should this be solved? Lack of ferry capacity during high season. The state's removal of tax discount for young employees The guests' wishes regarding sustainability cannot always be met due to economic reasons The municipality should inform and educate visitors about sustainability issues Many of the guests are not acting sustainable, we can't control everyone what they do! Joint certification on sustainability at hotels is lacking globally Communication channels to the guests are missing. You need other actors. Important with an external partner There is no coordination in the municipality. Being critical is good, but you also have to create solutions!

have with regards to becoming more sustainable in their operations". Participants' responses also highlight that they are particularly aware of the environmental impact of their business, and for this reason they wish to implement sustainable measures. This finding is interesting because it differs from previous studies (see Vernon et al. 2003 in South East Corwall, Tzschentke et al. 2008a, b in Scotland, and Van Haarstert and De Grosbois 2010 in Southern Canada) that claim that many BnB owners have limited awareness of the impact of their establishments on the environment and possible initiatives they could implement. Many participants feel that their efforts and human capital is sometimes going to waste because of lack of communication between them and Region Gotland as well as among the various region's departments involved in sustainability and tourism development.

Some of the participants wishes for a more inclusive and democratic system in which Region Gotland not only inform about an entrepreneur's obligations but also, and in particular, about his/her rights. Some of the comments touched a broad range of issues, from social to environmental. This lack of clarify, communication, and collaboration between Region Gotland and small, rural, and family-oriented BnB has important consequences. BnB owners feel that the current legal and policy framework does not encourage the formalization of their business, creating an interesting parallel between Gotland and Cuba (see Henken 2002). They feel left out and not supported both financially and through informative and educational events to implement sustainable measures in their establishments. This situation deprives Gotland from; further developing sustainable environmental and economic measures in the countryside, and being able to formalize, control, and get revenue from BnB, thus offering guests a safer environment. It must be said that only three BnB out of ten were registered with Region Gotland and annually inspected by the food and health department.

BnB owners, however, continue to hope for a valuable collaboration between Region Gotland and had plenty of suggestions.

The main themes concerned further education on how to run a BnB, on how to be more sustainable on a small scale, improving the island's public transport system so that guests can reach the BnB via bus instead of renting a car, create information groups where entrepreneurs with same interests can meet with Region Gotland, sponsor those business that work towards sustainability, better technology to reach more guests and become more efficient.

22 Hinders at the Hotels

Lack of communication, clear rules, and heavy bureaucracy within Region Gotland is also pinpointed by hotel managers as a main hinder for sustainable goals and actions. Hotel managers talk about the lack of a global and common certification for the hotels. The amount of different certification models makes it difficult for them to choose a suitable model for their hotels. In addition, they complain about the models used to not offer the desired feedback. The certifications are perceived

as a control instrument and provide no advice or support for further development of the operations. This in turn shows that hotel managers do not use these results to evaluate and develop their organizations (Bergman and Klefsjö 2012). The hotel managers also testify to the lack of cooperation and lack of network with other actors and hotels on the abroad and mainland, but also on the island. This means, probably, that they feel that they do not have the supporting structures they would want and need in their daily work.

Respondents also address aspects that are directly linked to their economic reality. Local traffic on the island is deficient and counteracts sustainability thinking. The ferry traffic between the mainland and the island during the high season is perceived as under-dimensioned. This causes uneven guest influx due to cancellations. Hotel managers also show a dissatisfaction with the abolished state tax benefits for young employees. All the hotels multiply their staff during the high season (April-Sept). Most workers come from the mainland, are young and have little or no education in the hotel industry This seasonal staff structure seems to make it uninteresting for many of hotel managers to train their staff on sustainability issues.

Other areas that managers want Region Gotland to take on greater responsibility and help is with energy conversion. They want to be offered subsidies to reduce their energy costs. Another area that they want help with is to educate visitors in the sustainability thinking. As one of the hotel managers expresses it: 'Many of the guests are not acting sustainable, we can't control everyone what they do!'

Statement shows that they really don't have communication channels to the guests. All these statements above show that responsibility is strongly linked to the economic sustainability at the hotels, that is, to accountability. Still, managers note that they can't fulfil all the wishers of guests, regarding sustainability, due to economic reasons. One of the ten managers seem to take her responsibility by stating that being critical is good but you also need to find and create solutions.

23 Conclusions

Sustainability is increasingly attracting attention within global hospitality industry including marketing variations in the volume and the detail of the data and information expressed by the owners and managers. This exploratory study discusses how some BnB owners and hotel managers in Gotland reflect on issues of sustainability, what kind of solutions they implement in their establishments and what are the potential policy impacts. It is stated that collaborative consumption strategies can achieve sustainability in businesses. The sharing economy is based on network effects in which consumers-peers (both hosts/mangers and guests) not only exchange goods and services (a room in a BnB/hotel) but also act upon each other's knowledge, experiences, and social and cultural capital to create a valuable product. An individual's network of connections is thus essential part of the societal structure. Here, human capital creates a social-relational bridge between consumption and production, mak-

ing both the guest and the host active makers in creating potentially more sustainable tourist experiences and strategies.

Many of the BnB hosts who participated in the study can be defined as part-time life-stylers, that is, small entrepreneurs who often have a clear orientation towards non-economic motives. Results show that knowledge acquisition on issues of sustainability among these lifestyle entrepreneurs, interviewed in this study, is a work in progress. Although informants are well aware of issues of sustainability and many of them are already implementing sustainable solutions in their facilities, their efforts seem to be often hampered by high investment costs and sluggish bureaucracy at regional level. They also express their willingness to gain more knowledge of sustainable solutions by joining a network where they can meet other entrepreneurs for the exchange of knowledge, but also meet sustainability experts such as academics.

The co-creating processes with the guests give the hosts an opportunity to knowledge sharing about sustainability issues. The discussions on sustainability issues with the guests can, at best, make the hosts to ambassadors of sustainable solutions in accommodation business, helping to make tourism more sustainable. In this study only three of ten BnB establishments are under formal municipal control. Small-scale rental of rooms is not regulated by local authorities in Sweden other than income from the renting of rooms which is taxable (for 4 rooms or less, see Verksamt (2018) for current renting regulations in Sweden). However, the informal sector of housing recruitment is growing, which means that a large proportion of providers are outside municipal supervision but also support. The study shows that there is a genuine willingness among BnB organizers to offer sustainable accommodations within the BnB industry. Nevertheless, the research also shows that they need support both in terms of knowledge and opportunities.

One way to support BnB providers could be that of creating a network where both hosts and local tourist organizers can meet for knowledge sharing. This network could also include local authorities and researchers in tourism and sustainability issues.

What comes to the hotels in this study, it shows that the external factors are influencing not only the structure of these organizations but also leadership, culture and number of personnel. The question here is to be put: are these external factors really hindering them in implementing sustainability issues internally or is there something else that stands in their way?

In order to be able to co-create values of sustainability, with both staff members and customers, managers seem to need awareness and understanding of responsibilities as well as skills of dialogue. Furthermore, their need to balance between the four pillars of sustainability in their actions or work towards sustainability. Difference between hotel managers and BnB providers is, of course, substantial, due to organizational reasons. BnB providers do not always have personnel or they are only few. In addition, they are themselves leaders of their business and do not have to consider profit aspects, although the economic conditions are important also for them. They are accountable only for themselves.

Beyond organizational structure, the ability to adapt to change is a strong predictor of accommodations' adoption of sustainable innovations (DeCanio et al. 2000; Higa et al. 1997). Research has revealed a number of environmental factors that can block

innovation, such as norms of harshly criticizing new ideas, political problems within the organization, an emphasis on the status quo, a conservative and low-risk attitude among top management, and excessive time pressure (Amabile 2012). Organizational support for sustainable work establishes a friendly environment for encouraging information exchange and the communication of ideas, as well as a reward system for recognizing the initiation of creative ideas (Horng et al. 2016). Although innovation efforts can fail, organizations must do their best to eliminate obstacles or issues that hamper the implementation of innovation procedures. Maybe the best motivator and a tool for creating co-operation and co-creation for and towards sustainable development, in all kind tourist establishments, is dialogue.

In order to summarize the results in this study it can be stated that these two types of accommodations for visitors are different in many ways. At the same time, there are similarities, not least with the organization of work towards sustainability. BnB providers can be seen as life-stylers who work for sustainability based on their private beliefs and try to take responsibility for the whole planet. They have come a long way with their sustainability work at their homes and are happy to discuss sustainability with their guests. They often lack personnel and do not need to follow so many regulations. They feel, however, isolated from like-minded actors and, not least, they want the municipality to take its responsibility and organize and support more education and create network for them in sustainability issues. It can be argued that their motivation for the creation of a sustainable establishment originates from their own lifestyle.

Hotel managers, entrepreneurs, in turn, seem to have stuck in some type of instrumentalism in their work towards sustainability. It can be argued that they use more extrinsic motivations in their work by being accountable for the implementation of various kinds of follow-up of sustainability work in the form of certification and evaluations and lists. A bigger part of the sustainability work aims to provide an economic value for the company and almost completely misses the socio-cultural sustainability approaches. Most of the hotels in this study lack training for staff on sustainability issues. However, this does not apply to all establishments. Some private hotel entrepreneurs seem to work more like life-stylers and do put great effort and value on sustainability work by co-creating with their guests.

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Brazilian Legal Time of Sustainable Development: a Short Term View in Contrast with Agenda 2030

Carlos Luiz Strapazzon and Clarissa Bueno Wandscheer

Abstract Brazil's commitment with SDG might be mere demagoguery without a suitable regulatory framework to grant the continuity of actions in long cycles of policies. This paper explores the existing contrast between the Brazilian model of planning its policies and the view of AGENDA 2030. The significance of the time of development has emerged with MDG Agenda, but it seems to be even more relevant nowadays. In both Agenda, goals and targets have a 15-years duration. Such guideline was meant to implement goals progressively, avoiding setbacks. This paper is aimed at presenting the time, form and somehow the substance inherent to Brazilian regulatory model of planning public policies as well as underline legal barriers existing therein to achieve sustainable development goals. In doing so, it points out three major legal obstacles: (1) the one-dimensional meaning of sustainability noticeable in such regulation, (2) the weak regulation of Agenda 2030 and (3) the legal model of planning development, usually limited to 4-year cycles. It is argued that the Agenda 2030 will fail in Brazil should a new model of regulation suitable with innovations required to implement ODS in 15-year cycles is not set out.

Keyword Brazil · Sustainable development · Discontinuity of public policies · Narrow sense of sustainability

1 Introduction

From 1824 to 1988, Brazil has experienced the worse aspects of the so called *third world* and the best of the so called *first world.* Together, as a dialectic pair, both have

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designed one of the most iconic landscape of the Latin American *underdevelopment.* It is for that very reason that Constitutional Assembly enshrined *development* as a special matter of the Constitution that entered into force in 1988. *Development* was supposed to be a key word of the new democracy grammar.

Therefore, the word *development* has appeared nothing less than 53 times in such Constitution. For instance, taking the early part of the Charter which covers fundamental matters (Title I and II), one might see *development* as a *fundamental goal of the Republic*. Upon Title I, where fundamental principles are set forth (Art. 3o, II), *national development* is an end for all unities of the Federation, as it is for society as a whole. Notwithstanding, *development* was put together with three other goals in such Article, all of them equally named as fundamental goals by the Charter. Here are them: 1. Edificating a free, fair and supportive society; 2. Eradicating poverty and marginalization together with lowering social and regional inequality; 3. Promoting well being for all, without prejudice or any sort of discrimination. Thus, they are there toward complementing the sense of the broad word *development.* Such goals are truly *res publican values*, not merely governments goals. In turn, upon Title II is dedicated to a special group of Constitutional rights, called *fundamental rights*. Over there, the word *development* appears twice. Firstly, somehow as a vector arrow to intellectual and industrial property rights, since *national development* is the constitutional reason toward protecting such rights. Soon after, references to development are made within the context of small familiar farms, as to indicating special concerns with farm families as well as rural labour. It is also worth noting that Brazilian Charter has stipulated *national development* as a purpose for social and economic policies.[1] Although several provisions encompass general rules[2] and some stipulate partial content of such policies,[3] which is supposed to guide policies of all Federation bodies, there is the Art. 174 § 1, which imposes drafting a particular law so as to establish the guidelines and bases for the planning of a balanced national development. Therefore, laws must complete the meaning of constitutional words and harmonise national with regional *development* plans.

In a nutshell, Brazilian Constitution was written with the purpose of providing a legal framework to national development. Such concernings were at once the as highest as possible political answer to criticism against the *underdevelopment scenario* as well as an approximation to international new approaches upon development.

Taking for granted that the Charter does not adopt any particular development approach, on one hand it is fair to state it refuses the narrow sense of development as pure economic growth (Wolfe 2000, p. 726), on the other, it is quite clear that it is concordant with several partial elements of the UN sustainable and human development

[1] See Art. 21, IX.

[2] E.g. Art. 23 § un;.

[3] See Art. 21, XX, Art. 182 (urban development); Art. 180 (tourism as a source of development); Art. 35, III, e; Art. 167, IV, Art. 212, Art. 214, Art. 216-A, Art. 60-ADCT (development of education, health and cultural systems); Art. 174 § 1°, Art. 43, Art. 151, I, Art. 159, I, c; Art. 34 § 11-ADCT (regional development); Art. 218; Art. 219-A (development of science); Art. 219 (domestic market as a mean of development); Art. 239 (economic development; National Bank for Social and Economic Development).

programs (2000–2030). Nothing better illustrate this than the following: if socio-economic development is emphasized by the Charter, likewise it recognizes the right to an ecologically balanced environment[4] both to present and future generations.

As far as a broader vision of development is concerned, it is worthwhile mentioning the Declaration on the right of Development (1986) and the Brundtland Report of the World Commission on Environment and Development (1987), which seems to have opened the discussion upon development and enforcement of multidimensional view of human rights as well as sustainable development. Furthermore, the Earth Charter has associated sustainability to development of democratic societies. Shortly thereafter, the United Nations Development Program (UNDP-2000 to 2015) assumed a multidimensional vision of development within a long term program of actions. The multidimensionality of development was definitely established with the Agenda 2030 and its 17 SDG. From now on, multidimensional development encompass a new view on complexity of life in earth and inherent risks of the so-called Anthropocene age. Such new view includes promoting new styles of production and consumption along with commitment with protecting all fundamental human rights so as to strengthen personal freedom, resilience of communities and recovery, protection and sustainable use of the natural environment. Therefore, in order to be sustainable policies must align these 3 pillars of development: economic, social and environmental.

Certainly, it would be a mistake to assume a perfect connection between the Brazilian Constitutional view on development with such a new trend. But it would also be a mistake to state the Charter is insensitive to it. Although the Constitution does not specify a plain meaning to development in one particular provision, it does provide partial liaisons that suit the supra mentioned UN agendas. This means that Brazilian Constitution do recognizes the key contents of the sustainable development agenda. In other words, Brazil has raised a Constitutional order with substantive ties with the SDGs. Yet, such ties are not enough to protect its progressive implementation in 15-year cycles. The required long term running of such policies are not guaranteed by the Constitutional rules. This meant discontinuance in public policies is admitted. As far as one can see, this is a significant obstacle to the implementation thereof.

Three obstacles that seriously threat Brazilian commitment with the SDG shall be analysed here. Firstly, the prevailing one-dimensional view of sustainable development. Secondly, the feebleness of the legal framework which presently underpins the 2030 Agenda. Finally, the short-term as the prevailing time for the public policies cycles.

2 One-Dimensional View for Sustainable Development

It is well known that sustainable development stem from environmental debates UNDP 2010; Boff 2012; Niederle and Radomsky 2016). In addition, the classic motto of sustainable development evokes less environmental degradation, yet ideal would

[4]See Art. 225.

be non-degradation. Yet, this one-dimensional view has proved to be insufficient to achieve real sustainable development, once social or economic neglects immediately impact on environment. Unfortunately, this partial view of the phenomena is still dominant in Brazilian legal order.

With the aim to identify the most common sense of *sustainable development* applied by the Brazilian legislation it was undertaken an analysis on national legislation, both in form and content.[5]

The first analysis of the data corresponds to the period that comes from January 2010 to March 2018. Such time was chosen in view of the first UNDP Report addressing the theme of sustainable development yet still focused on the environmental aspect. Over this period of time, none Laws were found. As a matter of fact, only 7 Presidential Decrees were found mentioning the term *sustainable development* (Wandscheer et al. 2018). Out of this amount, 4 were substantially related to environment.[6] Thus, 57% of the norms were referred to environmental issues while 100% thereof were soft instruments of regulation: Presidential Decrees. The second part of the research has contemplated the period from September 2015 to January 2019. The database was again the federal legislation made available by the Presidency of the Republic. Sustainable development was present in 13 Presidential Decrees, 1 Provisional Measure[7] and 1 Legislative Decree, enacted by the Congress. Whenever the single word *sustainable* was adopted, the outcome was the following: 20 Presidential Decrees, 1 Law, 1 Provisional Measure and 2 Legislative Decrees enacted by the Congress. It might be observed that the second search encompassed all the outcomes of the first one. Therefore, there was no increase in regulations when the keywords were replaced. It is also observed that of the normative instruments analysed from September 2015 to January 2019, the term sustainable development appears in the descriptions (menus) of 29% of normative acts. In others it is an integral part of the provisions (articles) in the regulations found.

[5]The research focused exclusively on the use of *sustainable development* within the Brazilian legislation. The main goal was to know whether one-dimensional or multidimensional view was applied. This do not exclude other normative instruments that might have been edited without any references to *sustainable development*. As many countries have already done, in 2017 Brazil also carried out its National Voluntary Report on SDG, a comprehensive survey of all existing legislation so as to know to what extent the legislation and public policies in force were compatible with SDG. The study compared all 241 indicators and 169 targets of the SDG with 1.132 targets and 303 goals of the 2016–2019 Government Action Plan. Although the outcomes of such Report have never been confirmed by critics from outside the official establishment, it shows up that 86% of the targets and 78% of the ODS indicators were already covered by Brazilian legislation (BRAZIL 2017, p 27).

[6]As for the rest, 1 refers to the National Commission for the Sustainable Development Objectives, 1 establishes environmental licensing criteria and the last one on hiring of public administration.

[7]The Provisional Measure is enacted by the President in cases of both urgency and relevance. By one side, it is similar to Presidential Decrees, by the other, it is similar to laws because once in force it is as mandatory as a real law. It does not have the perenniality of the laws, though. Its temporal limit is 120 days. Once in force it likewise serves as a Bill because of the requirement of validation by the part of Legislative branch throughout the 120 days of enforcement. In case of approval, the provisional become perennial. A new number as well as a new law is enacted. As with any legal rule, should Congress overturn thereof, from that moment onwards it will no longer be a mandatory norm.

The Legislative Decrees issued within that period refer to grants of authorization to perform service by association. Hence, it is not an instrument able to guiding Agenda 2030. The Provisional Measure 782/2017 was converted into Law 13.502/2017 which, in turn, has been ent aimed to establish the organs of the Presidency of the Republic and its Ministries, and also that the term sustainable development looks like associated with sustainable rural development.

As for the 20 Presidential Decree, five of them refer to the structure of positions and functions of the Federal Executive structure, 2 refer to the organizational structure of Secretariats between Ministries and Civil House, 1 proposes criteria for sustainable development in contracted by the Federal Government, 1 creates the volunteer award for the development of federal public administration personnel. Therefore, 45% of the Decrees issued during the period do not directly interfere with the implementation of the SDGs.

Also regarding the Presidential Decrees aimed at creating the National Commission for the Sustainable Development Objectives and the National Prize for the SDGs, such decrees do not describe actions for the accomplishment of the SDGs.

As for the remaining Presidential Decrees, 1 was overturned; the others were related to the environmental interface of sustainable development from multiple perspectives. From the creation of conservation units, plans to strengthen extractive communities as well as to manage resources of the sea, creation of a national commission to reduce greenhouse gas emissions, particular rules to the Amazon Fund as well as toward regulating the Law 13.123/2015 upon the access to genetic resources and biodiversity. This set of subjects show up the concentration of regulation in matters related to the environmental view of sustainable development, that is to say, such kind of regulation reinforces the one-dimensional view of the term within the Brazilian public policies.

One might see the above mentioned Law n.13.186/2015 as an exception, once it has established the education policy for sustainable consumption and constitutes the solely initiative that covers economic along with environmental aspects of sustainable development. Although it is noteworthy that it stem from an Executive Provisional Measure, its approach to the economic pilar actually encourage changes in consumer and businesses behaviours, along with, again, stimulating special care to their impacts on environment, such as waste treatment, recycling and reuse.

Regarding particularly the SDGs, in 2017, Saad Alfarargi, Special Rapporteur on the right to development pointed out, among other problems, lack of engagement.

> Despite the progressive evolution of the concept of the right to development and its inclusion in some international and regional instruments and national constitutions, the general level of awareness and engagement for its implementation are low.

With the Presidential Decree 8.862/2016, Brazil has a first measure to lead with SDGs. For the first time a National Commission for sustainable development goals was created, without the feature of a President Council. This Commission is composed of representatives of the federal government, states and municipalities along with civil society. Its authority is quite broad: from elaborating a plan of action, proposing strategies, monitoring and monitoring the development of SDOs, until

promoting articulation between public agencies and entities of the federative units. Despite such conceptual evolution, up to February 2019, the only relevant action identified was the launch of the ODS Brazil Award.

The second significant measure is the Decree 9.203(2017), which has created the Intergovernmental Committee on Governance (IGC), with the purpose of advising the President of the Republic to implement a governance policy to the federal level of administration. It is an important breakthrough regarding the harmonization of policies at the federal level, but the Committee does not involve States and Municipalities.

By analysing these findings, one may see that Presidential Decrees in fact concentrate the regulation of sustainability. Yet, in democratic regimes such instruments are anything but complements, not real laws. Indeed, Decrees exist toward "detailing or complementing voids and gaps of the laws" (Pacheco 2013, p. 12).

3 Four Cycles and Nineteen Development Plans

For some decades now, *national development* has been an open subject upon the political arena in Brazil. This somehow reflects historical theoretical conflicts as well as the lack of consensus to set forth such idea as a Constitutional value. In fact, national and regional development were given the status of Constitutional value only in the midst of the sixties.[8] Indeed, political decision of creating national plans to achieve one or other assumption of *development* is rooted in the middle of the 20th century (Singer 1977; Bielschowsky 2000). For the purpose of this paper, it would be helpful recognize at least 4 different cycles of *development plans*, as explained.

The first cycle of national development plans began in 1946 up to 1964. It encompass the phase of so called *conservative modernization* (Moore and Barrington 1966) as it aimed at preparing the country for a so-called great transition: from an old-fashioned fragmented agrarian, catholic society towards an plural, urbanized, agri-industrial as well as politically populist society. There were 3 National Development Plans within this cycle. The I PND-National Development Plan, called Plano Salte, 1946–1950, followed by the Targets Plan (1956–1960) and 1961–1964, the Triennial Plan of economic and social development. The priorities of this moment were the expansion of industrialization, notably the agribusiness, the formation of national industrial capital, with intense participation of the State both as a fund agent and regulator. Development was decoupled from liberal laissez-faire as well as social welfare and protection of the environment. Such connections were not on the agenda. This cycle generated an annual average level of 7.4% GDP growth.

[8] See Art. 8°., XIII, Art. 65§6°., Art. 157, V; (Constitution 1967); Art. 8, V and XIV; Art. 21§4°, Art. 43, IV; Art. 63; Art. 160 (Constitutional Revision, 1969, Amendment n. 1). All of these norms, more or less, deal with *regional and national development plans, economic development, balanced national development, rules to fund development.*

The authoritarian military period (1964–1984) has somehow interrupted some elements of the previous phase while underscored certain others. Fragile democratic institutions were broken, national industry of machinery was weakened while a number of strategic state companies (banks, petroleum, aviation, telecommunications, energy, roads, seaports) along with private agribusiness was definitely set up. All these along with a massive urban marginalization far dissociated from any perspective of universal social welfare or environmental preservation. This is a very interesting moment because it offers a robust evidence on how industrialization jointly with authoritarian social policy, instead of enhancing well-being, might rather widen inequalities, stigmatize certain groups, as well as worsen human development conditions. Both South Africa in the Apartheid regime and Brazil within this years were labelled as models of such perverse inversion (Titmuss 2008 141). Either way, throughout those twenty years 7 new National Development Plans were elaborated. At the outset, the Castelo Branco Government's Economic Action Plan (1964–1967) was established. Then, between 1967–1976, the ambitious Ten Year Plan, the first experience of long-term developing planning. Then, between 1968 and 1970, the Strategic Development Program. Soon after, between 1970–1973, the Program of Goals and Bases for the Action of the Garrastazu Medici Government. Shortly thereafter, 1972–1974, another First National Development Plan, called PND-I, during the Ernesto Geisel Government (1974–1979). After that, the second National Development Plan PND-II (1975–1979) was enacted and, barely in the end of the military regime (1979–1985), the third National Development Plan, the PND-III.

Industrial growth was the main goal of this cycle. To get a better view, industrial growth reached the annual average of 7.9%, while GDP did 7.8% (Malan 1983, p. 9). Everything was done in name of setting up the national bases for credit, energy, transportation and urban infrastructure, with a view to establishing an agro-industrial economy, an urbanized society and attracting foreign investments. Such plans would produce an unprecedented migratory flows from the rural to the urban areas and, due to the lack of a universal social security mechanism, a precarious urban labor market, associated to the explosion of the *favela* phenomenon.

The next 10 years (1984–1994) form the 3rd cycle. Firstly, such period is characterised by an arduous transition to constitutional democracy. Moreover, due to the lack of control upon external indebtedness and hyperinflation both helped to deepen inequalities as well as poverty. Soon it became evident that authoritarian modernizing plans did not reach social welfare, not even effective basic public services, as health and education. In spite of that, the transitional government launched the first PND of the New Republic (I PND-NR) for the period 1986–1989. The period from 1991 to 1995, although circumscribed in the context of the new Constitution, might still be seen as a transitional regarding its economic and social agenda: inflation control, state reform and external debt. The new cycle will only initiate in 1994–96, in a context of inflation control and the adoption of the 2nd Multi-year Government Plan. This cycle generated an annual average level of 2.2% of GDP growth (PPA 1991).

By that moment it was notorious the mismatch between the modernization of certain sectors (banking, industrial and agroindustrial) and the precariousness of education, health, social insurance, services of justice along with environmental degra-

dation. The output of the previous three cycles of development was now unveiled: Brazil has managed to be an exemplary *underdeveloped* country. As said earlier, the worst of the "third world" and the best of the first ones came together in dialectical pairing to shape the so-called "*underdevelopment scenario*" (Furtado 1995, 2013). Even though the vocabulary adopted by the World Bank and neoliberal economic theories recommended to classify Brazil as a developing society (World Bank 1978), in the fact, after 11 national development plans and half of a century raising discontinuous and asymmetric experiences, at the early of 1990s Brazil actually was what it could be: an uneven mix of the worst and the best of the contemporary capitalism; of the worst of anti-Republican practices and the best of democratic will.

The fourth development cycle began in 1988. National development, once a pure initiative of governments, became a constitutional principle for the State. Now, the issue of development has become legally binding for local, regional as well as national governments. As for the formal aspects, the new Constitution set up three new institutions: the Multi-Year Plan (PPA)[9] along with the Budget Guidelines Law (LDO)[10]; it has also separated annual budgets in three parts: Fiscal budget, Social Security budget and Investment of the State budget.[11] From now onwards, the same law which set up the federal Multi-Year Plan (PPP) will likewise establish development regional guidelines. Thus, within the new constitutional and democratic landscape, governments are obliged by the Constitution to design plans for development. Following this new perspective, 8 of such plans have already been launched: PPA 1991–1995; PPA 1996–1998-Brazil in action; PPA 2000–2003-Advances Brazil, PPA 2004–2007-A better Brazil, PPA 2008–2011, PPA 2012–2015-The great transformation; and PPA 2016–2019. All of this represented an important step forward for public debate and, apparently, for development.

It is interesting to underline that two years before the Constitution to be enacted, in 1986, United Nations had published the Declaration on the Right to Development, which recognizes it as a legitimate human right. Brazil has not gone that far, but somewhat has followed the trend of strengthening the legal status of development. After all, it was a step forward in relation to the past: national development has become a fundamental objective of the Republic, along with eradication of poverty and marginalization and reduction of social and regional inequalities. Economic and social development now may be seen as narrowly connected.[12,13] Furthermore, it has also linked development to urban planning[14] as well as did not neglect the relationship between development and natural environment.

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[9] Plano Plurianual, see Art. 165, I.

[10] Lei de Diretrizes Orçamentárias, see Art. 165, § 1° and § 4°.

[11] See Art. 165, § 5°, I, II, III.

[12] An example: Article 165 § 7: Budgets (fiscal and social security must be)… compatible with the multi-annual plan, (e) will have among their functions to reduce interregional inequalities, according to population criteria.

[13] An example: Article 170. The economic order… shall observe the following principles: VII—reduction of regional and social inequalities.

[14] Art. 182: The policy of urban development… aims to order the full development of the social functions of the city and guarantee the well-being of its inhabitants.

Even though such a constitutional text did not explicitly formulate a single and clear commitment with sustainable development, there is certainly no doubts that it has adopted a new conception of development for Brazil, which is multidimensional. Whatever the explanation, now development ought to be committed either with non discrimination, decent work, education, social protection, public health. Social insurance must reach urban and rural workers. Misery must be eradicated, inequality must be reduced. As demonstrated above, development also need to be suitable with the natural environment and urbanism. It is a constitutional text that went even to the detail of setting minimum percentages of investments in health and education for local, regional and national branches of the federation. Although Social Security was not yet recognized as an individual right (again contradicting United Nations Conventions adopted by Brazil), the Charter has established mechanisms for social funding public policies upon minimum standards of social protection. Companies, employers, state and citizens are supposed to contribute to guarantee enough of resources so as to cover social security of income, healthcare, extreme poverty as well as situations of social vulnerability.

4 Philosophy of Discontinuity

Ever since 1946, Brazil has experimented 19 national development plans, whereas 8 of which were enacted under the current Constitution. All were made by particular governments, so it is not weird that such plans express fractionated priorities of the nation. In addition, they are short term plans because of their lasting of 4 years long. Despite some policies are supposed to be realized in a coordinate way, none of PPA have plain multilevel coordination involving local, regional and national governments.

In 1990, the United Nations initiated a successful Human Development Program, which adopted a new formula: it was taken in account the degree of realization of health, education, income as well as equality, which has found Human Development Index (HDI) as its statistical representation. In 2000, the Millennium Development Goals (MDGs) were issued. The most ambitious plan for the realization of the very core of basic human rights. Now, there would be goals and targets as well. For the first time, a plan of action, with metrics, articulating a progressive achievement of vital and existential minimum of human rights across the globe over a long period of 15 years. In spite of the progresses with MDGs, in 2015 the Agenda 2030 unveil alarming concerns with the Anthropocene: a new age of over occupation, exploration and degradation of the planet. Following a similar method of gathering global consensus for converging actions, a new momentum of challenging targets and goals have arrived. Agenda 2030 represents a breakthrough in the political field because "it arises from a broad debate in a context of democratic multilateralism, in which governments and various social actors have actively participated, and because the principle of common between countries, both in the environmental field and in the economic and social spheres" (Cepal 2016, p. 15).

Considering the Brazilian model of planning development within the 4-years PPAs, one might easily say that it is in striking contrast with the SDGs Agenda. Even though by one hand such model is clearly responsive to particular elected governments purposes, nonetheless, on the other it is clear such PPAs are not suitable mechanisms to implement national interests. Neither progressive implementation involving all units of the federation in the long run is assured, nor risks of setbacks are identified or repealed. What is worth mentioning is that such short term of planning is not a creation of Brazilian Constitution. Rather, it is a political choice of governments and Congress, revealing their preference for a *philosophy of discontinuity*. The Brazilian Constitution does not impose any temporal model to planning *development*. Quite on the contrary, it only determines that a Complementary Law sets forth the time of such plans, its multiannuality, as well as the National Congress participation. In no way it limits development to a view of 4 years, nor does it require the governmental individualization of PPAs.

That is to say the law which enacts the Pluriannual Plan could perfectly be a general law for 15 years long, as well as it might be engaging all parts of the federation, as required by the SDG Agenda. Carefully observed, not only development and budget in its broad sense, but also economic and urban development, production and consumption; protection of the environment, social security and health are all matters upon which either Union, States, Federal District as well as municipalities have the power to legislate concurrently.[15] This would be an original mechanism, something not experimented so far. Certainly original, but no sort of conflicts with the Constitution would arise from this.

5 Conclusions

Among others, the Brazilian Constitution has brought to the forefront two issues that divide political and academic arena throughout the past 50 years: the duty to ensure national development with multi-annual federal and regional plans grounded, at once, upon harmonious and convergent policies[16]; besides that, regardless of any specific content of development plans, all of them ought to respect and promote the minimum core of constitutional rights and principles.

At a first glance, there are no substantive contrasts between Agenda 2030 and the Brazilian Constitution. The substantive features of development as set forth in both documents are quite harmonious.

[15]The authority to Union, States, the Federal District and municipalities to legislating concurrently upon development and budget stem from Art. 24, II and IX jointly with Art. 30, I and II of the Charter. The above mentioned authority to all those parts of the Federation to legislate concurrently upon economic and urban development, production and consumption; protection of the environment, social security and health is underpinned on Art. 24, I, V, VI, VIII, XII, jointly with Art. 30, I and II of the Constitution.

[16]See Article III, Art. 165, Art. 170, Art. 174§1.

Regarding formal features, though, our findings unveil that Brazilian case is one of *weak regulation of sustainable development* and somehow expresses *lack of engagement*.

No doubts it would be better if laws (either *complementar* or *ordinaria*), instead of Presidential Decrees, were the prevailing legal instrument to implement public policies of *sustainable development*. But as it was shown, this is not the case. This feature notably points out the debility of the current regulatory framework.

The Brazilian model of planning its development within a short term view, without multilevel dialogue and full of discontinuities, somehow expresses *lack of engagement*. Although recent attempts to overcome this model, it is still dominant.

Whenever one observes the way UN have been addressing the issue of development, soon realizes that since the Declaration on the Right to Development (1986) up to Agenda 2030, efforts have been made to articulate human rights and implement executive plans that could be able to assure protection and progressive promotion of all human rights, as well as sustainable development in a multidimensional perspective. Such guidelines are not set forth explicitly in the Brazilian Constitution, but the Charter is fully receptive thereof. Beyond these standards, UN have been making intensive efforts with the help of States, toward managing a complex data system not only to monitor domestic implementation of action plans, but also to share outcomes.

Significant differences comes up with the means of implementing *plans of development*. So far, Brazil was not able to articulate national priorities domestically, neither with the convergence of PPAs from all members of the Federation, nor with a national system information on the implementation of the most part of public policies.

In addition, if to the UN guidelines the challenging changes toward sustainable development require continuity and progressive implementation of measures in the long run, in this particular point one meet sparking contrast between Brazil's model and that suggested by the Agenda 2030. Brazil didn't even dare creating a multi-annual plan of development based on broad national interests of the long run, in spite of the constitutional authority set forth to do so. SDGs targets and goals require commitments that might last longer than singular government mandates. Still, such plans require transversal actions as well as participation of multiple stakeholders. None of this have been part of the Brazilian model of planning development.

The SDG 2030 Agenda will fail in Brazil should a new model of constitutional and infra-constitutional regulation is not set out, clearly suitable with innovations required to implement ODS in 15-year cycles. Based on the current model, there are few chances towards Brazil implementing the Agenda 2030.

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Errors in Decision Making, Using Ecobalance—LCA (Life Cycle Assessment)

Viktoria Arnold

Abstract The world began to talk about the life cycle of a product in the 1960s. One of the first, who published his work on this subject, was Harold Smith. He calculated the cumulative energy consumption for production of chemical products. From 1997 till 2002 were created the standards in International Standards Organization (ISO) 14000 based on the LCA methodology. Since then, the ecobalance (LCA) has become an indispensable tool for decision-making in favor of environmental protection for all areas of human activities. However, due to the methodology is complex, often happens, that a deeper look reveals that the assessment was performed incorrectly. The methodology requires a definition of a goal and, in accordance with it, a delineation of boundaries for the assessment. Often this boundaries leads to the choice incorrect source data, then to a wrong decision and, as a result, to a more negative impact on the environment. This paper provides examples of ecobalance assessments, where were made wrong decisions. The article considers reasons for this phenomenon and suggests options to avoid such cases.

Keywords LCA · Ecobalance · Sustainable decision · Ökologischer rucksack · Goal and scope definition · Inventory analysis · Impact assessment · Interpretation

1 Introduction

During the work in the field of environmental research, the author often meets such decisions, as:

- Do not fly by plane
- Buy drinks in refillable bottles
- Ride a bike instead of cars
- Close coal power plants to reduce CO_2 emissions, etc.

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Once on the important event with the topic of "Sustainable development" with the participation of professors, representatives of firms and the head of a state someone threw an idea in Twitter and it was immediately supported by several participants. The idea was to turn off the air conditioning system in the room to save the environment. And at the end, it was off. Was this the right decision in conditions of high surrounded temperature (around 32 °C) and when the hall was filled with more than 500 people? When someone makes such a decision, it is necessary to keep in mind the likelihood that some of the visitors may feel sick. In this case, it is questionable, will the environmental effect of turning off the air conditioner be higher than emergency medical care for the injured?

At first sight, these are eco-friendly solutions, and people who make them sometimes stoically suffer from the hardships associated with them but being confident of their contribution to the environment preservation. Are these measures really useful if considering their consequences in general/complex way? What happens by looking closer?

2 LCA: Creation History

Santorio (1561–1636) one of the first has begun with balance and metabolism. In his work "Die Statica medica" he described the experiment of balancing in human body. Briefly, he put himself on the scales and constantly measured his weight. He found out that the body lost more substances than it entered minus left. He called the reason for this "emanatio invisibilis"—(Latin) invisible radiation (Müller 1998).

Later, in the 1800s, people began to talk about ecology as an independent science. The research of the ecobalance technique dates back to the mid-twentieth century. In parallel with Harold Smith's work, in 1969/70 Coca-Cola developed "Resource and Environmental Analysis" (REPA). This method became the forerunner of the resource and energy balance developed by the Midwest Research Institute Kansas City for Coca-Cola. This analysis focused primarily on In-and Outputs of resources and energy during package and beverages production (Bieletzke 1999).

Further development of the ecobalance took place mostly in Europe. In particular, it was the publication of the study assessment of the life cycle of packaging materials in 1977 by the Swiss Federal Office for the Environment (FOEN), which created a terminology of the "Life Cycle Assessments" (LCA). In other publications, a quantitative environmental impact assessment was determined, which was assessed by certain factors and was first presented as one indicator (Schebeck 2005). At the same time, similar changes took place in Germany. German Öko-Institut (Institute for Applied Ecology) has developed a concept "Product Line Analysis" (PLA) to provide an information about environmental impact assessments. The Netherlands and Sweden also published similar concepts during this period (Bieletzke 1999).

3 LCA: Definition

Ecobalance or Life Cycle Assessment (LCA) is a tool for estimating the potential environmental impacts of a product, process or company. The entire life cycle is taken into account from the cradle to cradle. Products are compared on the basis of their benefits. It is a standardized method and provides quantitative results (DIN EN ISO 14040 2009).

When LCA is made, two main principles must be taken into account:

- Cross-media consideration: All relevant potential adverse effects on the environmental media of soil, water, and air must be taken into account
- Flow-integrated analysis: All material flows associated with the system under consideration (raw material inputs and emissions from pre-and disposal processes, from energy generation, from transports, etc.) must be taken into account (UBA 2018).

LCA was mainly conceived for enterprises: their products and production processes. The main goals for this calculation are:

- Increasing the resource and energy efficiency of materials and constructions
- Cost reduction for required raw materials, product manufacturing, its using, material recycling and final disposal of waste-life cycle cost optimization
- Identification and implementation of competitive advantages (process selection, location, etc.)
- Identification and reducing of potential risks
- Optimization of material selection
- Avoiding problems during the life cycle
- Support in marketing and sales, etc.

4 LCA: Introduction of Norms

The framework and methods of ecobalance are summarized in regulations—ISO 14000 series (ISO 14040: 2006 and 14044: 2006 standards) and applied worldwide. Based on these standards, in Germany are issued the national standards DIN EN ISO 14040 and 14044.

On the basis of these norms, many tools and documents have been developed that simplify the use of ecobalance in practice. In Germany it is a responsibility of the German Environment Agency (ger. Umweltbundesamt-UBA), which continues to actively improve and facilitate the implementation of this methodology. For example, they are created an Internet portal ProBas (Process-related basic data for environmental management instruments) and updating its database for calculations constantly (UBA 2018).

Based on LCA there is created an EPD (environmental product declaration) for a product to inform a consumer about its ecological properties. An EPD is created for a particular product of a particular enterprise with all its features (location relative to suppliers and final consumers, the efficiency of technological processes, selection of raw materials, etc.). EPDs become publicly available and allow the consumer to make a decision in choice of a sustainable product, comparing it with its competitors. Due to a difficulty in understanding of EPDs, there are various voluntary certification systems for enterprises as narrow (for example, CSC for concrete), and more universal (as Blue Engel-ger. Blauer Engel). If a product is marked with this certificate, then it means for the consumer that the company fulfills the strict requirements for the protection of the environment in the production of this product.

5 LCA: Specialties of the Methodology

The life cycle assessment consists of four phases: goal and scope definition; inventory analysis; impact assessment and interpretation (see Fig. 1).

First of all, when preparing the LCA calculation, it is necessary to determine the goal—for what this calculation will be made (see above). It could be an increase of energy efficiency or the reducing of raw materials using for its production.

Depending on the goal, the study scope is established. It is necessary in order to simplify the calculation since it can take a lot of time to decompose the product into

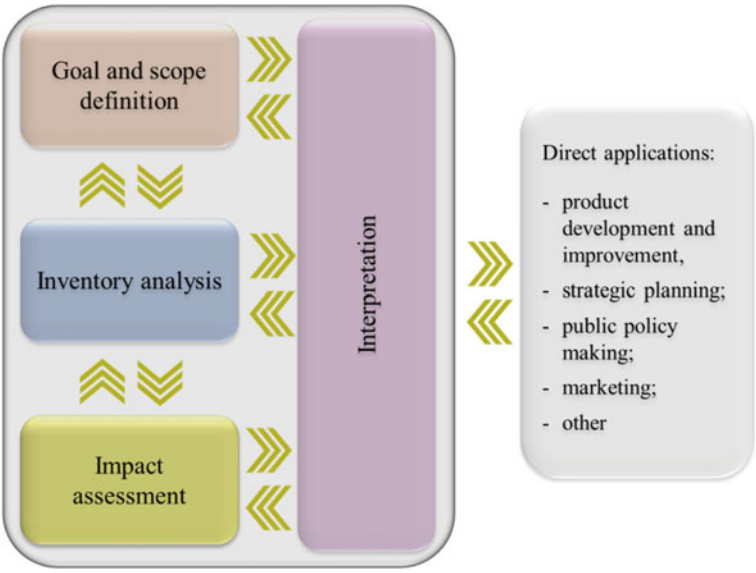

Fig. 1 Phases of LCA (ISO 14040)

components and the processes of their manufacture, or there may be not enough data for a detailed calculation. The LCA of any product can be figuratively represented as an onion. For example, we can take a simple bakery bun. For its manufacture were spent resources and energy. Bun—this is the first layer. Now decompose it into its ingredients: butter, milk, eggs, flour, sugar, salt, baking powder, and so on. Each of these ingredients (next layer) is a separate product with its technological processes and flows of resources and energy. Let's take flour. It was ground from the grain. Grain production is the next layer, and so on. In order not to get lost in these layers and not get bogged down into amount of data, it is necessary to outline the study scope correctly. On the other hand, the stage of establishing the scope of the study is fertile ground for manipulating the calculations to obtain the desired result. For example, knowingly exclude some process from the calculation in order to show your product as more environmentally friendly than a competitor's product. Therefore, the position of the scope line for the study at each stage should be clearly justified.

The definition of a target indicator is also a part of the system description. The target indicator characterizes a function of the considered product system and its performance. It serves as an indicator for the identified environmental effects (Kümmel 2000). For example, at the Paris Conference of the UN countries in 2015, the universal task was to cut in half emissions of greenhouse gases until 2030 compared with 1990. The goal was to hold the rise of temperature on the planet around 2 °C (Draft Bill 2016). In connection with the goal, when comparing the LCA of different sources of electricity, the CO_2 emission indicator is taken to be a target indicator. When contrasted, calculation showed that coal power plants produce relatively large amounts of CO_2 than other energy sources. In this regard, for example, in the European Union by 2030, it was decided to refuse such a source of electricity and close the coal power plants. However, this decision didn't take into account the available resources of the power plants production capacities, which for the most part are still not outworn. A lot of energy and resources have been spent for their building, as well as it will be spent on further disassembly/recycling. Such an omission is permissible in some cases only if the indicators excluded from the system's scope are relatively insignificant compared to the main effect of the measures; or if the excluded parameters are not as important as the main one, or at a given time or in a given location.

The next phase of LCA is inventory analysis. Within this stage, all processes relating to a product or to an action in investigation are modeled within the previously outlined scope of the study. At this stage, the quantity and types of natural resources, which are used, are exploring, as well as energy flows (from renewable and non-renewable sources). At the same time, in addition to technological processes, it is necessary to take into account the transportation also inside the enterprise.

Transportation is very important for the next phase of the LCA-impact assessment. Its calculation is based on the compiled model and the flow of energy and resources. In fact the logistics (transportation) of goods is sometimes responsible for about the same amount of emissions as the production itself. For example, in 1995, UBA considered and compared the effect of using reusable bottles and disposable milk package and came to an unexpected conclusion, that with increasing transport

distance, the advantage of reusable bottle turns into a disadvantage (UBA 1995). Emissions from the transportation of resources, components and the products themselves may be totally higher than the environmental effect of the production. For example, the environmental effect of using recycled aggregate for the production of concrete must be calculated for each specific situation. As a part of a project (named "RC-WE-Modul") of the research group Construction recycling at the Brandenburg University of Technology, was calculated that for this specific location of a demolition place, recycling plant, gravel plant, concrete plant and construction site it makes sense to use recycled aggregate for the production of concrete only by choosing recycling plant located at a distance of 80 km or less from the concrete plant. In this case, CO_2 emissions will be lower than using primary materials (RC-WE-Modul 2018). However there are other environmental effects, such as reducing construction waste, saving natural resources, energy resources and natural territories.

It is also very important to consider what type of transport is used, its tonnage and type of fuel. For example, when examining different types of transport for passengers, it turns out that airplanes, on average, most of all emit (CO_2/person)/km into the atmosphere (Transportation in the CO_2 comparison 2014). But there are some special aspects. Such a calculation should be considered depending on the distance. For example, an increase in demand and in the technical efficiency of aircraft have led to the fact that, over the long distances, CO_2 emissions from an aircraft per passenger are less than the traveling the same distance by car (Heinrich-Böll-Stiftung 2016).

Often there are errors in the calculation of the LCA due to unaccounted resources for a particular phenomenon. For example, if we compare the movement on a bicycle and a car, then a bicycle is often considered a priori a more environmentally friendly transport since it does not require any type of fuel and does not produce any emissions. However, in such cases, it is necessary to take into account not only such obvious resource flows. Consider two people moving from point A to point B on these two types of transport, for a distance 100 km. A person in a car will cross it without stopping by a country road in about an hour and will use in average 7 L of gasoline. An ordinary person on a standard bike will cover this distance with an average speed of 17 km/h and stops for snacks and lunch in about 8 h. After such a trip, the cyclist needs to take a shower, wash his clothes and have a rest. In addition, he will spend on this distance about 2900 kcal (excluding passive consumption), which he needs to fill with products (Sports Nutrition 2009), each of which has their own ecological rucksack, energy consumption, and environmental impacts. This is in contrast to the man on the car, which saved almost 7 h of time and other related resources. In addition, he can take on board another 3–4 people and a load with a slight increase in fuel consumption, unlike a cyclist. The conclusion is that a bike is effective only for relatively short distances and in congested urban areas, such as cities and metropolitan areas.

6 Conclusion

LCA is a very interesting task that requires solving in almost every specific situation. However, to obtain objective results, it is necessary to correctly define the scope of the study, depending on a pursued goal, but cross-media and material flow integrated. Sometimes the result is unexpected or even opposite. Since every moment of time each person is forced to make decisions himself, from our point of view, it is necessary to introduce LCA as a separate subject in school. This will help not only to instill a habit from childhood for environmental considerations but also to teach new generations the right approach for making sustainable decisions.

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Stakeholders' Engagement in Sustainable Development

The Fundão Tailings Dam Catastrophe: How Unsustainable Practices and Sloppy Management Led to the Disaster

Victor Meyer Jr., Diórgenes Falcão Mamédio and Milton Adrião

Abstract Dams are unique complex systems. Like nuclear and chemical plants, they are sensitive to negligence, errors and failures. This article provides an analysis, under the lens of sustainability sciences, complexity and emergency theories, of the Mariana Case, one of the worst catastrophes of its kind in Brazil. This is a qualitative case study, focusing on the collapse of the Fundão dam in Mariana, in 2015. Data were gathered from documental analysis, official reports and articles published in the media about the event. The analysis revealed that an unexpected small-scale seismic shock together with unsustainable malpractices represented by multiple neglected aspects in the technical and managerial areas, weakening layers of control, triggered the catastrophe, with the destruction of ecosystems and communities, with damage to fauna, flora and socioeconomic lives, affecting the balance of the system's resilience. Lessons derived from the disaster point to the need for a joint effort to achieve the sustainable management and development of such complex systems. Approaches based on the inculcation of high reliability culture, sustainable development, emergency management, managing the unexpected, mindfulness, and learning culture may play a pivotal role in building more reliable, integrated and sustainable systems.

Keywords Sustainable development · Complex systems · Mindfulness · Sloppy management

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1 Introduction

Sustainable development has been widely discussed since the last decades of the twentieth century. The discussion began with the publication of the "World's Conservation Strategy" (IUCN 1980) by the International Union for the Conservation of Nature and Natural Resources (IUCN). Focusing on the issue of environmental integrity, this publication highlighted the importance of social, ecological and economic dimensions and the role of organizations and governments in achieving sustainability, considering living and non-living resources as well as the short- and long-term advantages of alternative actions.

Since then, the relationship between society and environment began to be observed more critically, and the very concept of the environmental problem continues to be increasingly and more globally examined (Van Bellen 2005). Therefore, there has been more intense and closer integration and interdependence among countries with regard to decisions and actions that have an environmental and social impact on the planet.

Organizations and their complexity are perceived as open systems in permanent interaction with the environment, with the predominance of characteristics such as adaptability, non-linearity, agent autonomy, dynamic interaction of agents exchanging information, and self-organization (Stacey 1996; Cilliers 1998; McDaniel 2007). In this type of organization, behavior is determined by the nature of the interactions between agents, with decisions and actions influenced by divergent interests between the groups that compose them. Each of these groups has sufficient power and autonomy to ensure that their goals are legitimate and contribute to organizational purposes.

Complexity Theory refers to social organizations as living and dynamic systems, facing constantly changing environments, presenting chaotic behavior or unfamiliar patterns. In these circumstances, making non-short-term forecasts becomes a difficult task since these complex systems are extremely sensitive to their initial internal conditions and to external factors such as uncertainties and surprises.

The purpose of this paper was to analyze the catastrophe of the Fundão Tailing Dam under the lens of complexity and emergency theories, sustainable sciences and the management of complex systems, seeking to explore problems and some lessons learned from the catastrophe.

The paper contributes to the field by highlighting three main points. First, the fragility of dams and the mismanagement of a multi-scalar system. Second, the sloppy supervision and control of the dam's operations by public government. Third, some critical lessons from the catastrophe are discussed in an attempt to contribute to the building of a more reliable and sustainable system. These contributions are relevant to the management of a complex system in order to promote the sustainability of the system and the reliability of its processes.

The originality of this research is based on the case analysis from the perspective of organizational complexity, especially in the elements of complex systems. The highlighted elements were the non-linearity, the high number of interactions between agents, with each one making decisions about how to behave, unpredictability, dynamism and surprises. All of these led to the emergence of an overall behavior that cannot be described merely by describing the interacting parts. It is a differentiated approach, taking into account the lack of control over all the variables of a complex system, as analyzed in this case.

2 Complex Systems and Sustainable Development

Dams are complex and very sensitive systems. They are technical, environmental and social entities in which negligence, errors and failures can emerge from human actions. How and why do such systems change overtime due to a variety of organizational and environmental factors that continue to challenge their operations and performance?

The world functions as a set of complex systems that move in a self-organized way and show characteristics that emerge from interaction between the parts of each system and each other. Organizations and the environment are considered complex adaptive systems because they are in constant evolution and self-organization rather than presenting balanced and stable growth (Holland 1997; Pascale et al. 2000; Gleiser 2002). To adapt and evolve, these systems must be on the brink of chaos, a state in which stability and instability exist side by side, capable of making the system more creative, flexible and agile. Dams are unique complex systems. Like nuclear and chemical plants, they are sensitive to negligence, errors and failures. Unlike other complex systems, dams are not self-organized.

The interactive complexity of the system is the trigger that brings about self-organization and change. Simple principles, when combined in a nonlinear manner, lead to complexity and novel properties of the system. It may not be possible to anticipate these novel properties (Perrow 1999). Thus, a complex system coexists with a degree of uncertainty, random behavior and unpredictability.

Sustainable development is clearly loaded with values, with a strong relationship between the principles, ethics, beliefs and values on which a community and its concept of sustainability is based (Dahl 1997). This is a multidimensional concept, as it has relationships of interdependence between various dimensions, composing a complex system in which human beings are included. Considering sustainability, a dynamic and complex concept that encompasses a process of change, we consider the inherent risks of this complex system and especially the challenge of promoting effectiveness and reliability.

Sloppy management of various kinds can be tackled by establishing, strengthening and asserting appropriate forms of management control. The system's properties that constitute disaster preconditions are not so immediately accessible by management control. At both levels, managers in pursuit of high reliability should expect to have to make a range of trade-offs (Turner 1994).

3 Complexity and High Reliability Organizations

A high reliability organization (HRO) is one that engages in hazardous operations characterized by complexity and uncertainty, yet achieves relatively high levels of safety (Sagan 1996). The original studies of HROs were based on three industries: nuclear power generation stations, air traffic controls, and aircraft carriers (Sutcliffe 2011). According to LaPorte and Consolini (1991), the operating challenges of HROs are twofold: (1) to manage complex, demanding technologies, making sure to avoid major failures, and (2) to maintain the capacity for meeting periods of very high peak demand, and production.

However, Weick proposed HRO principles as a conceptual framework for reliability seeking organizations and developed the concept of "collective mindfulness" (Weick et al. 2008) that keeps them working well when facing unexpected situations. Mindfulness involves inquiry and interpretation grounded in capabilities for action (Fraher et al. 2017). The processes of collective mindfulness are indicated by a preoccupation with failure, reluctance to simplify interpretations, sensitivity to operations, commitment to resilience, and deference to expertise (Weick and Sutcliffe 2007; Weick et al. 2008; Hales and Satya 2016). In this context, HROs are distinctive because of their efforts to organize in ways that increase the quality of attention across the organization, thus increasing attention to detail to detect process variation and require a contingent response.

Solutions proposed by Perrow (1999) include (1) abandoning those systems where risks outweigh reasonable benefits, (2) making the system less risky despite considerable effort, and (3) enhancing those systems with the characteristics of self-correction or self-organization. Therefore, HROs are able to attain high safety standards because they apply the principles of collective mindfulness in their daily operations.

4 Managing the Unexpected

Unexpected events can get you into trouble unless you create a mindful infrastructure that continually tracks small failures, resists oversimplification, is sensitive to operations, maintains capabilities for resilience, and monitors shifting locations of expertise (Weick and Sutcliffe 2007, p. 21). In this context, the authors claim that the nature of unexpected events occurs in three ways: (i) when an event that was expected to happen fails to occurs; (ii) when an event that was not expected to happen does happen; and (iii) when an event that was simply unthought of happens. A significant action for managing the HROs is to improve understanding of the third form of the unexpected and to expand knowledge toward mindful practices (Weick and Sutcliffe 2007, p. 29).

In HROs, reifications may lead to established paradigms within safety and emergency management. Emergency is commonly defined as "the totality of technical, operational, and organizational efforts preventing a hazard from developing into an accident, or reducing the damage from the accident" (Aase and Tjensvoll 2014). In HRO literature, emergency can be defined as training, preparation, and management of something unexpected, surprising, and complex (Weick and Sutcliffe 2001).

Learning in high-reliability organizations and emergency management that strive for high performance in things they can plan for, can result in highly reliable organizations that are better able to manage unexpected events for which plans cannot be made by definition (Aase and Tjensvoll 2014; Caro 2016). The scale of possible consequences from errors or mistakes precludes learning through experimentation.

5 Method

The present study is a qualitative in-depth case study (Stake 2001). The purpose of the study was to analyze the catastrophe of the Fundão tailing dam under the lens of complexity and emergency theories, sustainable sciences and management of complex systems, seeking explanations and learning lessons of the disaster.

The rigor of qualitative research can be seen in efforts to verify and validate the meaning of documents, official reports and articles published in the media about the event. The data collection required ability to deal with a wide variety of evidence. The diverse data were compared and, from these comparisons, the research resulted in relevant findings. The data were processed using a three-step content analysis technique: (a) pre-analysis; (b) material exploration; and (c) processing of the results and interpretation (Bardin 2010).

The forms and reports prepared by Ibama (Brazilian Institute of Environment and Renewable Natural Resources) during the follow up to the event are sources of information formalized in the technical report of the disaster. Other sources are the documents sent by Samarco in response to notifications made by Ibama, forms of the Integrated Disaster Information System (S2ID) of the Ministry of National Integration, information obtained from the environmental impact studies of projects licensed by Ibama in the impacted region and bibliographic research. The technical report that was analyzed subdivides the impacts according to the areas of permanent preservation: impacts on fauna, socioeconomic impacts and impacts on water quality.

A limitation of the study is that the data analysis should take into account that the results are based on secondary data, such as the published official documents, and are derived exclusively from reported facts. No interviews were conducted with those involved in the disaster, although official published testimonies were considered in this study.

5.1 The Case: Fundão Tailings Dam Catastrophe

Tailings dams are possibly the largest structures built by man (ICOLD 2001, p. 17). In the afternoon of November 5, 2015 the Fundão Dam managed by the Samarco Company, in Mariana, Minas Gerais, Brazil, collapsed, causing the greatest environmental disaster in Brazil and the world's biggest accident involving tailings dams. Approximately thirty-four million cubic meters of mud, water and solid waste resulting from iron mining were released into the environment. An eight-meter-high mudslide tsunami devastated the Bento Rodrigues sub-district and seriously affected six other sub-districts, leaving a trail of destruction, displacing one thousand two hundred and sixty-five people. Nineteen people, all in Bento Rodrigues, lost their lives.

The United Nations Organization declared the disaster as a human rights violation event. A categorization of the impacts resulting from the accident by the Justice Department of Minas Gerais State listed damage to water quality and availability, soil quality and availability, biodiversity, the region's infrastructure and private assets. It also listed impacts on work and income, damage to public health and safety, mental health and suffering associated with the experience of tragedy, a violation of the right to water and related problems, short and long term contact with heavy metals, impacts on education, culture and leisure and damage to social organization.

The disaster was classified as a Level IV Disaster, "major disaster", according to the classification scheme established by the National Policy for Civil Defense. The National Secretariat of Civil Protection and Defense classified this disaster as 2.4.2.0.0 (2: Technological Disaster; 4: Disaster related to civil works; 2: Breakdown/collapse of dams; 0: type and subtype), according to the Brazilian Code of Disasters (COBRADE). The location of the catastrophe is shown in Figs. 1 and 2.

Fig. 1 Location of the catastrophe in Minas Gerais, Brazil. *Source* © OpenStreetMap contributors. The cartography is licensed under the open database license (ODbL)

6 Findings

An analysis of the case found that an unexpected small-scale seismic shock together with unsustainable malpractices represented by multiple neglected aspects in the technical and managerial areas were the cause of the disaster. These elements weakened layers of control and triggered the catastrophe, destroying ecosystems and communities, damaging fauna, flora and socioeconomic lives and affecting the balance of the system's resilience.

A complex adaptive system is one in which three fundamental characteristics are observed: (i) a number of heterogeneous elements, each making decisions about how to behave, decisions that can evolve; (ii) these elements (agents) interact (iii) patterns of interaction, which vary over time, lead to the emergence of an overall behavior that cannot be described by describing the interacting parts (Levin 1999; Green et al. 2005; Sullivan 2011). In this disaster, several technical decisions influenced

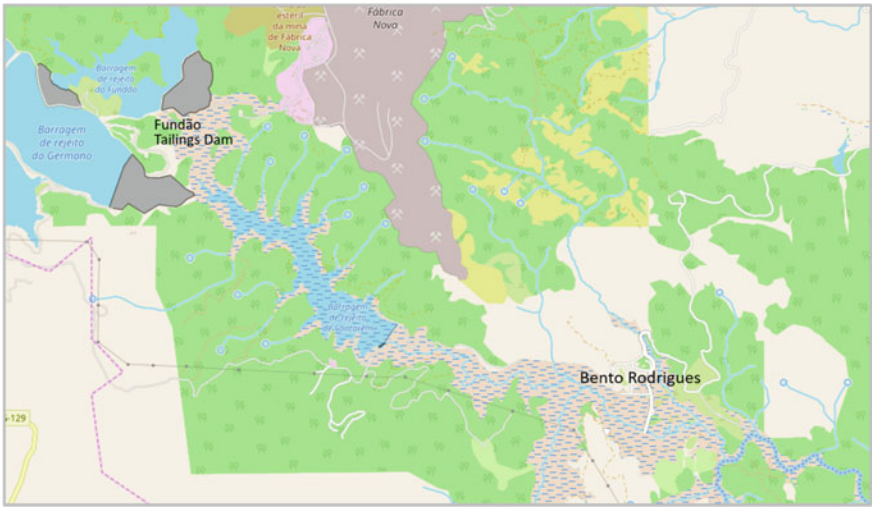

Fig. 2 Location of Fundão Tailings Dam. *Source* © OpenStreetMap contributors. The cartography is licensed under the open database license (ODbL)

by economic, social, and political interests led to the growing fragility of a massive physical structure whose collapse was only anticipated by the seismic shocks that acted as a trigger.

Right after the disaster, several hypotheses for the cause of the dam rupture were raised. Samarco and its parent companies, Vale and BHP Billington, hired a group of specialists in dam engineering and safety to form the Fundão Tailings Dam Review Panel (2016) for the purpose of identifying the causes and dealing with criticism of the lack of information. This panel presented its report in August 2016, ten months after the disaster. The report on the immediate causes of the accident focused on the technical elements that shaped the conditions that led to the rupture of the dam.

According to this report, "the evolutionary character of its design and operation make the Fundão Dam extraordinarily complex". Several unplanned events during the construction and operation of the dam influenced the way the tailings were deposited on site and contributed to the disaster. The first incident occurred in 2009 due to construction defects that allowed mud to reach the sand lagoon, violating a principle of the design. This problem led to a revision of the original project that, in 2010, introduced a liquefaction potential due insufficient draining capacity owing to the continuous increase of mud and sand deposition. In 2011 and 2012, while the revised project was under construction, the inobservance of engineering criteria led to mud deposition where not allowed. Changes reduced the area that stood between the lagoons for sand and mud that must not mix to prevent liquefaction.

In 2012, a concrete gallery under the left abutment of the dam was "structurally deficient and unable to support further loading" and should have been filled with concrete and deactivated. To maintain operations, the alignment of the dam on the

left abutment was moved from its previous position, placing the mass directly on top of the previously deposited sludge. All conditions for liquefaction were created.

The expression "complexity-awareness" has recently been adopted in the context of social change, participatory research, and project management by nongovernmental organizations (USAID 2018). Complexity awareness recognizes the prevalence and importance of nonlinear and unpredictable interrelationships, nonlinear causalities, the existence of emergent properties, and that cause-effect analyses can only be conducted retrospectively. With hindsight, it can be seen that the development of an originally robust engineering project, because of implementation difficulties, concept and design revisions and unanticipated conditions of use, led to a disaster waiting to happen.

The trigger was the seismic shocks that struck the region approximately 45 min before the dam ruptured. Although small in magnitude (2.5° on the Richter scale, according to reports from the Center of Seismology of the University of São Paulo), the mathematical model developed by the Panel indicates that this earthquake would have caused a displacement of 5 mm in the left abutment, where mud and sand were mixed. The Fundão Tailings Dam, already in critical condition, collapsed because of a seismic shock that would have gone unnoticed had it occurred in a densely populated urban area.

The Fundão Tailings Dam Review Panel emphasized technical issues; organizational failures are not explicitly affirmed. This is nothing new. Some authors have repeatedly stated that it is difficult to place or assume responsibility for disaster events, with studies generally focusing on technical issues, as they are the main cause of the inevitability of disasters (Weick 1987; Turner 1994; Sagan 1996; Rijpma 1997; Perrow 1999; Sutcliffe 2011; Aase and Tjensvoll 2014; Caro 2016). All these authors reiterate the need for managers to pay special attention to weaknesses, warning signs, different world views and unexpected situations.

In the Mariana disaster, not only the company but also public agencies and other organizations failed in their missions to analyze and monitor mining projects and activities. Again, with hindsight, the Minas Gerais Civil Police reported failures in the continuous monitoring of the water level and water pressure. They also noted the existence of defective monitoring equipment, whose readings were not carried out when the dam safety report was issued, and poor monitoring due to the reduced amount of equipment installed in the dam. They also found that the dam was rising by approximately 20 m per year, on average, twice the maximum recommended in the technical literature.

The Minas Gerais State Attorney's Office, in turn, stated that the company had been notified of risks related to the Fundão Dam as early as 2013. Indeed, the Public Prosecutor of Minas Gerais considered that the disaster began in 2007, when Samarco requested and received authorization from the Minas Gerais State Government to build the dam, providing only some basic data about the project. These incomplete data were considered sufficient by the Minas Gerais State Environmental Foundation. According to the office, this was the first fault in the list of failures.

In addition, the lack of evaluation of geological studies on rainwater runoff, which would make it possible to certify the safety of the structure, was considered the

second major fault. These studies were not presented when the second license for the construction was issued. A report by the engineering consultancy firm contracted by Samarco warning about the danger of water compromising the safety of the Fundão was found by public representatives during investigation (Serra 2018).

Looking back, it is crystal clear that unsustainable malpractices represented by multiple neglected aspects in the technical and managerial areas, weakening layers of control, during a long period of time, also created the conditions for the catastrophe. In fact, both the technical and managerial failures produced each other recursively, as can be seen regarding the issue of controls (Turner 1994).

Even though the use of supervision and control in complex systems is a form of promoting reliability in the system, avoiding mistakes and errors, the same system paradoxically tends to lead to complaisance and paves the way for accidents and disasters (Smith and Lewis 2011). Although it seems obvious that controls should be deployed, reinforced and evaluated as a way to avoid such events, this is only partially appropriate because there are important limitations.

Disasters are socio-technical events. Some are caused by management inadequacies or unprofessional behavior, while others occur when disaster conditions are generated as a result of the normal operation of larger administrative and technical systems. Only a small number of significant accidents have technical causes. Most have social, administrative or managerial causes. The same rates apply to corrective measures and recommendations. Thus, it is necessary to consider not only the technical controls, but also the managerial ones, with emphasis on these.

Significant accidents have preconditions that are emerge over time. Minor causes, misperceptions, misunderstandings and communication failures accumulate unnoticed, with accidents waiting to happen. These variables exist in management organization or practices, ready to contribute to a major accident, unless something neutralizes them. Moreover, there are trade-offs, ambiguities, and paradoxes that set limits on management practices.

Although Turner (1994) considered as trade-offs the mutually incompatible demands of the technical systems, with respect to technical and managerial controls (e.g., fast decisions versus accurate, strong and well-defined hierarchical structures versus involvement of the lower levels of the organization; quality decision processes that use masses of data), non-technical elements also impose trade-offs. For example, high indebtedness and falling iron ore prices led Samarco managers to focus on financial management and the recovery of the profit margin to the detriment of investments in risk prevention.

The disaster caused by the collapse of the Fundão Dam revealed much irreparable damage (Serra 2018). Not only the known consequences, but new situations were identified after the catastrophe. One of these was the case of shrimp fishermen from Vitória, the capital of Espírito Santo State. In April 2018, t was recognized that they were also affected by the disaster, even though the region is apparently far from the Fundão Dam. If, according to Richardson (2008), the central element of a complex system is nonlinear feedback, which allows for emergence, self-organization, adaptation, learning, and others terms used as synonyms for complex thinking, it is time to revise technical, managerial and sociotechnical practices.

7 Discussion

Disasters send signals, which most of the time are either not perceived, misinterpreted or even neglected by managers and operators. When the context is a complex system, the consequences of such behavior escalate, causing disasters with unexpected and catastrophic consequences (Turner 1994; Perrow 1999). Typical examples of this kind are accidents involving airlines, nuclear plants, weapons systems, chemical plants, mining, air control and commercial aviation, and are well known. Cases like Union Carbide (Bhopal), Three Mile Island, the Tenerife Islands KLM/PANAM Crash, Chernobyl, British Petroleum (Gulf of Mexico) and the Air France Flight 447 disaster are representative of the collapse of complex systems.

More recently, the Fundão Dam revealed a complex system sensitive to environmental forces, and therefore, subject to errors, failures, accidents and disasters. Most of these cases indicated human-made catastrophes. Formal investigations and reports of disasters tend to search for particular faults or failures that lead to blame being placed on the operators and/or managers.

The examination of the Fundão Case revealed that even though dams are not a typical example of complex tightly coupled systems, they are complex systems that are extremely vulnerable to socio-technical failures and highly sensitive to environmental forces. Therefore, their operations were hurt by both unexpected events stemming from topological nature (seismic shocks) plus human errors by operational people and mismanagement and technical negligence.

The lessons learned from the case can be classified into two kinds, each of them requiring distinct stances and clear responses to two crucial problems: lack of supervision and unsustainable managerial malpractices, both of them linking mistakes, misconduct and disaster (Vaughan 1999). As the first problem indicated, there is a need to inculcate a mindfulness principle or mentality (Weick and Sutcliffe 2006) within the company, particularly among the technicians in charge of inspecting the dam, contributing to building a more reliable and safer system. The mindfulness approach leads to the examination of contingencies as a way to cope with failures and manage unexpected events (Weick and Sutcliffe 2006; Sutcliffe 2011).

The second problem dealt with the signals sent by the imminent disaster, which were initially incubated (Turner 1994) and later unnoticed, misinterpreted and even neglected by operators and managers. When the context is a complex system like the Fundão dam, the consequences escalated, with unexpected and catastrophic outcomes (Turner 1994; Perrow 1999). To what extent could the Fundão Dam catastrophe have been avoided? This is quite a difficult question to answer, but the fact is that the nature of the catastrophe that caused the destruction of a small town, deaths and serious social, economic and environmental damages in a large region require strong responses. In this respect, the building of a more reliable (Weick 1987; Roberts 1990, 2011), safer (Levenson et al. 2009; Catrino and Patriotta 2013) and complex responsive system (Stacey 2010) will be required to enhance the performance of complex systems and achieve sustainable development (Sachs 2015).

Because of its consequences locally and regionally, the Fundão Case is considered both an emergency event and a catastrophe (Thomas et al. 2015). Therefore, due to the nature and characteristics of the dam as a complex system, the organizational responses required the collaborative effort of a multi interdisciplinary group of professionals and public officials and experts in the field. There is a belief that managers of complex systems have a clear understanding of the organization beyond control of operations and awareness of possible risks facing the system. However, as the analysis of the case indicated, the situation of the management of the Fundão Dam was quite different, revealing just the opposite.

After the disaster, managers underestimated its impact, and, in some cases, initial information was distorted, helping to heighten the consequences of the catastrophe in the eyes of the company in charge of the dam's operations, public officials, the community and society at large. This can be explained by the paradoxical approach (Smith and Lewis 2011) that is typical in complex and high reliability organizations. In this context, when opposite forces like robust systems to prevent accidents represented by the adoption of compliance systems are set, they can at the same time bring about mindlessness behavior, which compromises both the reliability and safety of the system.

In this case, robustness and vulnerability tend to void each other (Smith and Lewis 2011), and therefore, impact the defense of a complex system. The Fundão Dam catastrophe, at least partially, could be seen as an outcome of such a paradox, representing a contribution to the reliability and safety theory, pointing out to managers of complex systems the need to find ways to integrate the two poles (Smith et al. 2016) in order to succeed.

8 Concluding Remarks

The challenge for managing complex systems like the Fundão Tailings Dam is twofold: the first is to build safety devices into high complex systems, whose functioning is based on the tightly coupled interaction of multiple elements of a technical, human, environmental and political nature. These factors are somehow intertwined, generating unpredictable or unforeseen outcomes and consequences regardless of managerial efforts.

The second is to disseminate a culture of mindfulness (Weick and Sutcliffe 2007) and safety (Levenson et al. 2009), spreading a continuous alert to signs of problems that indicate mal functioning within a system. Unsafe systems do not detect the first signs of disaster during the incubation period (Turner 1994). These are usually key elements of an accident waiting to happen (Roberts 1990).

However, in spite of an effort to build a reliable and safe system apparatus, there is always room for socio-technical failures such as negligence, mistakes, misconduct, misinterpretation, neglect and sloppy management, in addition to unpredictable environmental and topological forces like seismic shocks, hurricanes and earthquakes, which could all lead to disasters.

Learning from experience is becoming quite a challenge to workers, technicians and managers involved in complex systems. In this context, unlearning occurs before unexpected events, especially under conditions of urgency or emergency, when routines and protocols are powerless when it comes to solving problems and the stakes are high. On some occasions, like the Fundão case, there is no time for trial and error, and decisions have to be made in the context of a catastrophe, when the cost of failure is high. Behavior in such situations requires a deviation from standard procedures and timely responses to threats.

The research literature in the field of managing disasters is scanty, but growing with the contributions of researchers in fields like engineering, management, social psychology, sociology and political sciences, to name a few. In this field, professional experience of this nature is rare, and critical decisions are made not only under the threat of disaster but also in the midst of the disaster and post-disaster following a thorough investigation. Sustainable development lies in mindfulness in creating high-reliability organizations, with the managerial ability to deal with unexpected and unpredictable situations.

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Methodology for the Environmental Service Suppliers' Qualification, Under the Approach of Sustainable Procurement and Collaborative Initiatives: A Case Study of Industries in Curitiba

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Abstract Some companies have organized themselves to develop joint supplier's qualification processes in order to avoid multiple audits and evaluations, reducing resources spent on these activities and the risks related to sustainability. This article presents the results of a study involving a university and a group of volunteer companies aiming at developing a methodology for collaborative qualification of environmental service suppliers. The study consists of a tool for prioritizing categories and a verification process with the pre-qualification and on-site audit form, allowing the results sharing among industries which have mutual suppliers. The volunteer companies which took part in the research constitute a network of industries in Curitiba and contributed with their practical experience.

Keywords Sustainable supply chain · Environmental goods and services sector · Supplier evaluation and qualification

1 Introduction

A supply chain is a set of activities and processes performed by a company and its suppliers with the purpose of delivering a product to its final consumer. This procedure involves organizations, people, activities, and resources. Sustainability can be understood as a way to meet present needs without damaging the ability of future generations to meet their own needs. Sustainable supply chain can be seen as a managed operation which takes into account factors such as risk, environment,

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waste costs, social and economic effects, while minimizing environmental impacts and maximizing the social welfare.

Over the past few years, the expansion of the environmental technologies market has led to a consolidation in the industrial sector, both inside and outside Brazil, and this area has received increasing attention. There has been an increase in sectorial initiatives for supply chain management, as well as in the amount of integrated actions among industries, joining efforts to achieve efficiency in sustainability, monitoring and cutting transaction costs.

We propose a methodology in order to allow the collaborative qualification of environmental services suppliers. This methodology was developed through a study with a partnership between a university and a group of companies, which are part of a network of industries in Curitiba, and contributed with their practical experience. To develop the methodology, first were defined the categories which would be evaluated, then, a tool was applied for classifying such categories according to their risks. For those identified as critical (high risk level), a verification process was elaborated, based on data and information provided by volunteer companies. The process was validated by these companies, through work meetings at the University and the practical application in three suppliers. The resulting methodology consists of a tool for prioritizing categories according their risks and a verification process with a pre-qualification and an on-site audit form.

This paper is organized as follows. First, we present an overview of sustainable supply chains. Second, the contributions of environmental services suppliers to the Sustainable Development Goals. Third, we give a brief description of a partnership between a university and a group of companies in order to come up with a methodology for collaborative qualification of environmental service suppliers. Last, we present the steps for the elaboration of the qualification process, as well as a brief conclusion on the achieved results.

2 Sustainable Supply Chains

According to Pal et al. (2013) at high technology firms, purchased materials and services represent the largest percentage of the total product cost. Therefore, selecting the right suppliers is important to procurement process, and represents a major opportunity to reduce costs and risks.

Companies have learned that the traditional approach to supplier selection, on the basis of price, quality, delivery and service, is not efficient. They have turned into a more complex multi-criteria approach, that consider environmental, social, political and customer satisfaction (PAL et al. 2013).

According to Hassini et al. (2012, p. 2) sustainable supply chain is "*the management of supply chain operations, resources, information and budgets in a way that maximizes profitability, while minimizing environmental impacts and maximizing the social well-being…*" considering the concept according to which social well-being is the relationship with employees, clients and the community in general.

According to Srivastava (2007, p. 54) Green Supply Chain Management (GSCM) can be defined as: "*integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to consumers, as well as product end-of-life management after its useful life*".

Extending sustainability management to the value chain has to do with risks managing. It is possible to enumerate several episodes in which bad conducts of the suppliers have caused negative impact in the image and in the businesses of big corporations, by incidents related to social or environmental aspects. Workers subjected to conditions similar to slavery, accidents and fatal fires in industries and clothing, incorrect disposition of toxic wastes, effluents and chemicals, as well as cases of corruption, informality and unethical behavior, lack of preparation for new legal or competitive requirements, lack of skilled labor, among other problems. Such episodes can directly affect the costs, reputation, and operation of an organization. In this way, a company can only be considered as sustainable, when its supply chain shares the same principles and values regarding these subjects.

3 Environmental Goods and Services and Their Contributions to the Sustainable Development Goals

Over the past few years, the expansion of environmental technologies market has led to a consolidation in the area, both inside and outside Brazil. This sector has received increasing attention from the productive sector, stimulating demand and generating new opportunities, technologies and innovations (ABDI 2012). The terms internationally used to name such a segment are Environmental Goods and Services (EGSs) or Environmental Goods and Services Sector (EGSS) (ABDI 2012; EUROSTAT 2009).

OECD member countries, together with Eurostat, presented the first definition for EGSS (ABDI 2012; ITC 2014), which deems "*activities that produce goods and services that measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to litter, noise and ecosystems. This includes cleaner technologies, products and services that reduce environmental risk and minimize pollution and resource use*" (OECD and EUROSTAT 1999, p. 9).

The System of integrated Environmental and Economic Accounting (SEEA) was the first international statistical standard for environmental and economic accounting adopted by the United Nations Statistical Commission. According to the United Nations (2016, p. 78) the scope of environmental activities includes "*economic activities whose primary purpose is to reduce or eliminate pressures on the environment or to use natural resources more efficiently. Examples of such activities are the restoration of polluted environments, the conservation and management of resources and the investment in technologies aiming at avoiding or reducing pollution*".

The UN Agenda 2030 is the plan drawn up by world leaders in which countries share responsibility for the global common good and commit themselves to the seventeen Sustainable Development Goals (SDG), which goes through the social, environmental and economic dimension (BMU 2018).

The SDG 9—Industry, innovation and infrastructure—has as one of its goals modernizing the infrastructure and rehabilitate industries, pursuing to make them sustainable, using resources in a more efficient way, and adopting clean and environmentally adequate technologies, and industrial processes by 2030 (ONU BR 2018a).

The SDG 12—Sustainable consumption and production—has the capacity to make feasible the reach of many of the other ODS in an integrated and embracing manner, as they act on changes in production and consumption patterns. This implies cleaner and more efficient production practices, training, innovation and technological change across the entire value chain of products and services, as well as behavior change and consumer choices, along with public sector procurement strategies (ONU BR 2018b).

The Brazilian Sustainable Production and Consumption Plan (PPCS), launched in 2011 by the Ministry of the Environment in partnership with several organizations, entered the second cycle of 2016–2020. The main goal is to foster changes in the current paradigm of production and consumption, considering, among the thematic axes, sustainable public procurement, sustainable industry and solid-waste management (ONU BR 2018b).

The concern with sustainable purchasing has gained worldwide importance over the last years, culminating in the recent publication of a specific standard, the NBR ISO 20400: 2017: Sustainable Purchases - guidelines, elaborated by ABNT (Associação Brasileira de Normas Técnicas), responsible for the elaboration of technical standards in Brazil. According to this pattern, sustainable purchases are "*purchases that have the greatest possible positive environmental, social and economic impacts throughout the life cycle and that seek to minimize adverse impacts*" (ABNT 2017).

The SDG 17—Industry and university partnerships, collaborative initiative - aim at strengthening the means of implementation and revitalize the global partnership for sustainable development. According to NBR ISO 20400: 2017, examples of joint initiatives include sectorial programs whose goal is to generate adequate working conditions in the supply chain, promote more sustainable alternatives and share audit data.

According to a study presented by Ecosense (2017), in the last 15 years there has been an increase in sectorial initiatives for supplier management, as well as in the amount of integrated actions among industries, joining efforts to achieve efficiency in sustainability monitoring, and cutting associated costs. In this sense, we can mention several joint activities, such as the establishment of standards, instruments and positioning in common public affairs amongst companies, conducting training, monitoring and collaborative audits.

Even observing an increasing number of collaborative initiatives related to suppliers' management, especially at international level, it is possible to notice that regarding to specific initiatives in the environmental segment; the scope of audits is concentrated mainly in regions of Europe and North America.

It is awaited that the joint qualification of environmental service suppliers enables contractors to reduce costs and time, mitigate associated risks with inadequate supply, and non-compliance imposed by legislation, besides reducing reliance on suppliers.

In addition, by decentralizing this operational control to manage professional suppliers, working in the environmental field can focus on more strategic issues, such as reducing waste generation, developing more efficient packaging with suppliers, and seeking greater efficiency in processes; in other words, to dedicate themselves to activities that generate added value to the company. Also worthy of note is the benefit that could be generated for small and medium-sized enterprises, which have the same obligations as large companies, regarding the shared responsibility of their products and services.

For the service suppliers, the main advantage is the sharing of the evaluations results with several companies, allowing the reduction of the audit numbers carried out in their facilities, and opening new markets.

According to suppliers' management rules, the fact that companies induce collaborative practices places them at a level of leadership for sustainable development, since they can positively influence the sector and the region where they operate and mobilize stakeholders interested on the theme.

4 Partnership Between the University and Industry to Develop a Methodology for Environmental Service Suppliers' Qualification

The partnership among university and industries was carried through aiming at the elaboration of a master thesis that could have practical application, through the (Professional Master's Degree Program in urban and industrial environment) Programa de Mestrado Profissional em Meio Ambiente Urbano e Industrial (PPGMAUI).

The network of partner companies for the case study was formed by the Group of Environmental Professionals from Paraná state Industries (GPMAI PR), which acts as a forum for discussion and exchange of solutions and alternatives for improvement in the field of environmental issues in the industry scope. The five companies that took part as volunteers were: Hexion Química do Brasil, Novozymes Latin America, Renault do Brasil, Tecnotam Embalagens Industriais and Treves do Brasil.

The elaboration of the shared qualification process for environmental service suppliers was divided into the following steps:

1. Categories prioritization: In the first stage were defined the categories of environmental service suppliers that would be evaluated, and then the parameters for the construction of the risk matrix were elaborated. As a result, the categories were analyzed and classified among the low, medium and high risk levels, and those classified as high level were denominated as critical categories;
2. Qualification process elaboration for the most critical categories: meetings were held with the GPMAI PR volunteer companies to collect information regarding

the supplier's qualification processes used by them, as well as consulting other references. The result of this stage was the elaboration of the common form among the companies to verify suppliers belonging to the critical categories;
3. Qualification process validation of the critical categories with volunteer companies: The validations were carried out through work meetings with volunteer companies and practical application of the verification process in three suppliers.

5 Step 1—Prioritization of Environmental Service Suppliers by Risk Level, and the Categories Relationship with the SDGs

According to Moura (2009), the qualification is the conformity assessment of potential suppliers, performed through audits to verify compliance with established requirements. The company that performs the qualification aims at ensuring the hiring of qualified partners, who meet the established conditions and the company needs. A compliance assessment program, directed to supplier certification, has the initial verification moment materialized by the audits and is followed by a set of monitoring and control actions, so that the company can ensure that the product or service is effectively in accordance with the criteria for them established (Moura 2009).

According to Teixeira (2015), the main goal of a supplier selection process is to reduce the risks involved in the purchase process, maximize the buyer's overall value and develop long-term relationships among those involved in the negotiations.

According to Rangel (2012) the risk is composed by impact and probability that, after being evaluated and combined, allow prioritization according to their level of criticality. Impact assessments can integrate qualitative and quantitative aspects, using decision theory methods which allow evaluating the risk impact through indicators. According to Arena et al. (2010) the risk analyses can be carried out using qualitative, quantitative or mixed methods.

According to Sellitto et al. (2013) risk management is necessary to deal with uncertainties and potential losses caused by possible ruptures in the chain. In consonance with GVces (2015), the risk matrix is a way of analyzing the supply categories and identifying where the main vulnerabilities or opportunities for the business are.

Risk management is fundamental to sustainable purchases, since it allows identifying and analyzing the criticality of risks, integrating appropriate activities to treat them, implementing, and managing effective risk management actions (ABNT 2017).

In the qualification process, the prioritization aims at analyzing the risks, and opportunities of sustainability to which the categories are susceptible, with the purpose of enabling the categories ranking in order of importance and criticality.

The scope of the suppliers evaluated in this work was directed to environmental service suppliers, and the qualification model elaborated was intended to be used by a group of companies, from several segments, for evaluation of mutual suppliers.

Therefore, the result of the prioritization was focused on the risks classification of each supply category, instead of classifying each supplier.

The methodology used to prioritize the categories was the "Risk Matrix Protocol" from GVces (2015), which describes the necessary steps for the analysis elaboration and for the risk matrix construction.

After defining the evaluated categories, determining the risk exposures factors in sustainability and other parameters (weights, scales and metrics), a specific risk matrix was developed for the environmental service suppliers' categories, which made possible the prioritization by risk level, as well as the identification of the most critical, in other words, those categories are more likely to have a negative impact on the customer as a result of the service provided.

To define the categories that would be evaluated, the list proposed by the OECD and EUROSTAT (1999), along with GPMAI PR service providers were used. All the categories proposed by the OECD and EUROSTAT could be used for analyses in the risk matrix, however we opted for the categories that were most related to the activities contracted by GPMAI companies.

The sustainability risk exposure factors were elaborated taking into account the main social and environmental problems related to the categories of environmental service suppliers. Table 1 shows the factors and other parameters adopted to construct the risk matrix.

After defining the parameters, each category was analyzed in relation to internal and external factors, and the respective scores computed in the table for calculation. The numerical results of each dimension were plotted on a scatter diagram in which the X-axis contains the internal factors and the Y axis contains the external factors. The position of each category is the junction of these two results. The cut-off scores for delimitating the risk levels were defined as follows: from 1 to 2, low risk; from 2.1 to 2.5, medium risk and from 2.6 to 3.0, high risk. Categories in the high-risk quadrant are called critical categories. The result is consolidated in the risk matrix for environmental service suppliers' categories, shown in Fig. 1.

For the category analyses, the bias risk was considered, since the analysis of the relevance of each activity to the environmental segment was not part of the scope. Traditional and consolidated criteria of the purchasing process in organizations such as price, term, quality, financial credibility and supply history, were also not addressed. Following are some points about the categories positioning in the matrix, the main requirements considered in the suppliers' qualification processes, and the relation of each category with the SDG.

The categories "Education, Training and Information", "Consulting, and Engineering", classified as being of low risk, are predominantly of intellectual work, and from the suppliers' qualification point of view do not really present critical issues. The analysis and definition of the supplier consider technical aptitude, professional certifications, and capacity to meet the deliveries established in the contract.

In the category contracting "Equipment and materials", also classified as being low risk, the technical specifications of the product for decision making prevail. There are several available channels for purchasing (retail stores, direct from the

Table 1 Definition of weights, scales and metrics for evaluation in the matrix

Factors		Weight (%)	Scale	Metrics
Intern dimension	Service dependency for the company operation	50	1	Absence of the service doesn't affect the operation
			2	Absence of the service affects moderately the operation
			3	Absence of the service is critical to the company operation
	Co-responsibility	50	1	Contracts that do not require presentation of legal documents
			2	Contracts that require presentation of legal documents at the time of hiring or performing the service
			3	Contracts that require presentation of legal documents and continuous reports throughout the performing service
External dimension	Labor intensity	20	1	Low: Production predominantly automated
			2	Medium: Production combines automation and human labor
			3	High: Predominantly by human labor
	Potential risk degree of manipulated materials[a]	30	1	No material handling
			2	Non-hazardous, inert and non-inert (Class II A and B)
			3	Hazardous—Class I
	Potential risk degree of environment negative impacts	20	1	Activity with low degree of environmental impact
			2	Activity with medium degree of environmental impact

(continued)

Table 1 (continued)

Factors		Weight (%)	Scale	Metrics
			3	Activity with high degree of environmental impact
	Conformity	30	1	Activity without rule requirement of specific legislation
			2	Activity requires certificate presentation/document that proves service capacity
			3	Activity with specific legislation requirement

Source ROSA (2018)
[a]Materials classification according to the Brazilian standard ABNT NBR 10004: solid waste—classification (2004)

manufacturer, distributor, among others), but further requirements apart from those related to the product are usually not verified.

These categories have influence with the SDG 4—Quality education, SDG 9—Industry, Innovation and Infrastructure and SDG 12—Sustainable Consumption and Production. Such activities enable the generation of knowledge and skills required to promote sustainable development, increase resource efficiency and increase the use of clean and environmentally sound industrial technologies and processes, as well as strengthening scientific and technological capabilities, seeking more sustainable standards of production and consumption.

The categories located at medium and high levels showed an increase in the internal dimension, influenced by the co-responsibility factor. This is because most of the activities are executed within the contractor's premises, requiring verification of service suppliers', regarding compliance with labor legislation and continuous management of third parties. The co-responsibility factor is associated with SDG 8—Decent Work and Economic Growth, which establishes the protection of labor rights and requires safe and protected work environments for all workers.

There is great consumption of natural resources and waste production in "Construction and unities installation". The market has presented solutions to improve materials efficiency and civil construction projects, and there is a tendency for companies to adopt sustainable construction criteria in their contracting processes. This category contributes to ODS 11—Sustainable cities and communities, enabling the transition to economic relations, social and environmental relations between urban and rural areas, reinforcing national and regional planning for sustainable and robust buildings.

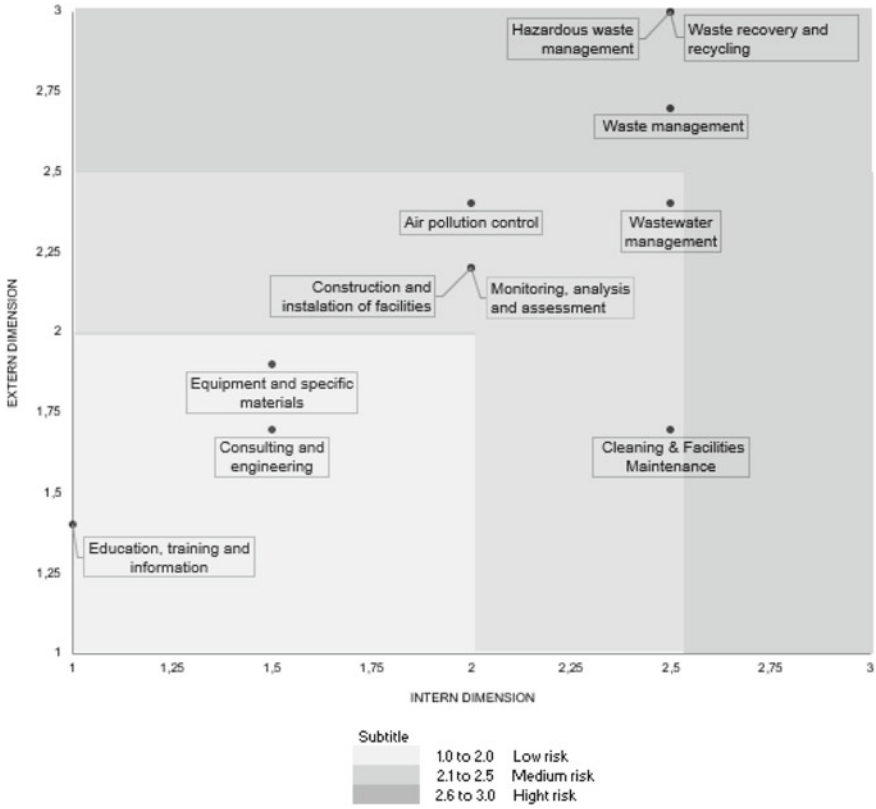

Fig. 1 Risk matrix for environmental service suppliers' categories. *Source* ROSA (2018)

There is an intensive use of equipment and treatment systems in the "Air pollution control" and "Wastewater management" categories. Prevailing in the matrix are the risk factors related to materials, arising from the type of material that can be absorbed or collected, and in compliance, as there are relevant legislation. Contracts may include equipment purchase, facilities and maintenance, and monitoring services with the same supplier or the contracting of these items separately.

In the case of wastewater there are situations where it is not possible to carry out the treatment in the industry, either by the impossibility of installing the treatment plant, by the complexity, or the volume of the generated effluents. In this case one can opt for outsourced treatment centers. It is noteworthy that, in this job, if there was a generation of waste, the operation was classified in the category of waste management.

The "Air Pollution Control" category is related to SDG 13—Action against global climate change, since the emission of polluting gases is one of the factors that generate the greenhouse effect imbalance. The "Wastewater management" category has repercussions with SDG 6—Drinking water and sanitation, with the capacity to

reduce pollution of water resources by eliminating chemical and hazardous material releases, reducing the proportion of untreated wastewater and increasing efficiency of water use.

At the high risk level are concentrated the activities of waste management, represented by the categories "Management of non-hazardous waste", "Recovery and recycling of waste" and "Management of hazardous waste". In these activities the handling of materials, collection, storage, transportation, treatment and disposal of waste and tailings, which require a high level of management, takes place.

This result is consistent with Brazilian regulations, since strict legislation is applied in all stages of the waste management process, from collection to final disposal, especially for those wastes considered to be hazardous. These activities are considered to be effective or potentially polluting. This has a direct impact on the service supplier contracting, as there is a need to verify and monitor compliance with the requirements specified by law.

The categories involved in waste management have the potential to contribute to SDG 12—Sustainable Consumption and Production, regarding the environmentally sound management of chemicals and all waste, significantly reducing the release of these elements into air, water and soil, seeking to minimize their negative impacts on human health and the environment.

The categories considered to be of high risk require greater control and power of influence on the part of the contracting companies, that's why the verification process was elaborated for them.

6 Steps 2 and 3—Unified Verification Process of the Most Critical Categories and Validation

The verification process for the most critical categories was prepared with the GPMAI volunteer companies' collaboration, which shared the suppliers' qualification methods used in their companies and participated in the structured methodology validation steps. What motivated the companies to take part was the interest in implementing or improving their suppliers' qualification processes, and especially, the possibility of sharing the results.

In the first stage, to prepare the verification process, a meeting was held with the companies to present the research proposal and to establish a partnership with those which accepted volunteering. The companies then submitted their internal suppliers' qualification procedures, document requirements, and on-site verification forms.

From the analysis of the submitted materials, two subsequent stages of verification were established to determine the service suppliers' qualification. In addition, two forms were also elaborated: (1) Register of environmental service suppliers; (2) Critical supplier verification form.

The first stage is the pre-qualification, which consists of the register, and the documents received, allowing evaluating the company suitability for the exercise of

its activity. With the presentation of all valid documents the service supplier is pre-qualified, and then goes through the second verification, which consists of the audit of their premises, through form application. The main verified items are described below, organized according to the framing in the form:

(1) Legal Indicators Requirements

Documents proving the minimum compliance with the legal requirements, needed for the exercise of the activity.

(2) General Indicators

Related to management system, risk mitigation practices, health and safety, labor relations and working conditions, environmental compliance and pollution control.

(3) Specific Indicators

Related to laboratory, transportation, installation conditions, storage and handling, treatment operation.

The verification process validation for the most critical categories was carried out through a work meeting and the on-site application in three suppliers. In this meeting, held with the volunteer companies, the group analyzed each of the indicators, and defined which ones should be changed or excluded, presenting their justifications. It was also assigned the classification for the indicators by the degree of importance, converted into weights later. Finally, the form was changed according to the considerations, culminating with the insertion of the weights and calculations for the indicators.

The main consensus among the group members, which guided all the decisions in the analysis indicators, was that the form would be applied when selecting the suppliers and this would imply the analysis of at least three candidates in each competition process. This way, the form should be clear and objective.

Another consensus was that it would not be necessary to deepen the issues related to suppliers' internal processes, but only in the operations inherent to activities that are hiring objects. It was also decided that some indicators would not be verified if the supplier had ISO 9001, ISO 14001 or ISO 45001 certification.

To ensure that the prepared form was functional and efficient, the second process validation was carried though from the application in loco. Volunteer companies indicated and brokered the contact for scheduling, pre-qualification and on-site verification with three suppliers, from the accelerated composting, packaging recycling and blending sectors for co-processing.

In the first verification stage, suppliers sent their fulfilled registers and documents, making it possible to analyze them before the audits, what were the activities performed in their facilities and if they met the requirements for pre-qualification.

In the second verification stage, the audits were performed along with the volunteer company's representative, who, in turn, intermediated the contact with the suppliers. It was possible to apply the critical categories verification form and verify

the indicators fulfillment, meeting the attribute of objectivity requested by the group at the time of the form validation.

After the audits were carried through, the information was posted on the appropriate form, and then, the results were generated, based on the spreadsheet calculations. Such results, showed agreement with what was verified on site, confirming the feasibility of applying the proposed form. After performing the verification at the three suppliers, the partner companies received the final results and made their comments on the process and final suggestions for improvement.

7 Conclusion

This paper presented the partnership results among the Federal University of Paraná and industries in the region of Curitiba (PR), to elaborate a shared environmental service supplier's qualification process. The referred procedure was designed for companies' joint application from different fields of activity, enabling the sharing of information and results among industries.

First, in order to delimit the scope checks for the most critical categories, a risk matrix was elaborated for prioritization, according to risk degree. The categories were analyzed in order to be fit among the low, medium and high levels. In the discussions on the matrix results, the relationship between the activities carried out by the categories and the SDG's was also debated, in order to explain what social and environmental impacts can be minimized with the proper contracting of environmental service suppliers.

The three categories of waste management were classified as high risk and were therefore, considered the most critical. For these categories, a specific qualification process was elaborated, encompassing registration, previous analysis of documents, and on-site verification form for environmental service suppliers.

The criteria indicators we sought to contemplate the main sustainability issues applicable to the supply chain, namely: legal requirements, management system, health and labor safety, work related relations and the environment. Included were also specific indicators of the evaluated activities: laboratory, transportation, storage, handling, and waste treatment.

The referred process to qualify the most critical categories was prepared with the contribution of volunteer companies, members of the GPMAI and also validated through a work meeting and the practical application in three suppliers.

This paper main result proposal was to facilitate the formation of a collaborative initiative, so that organizations with similar contracting objects can join efforts in the shared qualification processes application.

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India's Emerging Ecological Public and the Western Ghats: The Gadgil Committee Report and the Responses of Contiguous States

Rose Veera D'Souza

Abstract Constituting the Western Ghats Ecology Expert Panel (WGEEP), popularly known as the Gadgil Committee was a significant move of the Government of India in conserving the Western Ghats. The Western Ghats are known as the 'hottest hot spot' and a treasure trove of biodiversity. Considering the earlier reports and scientific writings, the Gadgil Committee report provided a handle to engage with the key issues relating to ecology and sustainable development in the region. It anticipated the targets that the Sustainable Development Goals (SDGs) specifically signify on ecology. The report has an account of the rich diversity as well as the catastrophic ecological disaster awaiting the region. This paper attempts to trace the ecological concerns in the report and their bearing on the sustainable development goals. It also endeavours to analyse the different reactions and responses of the contiguous states vis-à-vis the idea of development which is an oft-repeated political slogan in India. This will also lead us to assess the nature and role of democratic dissent made with regard to such an ecologically sensitive concern and the challenges in achieving the goals of sustainable development enumerated in the 2030 Agenda for Sustainable Development. Needless to add that the recommendations of the Gadgil report and the response it has invoked has wider implications and can be profitably compared to similar concerns in countries like Brazil.

Keywords Sustainable development · Gadgil report · Western Ghats · Contiguous states · Democratic dissent · Ecological public

1 Sustainability and Conservation of Western Ghats

Western Ghats in southern India is considered one of the eight 'hottest hot spots' of biodiversity in the world (UNESCO 2012). It has rich endemic flora, fauna and shares biological affinities with the forests of south-east Asia. The Western Ghats

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rainforests have a historical role as part of a large carbon sink that reduces the effects of global atmospheric carbon dioxide elevation (Pomeroy et al. 2003). Tragically, this diversity is shrinking and distinct biological communities in the region are under the threat of extinction.[1] The growing concern with regard to this threat has led to the appointment of several committees and resultant research reports. The latest, the most discussed, and controversial in this regard is the Western Ghats Ecology Expert Panel Report of 2011, popularly known as Gadgil Report. The report has evoked a strong reaction among diverse interest groups and the contiguous states.

The Western Ghats is one of the three prominent mountain ranges of India[2] extending from Tapti in the Indian state of Gujarat to Kanyakumari in the state of Tamil Nadu traversing through the states of Maharashtra, Goa, Karnataka and Kerala along the west coast. It forms a practically unbroken relief for about 1490 km, with rich and wide-ranging flora and fauna. The three major east flowing rivers, i.e., the Godavari, the Krishna and the Cauvery of peninsular India originate in the Western Ghats. The region houses numerous ethnic communities that trace their descent to the distant past. At the same time it is a hub of vast swathes of plantations of coffee, rubber, cardamom and pepper and in recent years of the mining industry. They still hold large tracts of lush evergreen forests that elsewhere in India are fast depleting.

The constitution of the Gadgil Committee by the Ministry of Environment and Forests of the Government of India (MoEF) was a great ecological policy initiative. The recent devastating floods in the state of Kerala and Kodagu, in the state of Karnataka, India, wrecking large scale destruction and marooning thousands of houses have brought home the frailness of the Western Ghats, emphasising the need for sustainable development refocusing our attention on the Gadgil Committee Report.[3]

2 Precedents to the Gadgil Committee Report

2.1 The State Response to the Ecological Concerns of the Sustainable Development Goals

The Gadgil Committee anticipates several recommendations of the historic UN summit held in September 2015. As is well known, the summit envisioned an inclusive, ecologically balanced world with healthy livelihoods and sustainable development. The 17 sustainable developmental goals (SDGs) and 169 targets of the UN 2030 Agenda for Sustainable Development gave directions to the states in addressing

[1] Species are endangered due to poaching, shrinkage of habitats, atmospheric pollution etc. Western Ghats are considered as the World's second most vital forest for threatened species see Gandhi (*The Hindu*, Nov. 16 2013).

[2] The Himalayas and the Vindyas are the other two mountain ranges. They are covered with thick forests, which protect the soil and provide the rivers with an even flow of water.

[3] Many parts of Kerala and Karnataka that were affected by floods such as Idukki, Wayanad and Madikeri, were classified as Ecologically Sensitive Areas (ESAs) by the Gadgil Committee.

social, ecological and economic challenges. The Agenda 2030 is the successive document of the Millennium Development Goals (MDGs) following the Millennium Summit of the United Nations in 2000. MDGs were imperative in building the Rio Declaration on Environment and Development of the UN in 1992. Popularly known as Earth Summit, the Rio Summit is responsible for bringing clarity between sustainable development and environmental protection to which India has been a signatory. In this, the UN sought to help governments rethink economic development and find alternatives to halt the destruction of irreplaceable natural resources and pollution of the planet.

Through its mandate to transform the World, the UN envisioned sustainable goals such as conservation of ecosystems, strengthening the capacity of adaptation to climate change, extreme weather, drought, flooding and other disasters as critical to humanity and the planet. As such, the Government of India, by being a party to various international conventions, has demonstrated its deep concern for ecology and has audited the rapid deterioration of the environment. Many of the concerns on ecology reflected in Agenda 21 of the Rio Declaration have been voiced in India's Five Year Plans. The Pronab Sen Committtee set up by the MoEF in 2000 has discussed widely the mandate to implement the Rio Summit. The Gadgil Report has often referred to the Sen Committee Report and has utilised its inputs while classifying Ecologically Sensitive Areas (ESA) in the Western Ghats.[4]

The UN mandate to protect, restore and promote the sustainable use of terrestrial ecosystems, manage forests, combat desertification, prevent and reverse land degradation and biodiversity loss is well addressed by the Gadgil Report which also addresses the concerns of sustainable development goals more eloquently. It is in tune with the UN appeal to evince the collaboration of vulnerable populations of the region, government institutions, the private sector and civil society groups of the contiguous states while addressing sustainable development. In many ways the Gadgil Committee Report is a continuation of India's considerable interest in coordinating developmental goals and ecological concerns.

India had demonstrated its urge to industrialise, in order to compete with the developed world, immediately after independence. In a way, it ignored environmental concerns, downgrading itself to a phase conceptualised by ecological historian, Ramachandra Guha as 'ecological innocence' (Guha 1992). However ecological concerns began to re-emerge through articulate social movements in 1973. These movements charted a model of development to replace the ill-conceived resource-intensive development path that India had endorsed in its race for industrialisation. This brought to light the indiscriminate ecological destruction and reclaimed the role of locals in protecting the environment. The Gadgil Committee Report is in tune with the concerns and reflections that these movements highlighted.

[4]The Sen Committee proposed a series of species, ecosystem and geo-morphology based parameters to determine ecologically sensitive areas in India. Its foremost criterion for identification of an Ecologically Sensitive Area is endemism, and it stated that "the area of occurrence of every endemic species needs to be protected in its entirety".

2.2 Major Ecological Movements in India

The making of India's ecological consciousness could be located in the developments of the launching of 'Project Tiger'. It was one of the intensive conservation initiatives to save the tiger with the Government of India declaring the tiger as the national animal in 1973. The animated conservationists in India shored up by the international agencies, such as World Wildlife Fund and International Union for the Conservation of Nature, persuaded the government to create a network of national parks and sanctuaries. It resulted in 47 tiger reserves spreading out in 18 tiger range states promoting the conservation of other endangered species on similar lines (MoEF). In the same year B. B. Vora, a higher official in the Ministry of Agriculture, published the article titled "A Charter for the Land", in the popular journal *Economic and Political Weekly*, analysing various forms of land degradation and sought to raise ecological consciousness. Further, the Department of Environment set up in 1980 and a full-fledged Ministry of Environment and Forests established in 1985 are seen as the outcome of such an initiative (Guha 1992).

In the same year, the people's participatory movement to conserve ecology made its debut through a unique initiative called "Chipko". A group of peasants in Mandal, a remote Himalayan village, stopped a group of loggers from felling a stand of trees by hugging the trees, their action culminating in a series of protests reverberating throughout the nation. The movement revolved around issues relating to ecology, equity and social justice and promoted ecological dialogue. Several such other vibrant movements began to pop up, voicing ecological concerns throughout India.

These movements were instrumental in creating public awareness in balancing ecological concerns and development. As a result, the developmental projects that were antithetical to ecological conservation faced huge opposition and promoted dialogue of participatory, community-based natural resource management systems initiatives (Geetanjoy 2007). Two approaches to ecological concerns came to vie for policy attention: "a gentrified view of nature under siege protected by strong centralised efforts, and a populist view that seeks to redress the deeper systemic roots of the crisis by building on the experiences and struggles of those directly reliant on resource harvesting" (Rangarajan 1998).

The popular aspirations to conserve Western Ghats were manifested in 'Appiko Chaluvali', a people's movement that started on 08 September in 1983. A group of around 70 villagers from the Salkani village of Uttara Kannada district of Karnataka State stood hugging the trees of the Kalse forests, led by environmental activist Panduranga Hegde, against tree felling.[5] Falling within the state of Karnataka this movement gives a glimpse of the larger Indian experience on ecological sensibility bearing on a locality and in turn spilling over to other regions. Fashioned after the Himalayan Chipko movement in India, it is a watershed movement in the history of the Karnataka State's protest movements. An all-time record of 1.2 million saplings

[5]Appiko means "to hug" in Kannada. Villagers embraced the trees to be felled by contractors of the forest department. The protest continued for 38 days and the agitation spread to other places, launching the movement in 8 areas covering the entire Sirsi forest division.

were planted by people in the Sirsi area from 1984 to 1985. It was a spontaneous movement initiated by the collective strength of local communities to regain control over productive natural resources and to defend their livelihoods and lifestyles (Rao 2012). The movement sought to build a harmonious relationship between people and nature. It redefined the term development by making ecological concern as the basis for sustainable development. It considerably influenced the state authorities to prohibit destructive projects and spread awareness among the villagers of the region regarding the ecological danger posed by commercial and industrial interests in their forests.

The movement still continues to fight against tree-felling and deforestation in Uttara Kannada and other hill districts in Karnataka and Kerala with its popular slogan, "Ecology is permanent economy".

3 The Gadgil Committee Mandate

The Government of India Ministry of Environment and Forests (RE Division) in its order No. 1/1/2010—RE (ESZ) dated: March 04, 2010 constituted the WGEEP with Professor Madhav Dhananjaya Gadgil, an Indian ecologist, academic, writer, columnist and the founder of the Centre for Ecological Sciences, as its Chairman. In fact, Gadgil, a mathematical ecologist, is the pioneer of 'social ecological' research in the second wave of environmentalism in India (Guha 1997). The Committee had 13 members comprising scientists, academicians, legal experts, officials representing distinct government agencies and research institutes and NGOs with considerable involvement in the regional ecological wellbeing (WGEEP, Annexure A, pp. 111–113). The composition of the committee raised much expectation and initial goodwill from all stakeholders.

The MoEF order highlighted the context that led to the formation of the committee:

> The ecological and environmental problems of the area are complicated by the pressure of population and industry, including tourism, on land and vegetation; submergence of forest areas under river valley projects, encroachment on forest lands; mining operations, felling of natural forests for raising tea, coffee, rubber, eucalyptus, wattle and other monoculture plantations; infrastructural projects such as railway lines and roads, soil erosion, landslides and habitat fragmentation and rapidly declining biodiversity. The order declared that given the environmental sensitivity and ecological significance of the region and the complex interstate nature of its geography, as well as the possible impacts of climate change on this region, it is proposed to constitute a Western Ghats Ecology Expert Panel. (Government of India 2010)

3.1 The Mandate of the Panel

The key mandate of the panel was to demarcate areas within the Western Ghats region which need to be notified as ecologically sensitive zones under the Environment (Protection) Act, 1986. In doing so, the committee was asked to review the existing reports, the Hon'ble Supreme Court's decisions and recommendations of the National Board for Wildlife and consult all concerned State Governments. The committee had to assess the current status of the ecology of the Western Ghats region and make recommendations for the conservation, protection and rejuvenation of the Western Ghats following a comprehensive consultation process involving people and governments of all the concerned states. The committee had to recommend the modalities for the establishment of Western Ghats Ecology Authority under the Environment (Protection) Act, 1986 which was to be a professional body to manage the ecology of the region and to ensure its sustainable development with the support of all concerned states (WGEEP, p. 3).

3.2 Mode of Work

The committee held fourteen meetings deliberating at length on various issues related to the Western Ghats region, spreading over almost seventeen months. The committee obtained extensive inputs from the civil society, government agencies and technical experts with the help of a series of 42 commissioned papers, 7 brainstorming sessions, 1 expert consultative meeting, 8 consultations with government agencies, 40 consultations with civil society groups and 14 field visits. In addition, the government agencies and civil society groups in Goa were also consulted as two members of the Committee, Madhav Gadgil and Ligia Noronha were involved as members of the Goa Government's Golden Jubilee Development Council. The Panel also set up a public website to obtain civil society inputs. (WGEEP, p. 5). It considered the earlier reports on Western Ghats, especially the recommendations of the Pronab Sen Committee, drawing extensively from the Sen Report.

The committee compiled and organised the existing manifold data spatially on Google Earth Image Platform and published the database by employing scientific methodology in the January 25, 2011 issue of the journal *Current Science* to solicit feedback from the public. It encouraged discussions and consultations from a wider section of experts and stakeholders while working on a generic procedure for mapping Ecological Sensitive Areas (ESAs). The criteria for the classification was categorised into (i) Biological attributes (ii) Geo-climatic layers attributes (iii) Stakeholders' valuation. While the first two categories enumerated the physical and environmental background of the region, the third category widely sought the participation of local people, civil society groups and citizens in the conservation of ecology. The committee carried the work through research, stakeholders' consultation (region-wise and state-wise) including the administration, MPs of the Western Ghats Region and

local people, outreach/communication plan and implementation/constitution of the Western Ghats Authority and by organizing an information system. The committee had wide consultations with the members of local self-government bodies such as Gram Panchayat and Zilla Panchayat and also members of legislative assemblies of the contiguous states and the members of parliament.

4 Major Recommendations

The Committee regretted the 'rapid erosion of natural capital with the building up of man-made capital, imposing excessive, unnecessary environmental damage along with degradation of social capital. After careful and extensive compilation of information, and wide-ranging field visits, consultations and analysis, the Panel designated the entire Western Ghats as an Ecologically Sensitive Area (ESA).

The report pointed out that

1. The Environmental Impact Assessment reports of the projects at the region do not qualify the biodiversity and socio-economic requirements.
2. Depletion and pollution of ground water, siltation of water bodies, increased frequency of floods, loss of fertile agricultural land and deforestation are the result of existing industries (See details on sequential overexploitation by West Coast Paper Mill (WCPM) (WGEEP, p. 53).
3. The infrastructural development, the electricity lines and transportation system were adversely affecting the region.
4. The state of affairs in Ratnagiri and Sindhudurg districts of the state of Maharashtra was deplorable as the land use priorities were being constantly violated.
5. The inputs of public hearing were ignored, leading to social discord and discontentment.
6. The traditional wisdom (e.g.: sacred groves) and concerns of the local indigenous community were ignored and discouraged.
7. The role of the tribal population in conserving biodiversity was not acknowledged. The report pointed out that the tribal population was the worst hit and had borne the brunt, receiving no or meagre benefits from development. It stated that the vested interests had also blocked the implementation of acts such as PESA[6] and FRA[7] that were to provide them with some relief (WGEEP, p.12).

[6](PESA), 1996, decentralized existing approaches to forest governance by propelling the Gram Sabha to the centre stage and recognized the traditional rights of tribal's over "community resources"—land, water, and forests. PESA provided for a wide range of rights and privileges for the tribals and set principles as well as a basis for future law making concerning the tribals. The states were directed to promulgate their own laws to promote tribal's rights over local resources.

[7]The Government of India enacted Panchayat Raj Extension to Scheduled Areas Act (PESA) and the Forest Rights Act (FRA) to empower tribal's living in the forest to have an edge over minor forest produces and minerals. Several civil society organisations and non government organisations are working towards the appropriate implementation of PESA and FRA to promote dignity of life

The FRA brought in a significant regime change from the forest administration to the rightful owners of forest land (Mahapatra 2014).

The Committee classified the entire Western Ghats into three zones.

(1) Regions of highest sensitivity or Ecologically Sensitive Zone 1 (ESZ1)
(2) Regions of high sensitivity or ESZ2
(3) Regions of moderate sensitivity or ESZ3.

This classification was seen as being complementary to areas already declared as Protected Areas (PA) which would continue to be managed under regulations prescribed by pertinent acts such as the Wildlife Protection Act. Thus, WGEEP came up with four colour maps spanning the entire Western Ghats depicting PAs, and ESZ1, ESZ2 and ESZ3.

The Committee further felt that:

ESAs are not merely sensitive areas but are also Ecologically Significant Areas due to their biological value, ecological value, economic value, cultural and historical (both biological and anthropological) values and also for the fact that they are sensitive to external and natural pressures. Therefore they need to be conserved though with graded levels of protection depending upon their intrinsic value and extent of resilience (WHEEP, p. 99).

The Panel set broad guidelines for various sectors such as land use, waste water management, forestry quarry and sand mining, polluting industry (Red/ Orange), Non polluting (Green/ Blue Industry), energy and power generation, transport, tourism education, science and technology and information management by widely consulting the stakeholders.

In order to address the myriad environmental implications in the Western Ghats which are proposed as ESA along with various degrees of ecological sensitivity as ESZI, 2 and 3, the committee proposed an apex authority for the entire Western Ghats along with State Western Ghats authorities for each state and District Ecology Committees (DEC) within them. The Western Ghats Ecological Authority (WGEA) was to be the Apex multi-state authority for regulation, management and planning of all activities impacting all categories of ecologically sensitive zones within the states of the Western Ghats namely Gujarat, Goa, Maharashtra, Karnataka, Tamil Nadu and Kerala, and would be constituted under the relevant provisions of the Environment Protection Act, 1986. The Panel sought to strengthen the Western Ghats Ecology Authority (WGEA) as a statutory body comprising 24 members with a chairman who was either a retired Supreme Court Judge or an eminent ecologist appointed by the Ministry of Environment. The WGEA would consist of domain experts, resource experts and representatives from Nodal Ministries. The panel made a strong recommendation to replace the existing High Level Monitoring Committees[8] appointed by

for tribal population. The FRA is responsible for the regime change from the forest administration to the rightful owners of forestland.

[8]The High Level Monitoring Committees lack regulatory powers, financial and human resources.

MoEF with District Ecology Committees (DEC). The DECs were to work in collaboration with the district level Zilla Parishad/ Zilla Panchayat Biodiversity Management Committees. The panel sought to strengthen the existing Paryavaran Vahinis or environmental committees of the concerned citizens to serve as the watchdogs to monitor the environmental situation and also to build capacity at the grassroots level. The Panel cited that such committees were very vibrant in Dakshina Kannada District in the state of Karnataka in the 1990s and were well-promoted through Five Year Plans.

Recognising the contributions of various traditional communities in conserving ecology in the form of sacred groves, the Panel regretted the bias of the state with regard to these communities. It said, "Yet the official conservation efforts in the form of Protected Areas are being pursued on the assumption that it is the local people who are primarily responsible for loss of biodiversity and the highest priority should be given to excluding them" (WGEEP, p. 14). The Panel recognised the role of local communities like Soligas of Biligiri Ranganswami Temple (BRT) Hills in the forest conservation. The Panel established the need for relying on forest dwelling communities and local people through adaptive management against reckless, rigid methods of development and exclusive command of the forest authority. Apart from the above the Panel sought to:

- Extend the moratorium on new environmental clearances for mining red and orange category polluting industries and power plants in this region till an analysis is done of the status report of these regions.
- Evolve people's participation in deciding the future course of development to promote sustainable development that is not guided towards particular vested interests.
- Undertake cumulative impact studies of industrial mining, power generation and other activities in Ratnagiri and Sidhudurg districts.
- Persuade the State Forest Departments to proactively assist the Tribal Welfare Departments in the implementation of the Scheduled Tribes and Other Traditional Forest Dwellers (Rights over Forests) Act.
- Establish and activate biological diversity management committees and tailor environmental education projects to serve as instruments of participatory environmental monitoring involving local community members; connect such exercises in the preparation of People's Biodiversity Registers by the local Biodiversity Management Committees.

The panel argued that the WGEA should strive to make a transition from regulations and negative incentives to promote nature conservation-oriented activities with positive incentives. It recommended that the traditional practices such as sacred groves[9] are to be promoted. It cited the example of Kerala Biodiversity Board which paid the conservation service charges to a farmer for maintaining mangrove growth on his private land. The panel also demonstrated the need for undertaking a critical assessment of the efficacy of funds being deployed towards conservation efforts by WGEA

[9]Forest areas of natural vegetation preserved over generations on religious grounds.

and to redeploy such funds to provide positive incentives to local communities to protect biodiversity.

5 Responses to the Report in Contiguous States

5.1 Differential Responses of State

The forming of the Gadgil Committee was the initiative of the central government. The Committee mandated to determine ecologically sensitive zones and made recommendations for conservation, protection and rejuvenation of Western Ghats. The report fixed the modalities for the establishment of the Western Ghats Ecology Authority. But the ministry rejected the report submitted by the Panel and did not release it to the public citing economic interests of the concerned states until it was demanded by a public petition. When the ministry's action was challenged, the ministry set up another panel under space scientist K. Kasturirangan, the second such body constituted within a year to make recommendations on protecting the fragile ecology of the Western Ghats.

When the Gadgil committee report was published it evoked mixed responses. While the bureaucracy and the landed gentry widely opposed the recommendations of the report it evoked a positive response from several other quarters while the contiguous states reacted differently.

The Kerala government rejected the committee report and did not adopt any of its recommendations. The third generation successors of the government-supported settler farmers of yesteryears from the plains in the state of Kerala, who had an entry into the then inaccessible jungles of the Ghats, became the significant base for opposition against the report. They were a politically and communally powerful lobby, and the government failed to provide the true implications of the report, promoting opposition further. The Syrian Church which shared a huge interest with the pressure groups of such farmers, and the powerful lobbies with business and other vested interests in the Ghats, did not accept the restrictions enumerated in the report. They affected the interests of these groups in various domains such as quarry, construction, tourism or timber industries. The electoral interests also added to the conundrum. Public protests were instigated, spreading rumours against the report, saying that people would lose livelihoods, and would not be allowed to build houses, shops, hospitals and roads. Rumours were spread that within the ESA babies would have to be prevented from crying after six in the evening to avoid disturbance to wild animals or state highways passing through ESA would become elephant corridors.[10] These strong protests in Kerala were fuelled by information asymmetries, ignorance of the reports' contents, attendant disinformation campaigns and rumour-mongering and political partisanship, and created a panic situation (Nair and Moolakkattu 2017).

[10] "I was dropped because I stood for Western Ghats Conservation", *Interview* by Suchitra M., with P. T. Thomas in *Down To Earth*, 04 July 2015.

The same the report was applauded and supported by various parties in Kerala, including socially marginalised sections of the Hindu right-wing Rashtriya Swayamsevak Sangh (RSS) and civil society groups. The vulnerable social groups, including the Scheduled Castes and Scheduled Tribes and the Dalit organisations also displayed wide support. The chief of the Mannan (Adivasi) community, who had influence over 46 hamlets in the forests of Idukki district, defended the Gadgil report saying the implementation of the report only could save the shrinking forests (Nair and Moolakkattu 2017, p. 60). The non-Syrian sections of the Church, the Bishop of the Madhya Kerala Diocese, Church of South India, Thomas K. Oommen, gave staunch support to the voices of the KDMS, (Kerala Dalit Mahasabha) who supported the Gadgil report. The Bishop also cautioned the vested interests of the mining, resort-owning and sand mafia elements that were sponsoring agitations against the Western Ghats conservation. The Kerala Sasthra Sahithya Parishad (the people's science movement in Kerala), a voluntary organisation revived its campaign to support the report on the environment day on 05 June 2014 (India, June 2014). Out of the six states, Kerala expressed strong protests against the report.

In the state of Karnataka, the Karnataka Prantha Raitha Sangha (KPRS) demanded that the State government should reject the report terming it "anti-tribal", "anti-farmer" and "anti-people". In fact, Karnataka state declined to accept the notification of MoEF declaring the Western Ghats as eco-sensitive area (ESA) arguing that such an act will have an adverse effect on the state's economy. It opposed the panel's recommendations that "All red category industries will be restricted in the Ghats".[11] While Karnataka state strongly opposed the notification of ESA the remaining five contiguous states agreed to accept some proposals of the Panel. However the notification that 75% of the Western Ghats area to be declared as ESA was highly contested by the states. The panel's appeal to involve the local bodies and villagers in deciding the development projects received maximum opposition. The State of Tamil Nadu put forward the argument that its own forest laws were sufficiently rigorous and no central initiatives were necessary. Karnataka, though it agreed to the mining ban, expressed its desire to continue stone and sand mining.

6 Accommodating Democratic Dissent and the Future of Western Ghats

The ecological movements bearing on the Western Ghats that preceded the Gadgil committee initiative trace their own trajectory, a few of them subsequently merging with the larger democratic assertions. What I am concerned here is the rise of new initiatives following the Gadgil Report that resulted in a qualitatively different phase of ecological sensitivity with regard to the Western Ghats. Environmental movements have grown in frequency and intensity involving people from all social strata. They revolve around competing claims and also incorporate the struggle of the victims

[11] Red category industries are heavily polluting industries like pesticides, petrochemicals etc.

of environmental destruction. Therefore it is important that the state takes the right kind of initiative and help expand the space of the ecological public. The Gadgil Panel was the initiative of the state though it could not effectively negotiate with the contending claims and had to water down the panel's recommendations with another committee, the Kasturirangan Committee. The Panel's propositions that 'Public land should not be converted into private land and for all settlements and built areas, certain types of areas would be no-go areas, including water courses, water bodies, special habitats, geological formations, bio-diversity rich areas and sacred groves', did not go well with the state developmental goals. The Panel felt that institutions need to be restructured. The entire Western Ghats Ecological Authority (WGEA) along with the State Western Ghats authorities for each state and District Ecology Committees (DEC) sought to address the various environmental challenges of the Western Ghats. The committee also commended the legislative opposition and processing the validity of people's claims through it. The legislation from time to time too has addressed the issues of ecology. The National Wildlife Action Plan (NWAP 2002–2016) replaced the earlier plan adopted in 1983 and was introduced in response to the need for a change in priorities given the increased commercial use of natural resources continued growth of human and livestock populations, and changes in consumption patterns. The NWAP contains various recommendations to address the needs of local communities living outside protected areas and outlines the need for voluntary relocation and rehabilitation of villages within protected areas.

The forest policy of India with all its ups and downs acknowledges and maintains the linkages between tribal lives and forests.[12] In fact, several interventions by the Supreme Court, the highest apex judicial body in India have from time to time scrutinised the forest policy in India. The ecological questions are upheld by the apex judicial body in India in several instances. While delivering justice for a public petition against mining, the Supreme Court had barred 19 companies from all types of mining activities in Ramamnamalai, Swamimalai and the north-east block of the forest areas in Bellary district in Karnataka state prior to the Gadgil Report submission. Much earlier in 2009 the High Court in Karnataka notified the setting up of an exclusive Green Bench to provide a legal space for environmental and ecological issues.

In India, environmentalism arose out of the fight of the poor, with concern for social justice and sustainability (Guha 2013). The race for development by neglecting sustainability and the lavish patterns of resource use have rendered the local communities disadvantaged and have confounded the natural environment. In fact, in the bargain of systematically transforming the erstwhile resource management by the traditional owners of the region into commodities to generate profits and government revenue, the local communities lost their stakes to conserve the forests.

[12]The policy clearly reiterated that the forests cannot be exploited for commercial purposes and should be conserved and used for subsistence needs of the forest dependent communities. The plantations should not be introduced in place of mixed forests and regeneration of natural forests must get precedence.

7 Conclusions

Contemporary democracies are often criticised for failing to address adequately the environmental concerns. This is much more evident when it comes to the Indian democracy where the dissenting voices are polarised and the spaces available for the public to interact freely are shrinking. Promoting the collective capabilities of citizens by enabling and institutionalising the democratic deliberations will improve the widening of the space of the ecological public. Such capabilities would go a long way to promote sustainable development as that would promote adequate spaces in enabling public policy debate freely and peacefully. In fact, The Gadgil Report breaks new ground as far as the new public policy initiative with regard to ecology is concerned. It takes cognizance of the earlier ecological initiative as well as rising global sensitivity towards ecology. It demonstrates the significance of the right kind of state initiative with regard to ecological questions. It also suggests a deliberative platform for contiguous states as to how this initiative can deepen and broaden the ecological public. It begets new modes of democratic dissent and opposition, seeking state accountability on environmental issues. The state is often compulsively caught in the ambivalence of negotiating the interest of different stakeholders and pressure groups. This is much more conspicuous in the case of the contiguous states of the Western Ghats. Hence democratic dissent can be a big challenge to the state as well as an opportunity.

The protest to the report brings in the nature of politically motivated groups in appropriating the common natural heritage for gain. The struggle to achieve a balance between conservation and development in the Western Ghats demonstrates the contentions in which the democratic dispensation in India, with its competitive parties, is caught in. Political will generally favour development where large monies are involved over the voices of the indigenous population who have the will and capacity for sustainable management and conservation capabilities. The big capital harnesses the vote bank politics and appropriates the agenda of development against ecological sensitivity. The failure of the Indian state to effectively combat the pressure of vested interests shows the limitation of a postcolonial democracy to effectively rally in favour of ecological concerns. The Gadgil report's advocacy to accommodate and negotiate the space for the rightful dissent of the marginalised is what is needed to garner support for sustainable development in the Western Ghats. The policy perspectives that the Gadgil report recommended, with its quest for sustainable development, is what is needed to be emulated for ecological sustenance.

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The Role of Neighborhood Origin in the Residential Satisfaction of Residents of Low-Income Areas in Bogotá, Colombia

Dario Vanegas and Mallika Bose

Abstract Cities in developing countries house low-income communities either in large areas developed as informal settlements or in social housing formally offered and delivered through municipal initiatives and/or the open housing market. City governments strive to address the 11th Sustainable Development Goal set out by the United Nations of making cities inclusive, safe, resilient, and sustainable (SDG, Goal 11. https://www.un.org/sustainabledevelopment/cities/) in developing countries, yet often without a clear understanding of what should or what can be sustained in low-income residential areas. This study focuses on residential satisfaction (RS), specifically on the views and experiences of residents of two kinds of neighborhoods, those of formal origin and those of informal origin. The purpose of the study is determine based on an analysis of the effects of neighborhood origin the extent to which residents of low-income areas in Bogotá, Colombia, report experiencing RS and the nature of the RS they report. An original dataset, yielding a total sample of 531 participants, collected from four formal origin and three informal origin low-income neighborhoods in Bogotá is used as the primary data. According to the results obtained, in the case of Bogotá, neighborhood origin does have an impact on RS. In particular, the results indicate the aspects of low-income urban environments perceived by residents as desirable and worth sustaining, which may be relevant to low-income urban environments both in Bogotá and in other countries as well.

Keywords Urban housing · Residential satisfaction · Sustainable development

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1 Introduction

In endeavoring to create sustainable urban environments, cities around the world need to draw on extensive research in adapting their policies and subsequent planning efforts. In the face of rapidly growing low-income urban populations, providing a high-quality urban environment constitutes a significant challenge, which sustainability research is called on to help address. Cities in developing countries provide a rich and complex field for sustainability research where environmental, economic, and social aspects intertwine with urban phenomena such as informality, expressed through living environments referred to as slums, favelas, or shanty towns. Such environments are defined by poverty and may also be present in other urban contexts. For Latin American cities, 20–70% of urban land has been informally developed to provide housing for the lowest-income urban populations (UN Habitat 2004). A small percentage of low-income housing has been built through formal housing delivery processes by governments and more recently through private–public partnerships (Ruiz 2006). Interest in the difference between planned (formal) and unplanned (informal) neighborhoods and the residents' perspectives on these is what drives the present research.

An extensive body of literature has been published on informally produced residential environments (Amin 2014; Dovey 2016) based on the well-established connections between the social and physical manifestations of cities (Tonkiss 2014). Even though the social aspects of residential environments have been acknowledged as key contributors to sustainability, research on the linkages between residential environment features and sustainability has been characterized as limited (Dempsey et al. 2011). A recent study considers residential satisfaction (RS) along with social capital and a sense of community as crucial social outcomes contributing to social sustainability.

It is our contention that low-income residents of neighborhoods of formal origin and low-income residents of neighborhoods of informal origin differ both in terms of their perceptions of the residential features of their neighborhoods and in terms of the residential features that contribute most to a sense of RS. This study focuses on RS, particularly on the views and experiences of residents of formal origin neighborhoods and likewise of residents of informal origin neighborhoods. Based on this user-centered approach, we are able to advance the field's understanding of objective measures of residential environments such as density, tenure, and mix of land uses.

2 Background

2.1 Residential Satisfaction

The field of RS research emerged as a scientific response to assumptions made about the quality of residential areas provided for low-and moderate-income people. Based

on the idea that all people have a fundamental right to housing, social housing was the product of governmental policies put in place with the goal of guaranteeing exactly that. In order to create effective policies, a comprehensive assessment was implemented, including an examination of residents' perceptions in addition to objective measures of the environment, such as density, cost, unit size, and neighborhood layout. On this basis, RS has become a vehicle through the demand-and-supply mechanisms of the market for expressing residential preferences, choices, and expectations of people who lack the means to engage directly with that market.

Researchers typically pursue one of three approaches to RS studies. In one approach, RS functions as a measure to evaluate the quality of a given residential area by identifying and analyzing the factors that best explain variations in the extent to which and the ways in which residents are satisfied with a given area. In this approach, RS is treated as a criterion variable, or the dependent variable. Some examples of studies in which this approach is implemented are Marans and Rodgers (1975), Galster and Hesser (1981), and Cutter (1982). A second approach takes RS as an independent variable to predict a specific behavior, particularly residential mobility. The model presented by Speare (1974) is a good example of this approach. A third option is described as a comprehensive approach in which RS is considered both as a criterion variable to assess housing quality and as a predictor of certain behaviors. The models presented by Weidemann and Anderson (1985), Francescato et al. (1989) and Amérigo and Aragones (1990) are good examples of this approach.

RS is operationalized through the examination of three interrelated factors: satisfaction with the dwelling, satisfaction with the neighborhood, and satisfaction with the community. Each of these factors has objective and subjective components that define residents' attitudes toward their residential environment.

A recent study by Arundel and Roland (2017) includes RS as an essential aspect of the *sustainability of the community* concept (Bramley and Power 2009). Thus, RS (i.e., stability and evaluation of current conditions), social capital (i.e., social interaction and mutual reciprocity), and sense of community (i.e., psychological attachment) are seen as key conditions for achieving collective involvement and community well-being.

2.2 Residential Satisfaction and Social Sustainability

In attempting to operationalize social sustainability in relation to the built environment, researchers have developed a series of variables related to two broad underlying concepts: *social equity* and *sustainability of the community* (Bramley and Power 2009).

Among these variables, three crucial indicators of sustainability of the community are highlighted in recent research: social capital, sense of community, and residential satisfaction. These indicators are used to examine the effects of urban form on social sustainability at the neighborhood level, eliciting the relationship between community and neighborhood features. The positive aspects of developing a strong

community are deemed worthwhile and remain an important goal of policy and planning (Dempsey et al. 2011).

RS is a holistic measure of the extent to which residents perceive a sense of contentment or even enjoyment of the environment in which they live, which includes their neighborhood and community. Thus, a high level of RS is a prerequisite for the sustainability of a community and provides a basis for identifying collective aspects of social life that are worth preserving and promoting.

2.3 Neighborhood Origin

Urban form is a result of a complex synthesis of factors that vary in terms of relative weight and thereby make every city unique. In developing countries, a tendency toward rapid urbanization entails informal occupation and development of large parts of the city in the form of slums, shanty towns, barrios, or favelas (UN-Habitat 2004). Referred to as informal settlements, these areas are unplanned, consist of unauthorized housing and, therefore, usually lack adequate basic services and/or are located in hazardous areas. Most of these informal settlements house low-income populations with limited access to city services (water, public transportation, health) and opportunities (employment, cultural activities).

However, low-income populations in cities of developing countries also live in housing produced and delivered through the formal sector. Many cities have moved from state to private housing provision such that low-income housing has become another tier in the housing market (Hardoy and Satterthwaite 2014). Others have implemented a mixed strategy through land banks (city owned) and private construction companies with subsidies for both buyers and developers (Hardoy and Satterthwaite 2014). Regardless of the strategy, the idea is to regulate and formalize housing production and delivery to keep city growth under control and within planning constraints while fulfilling the goal of providing safe and adequate housing to low-income groups.

The assumption from the city-planning perspective is that formal housing delivery is preferable because it guarantees the provision of public services, controlled land allocation for public and private use in neighborhoods, controlled density, adequate land use mix, and overall alignment with the vision for the city and the policies associated with it. However, given the high percentage of neighborhoods developed as informal housing in the cities of developing countries, it is not feasible to replace all informal settlements with formal housing. Yet, we are not advocating for the informal development of cities. Instead, we see that neighborhoods of formal origin and those of informal origin differ in terms of what they provide as residential environments and that these differences are worth examining from the perspective of the residents. Overall, we are pursuing this line of inquiry to achieve a better understanding of the nuances of formal and informal neighborhoods, thereby providing a basis to help cities more effectively address the challenge of becoming more sustainable than is presently the case.

2.4 Sustainable Development Goals

As established in the United Nations' 11th Sustainable Development Goal, city governments are challenged to ensure that their cities are inclusive, safe, resilient, and sustainable. The challenge is even more formidable for cities in developing countries where rapid urbanization has resulted in large populations settling in informal origin neighborhoods. As the physical and social characteristics of these settlements vary between cities and within them, government efforts to foster sustainability require community participation if a stronger understanding of the rights and responsibilities of living in urban areas is to be achieved.

However, there is an intrinsic distance between informal settlements and the formal structures of the city. Given that this is the case, working toward sustainable urbanization in developing countries where a high percentage of the population live in unplanned, unauthorized, and/or inadequately serviced residential areas requires identifying features that can help bridge the gap between informal and formal low-income settlements.

To address this challenge, it is useful to explore the concept of social sustainability given its strong connection with issues of accessibility and sense of community. Researchers have conceptualized social sustainability in terms of two components: *social equity* and *sustainability of the community*. Social equity means having equitable access to community services, whereas sustainability of the community relates to the ability of a community to continue living as a healthy, functioning, collective entity (Bramley and Power 2009).

Transitioning from informality to formality in urban areas goes beyond granting people access to services (Ward et al. 2015). As social sustainability by definition is concerned with the viability of urban societies in the future, it is fundamental to ensure that all people feel both that they belong and that they have a role to play in defining that future (James 2014). To find out what people wish for the future as urban residents, it is necessary to ask people directly. Participatory processes in housing delivery have a long history with varying levels of success (Lara 2012). However, it is reasonable to assume that if people are to feel that they are part of a community it is better to encourage participation than to restrict it.

A community-centered approach can be useful in assessing neighborhood sustainability. Whereas a healthy community supports the preservation of social aspects, RS helps to identify the connections between built environment characteristics and social aspects that for a given community are either worth sustaining or in need of addressing in some way. In the present study, the results presented derive from a community-centered approach to assessing RS by capturing residents' perceptions of their lives in relation to the residential environment in the context of low-income housing in formal origin and informal origin neighborhoods.

3 The Study

The relationship between urban form and social outcomes such as social sustainability, resident satisfaction, and social capital has been examined in several studies (Bramley and Power 2009; Howley et al. 2009; Addo 2016; Brueckner and Largey 2008), with the overall conclusion that the built form has a significant effect on all these outcomes. In some studies, positive correlations have been found between residential satisfaction and aspects of urban form such as density (Bramley and Power 2009). However, other studies show that it is not high density per se that is the source of dissatisfaction for respondents, but rather related factors such as poor environmental quality, a high level of noise, a high level of traffic, a lack of community involvement, and a lack of services and facilities (Howley et al. 2009). Even though RS in low-income areas in developing countries has been examined in some studies (for example Addo 2016), we did not find any such studies that compare the effects of the specific urban form of formal housing or informal housing in developing countries.

As informal settlements provide housing for the majority of low-income groups in developing countries and as governments are also involved in the provision of low-income housing through the formal sector, in this study we are principally interested in residents' views of and experiences in neighborhoods of both formal and informal origin. We used a validated self-report tool, the Perceived Residential Environmental Quality Indicators (PREQI) (Fornara et al. 2010) to capture the participants' perceptions of their residential environment. This tool measures subjective environmental quality reflecting a user-centered approach intended to complement objective measures such as density, land use, tenure, and mix of land uses.

Specifically, we present an analysis of the effects that neighborhood origin (formal/informal) has on RS in low-income areas in Bogotá, Colombia. We hypothesize that a difference in RS exists between residents of low-income neighborhoods of informal and formal origin. We hypothesize further that of these two groups, residents of neighborhoods of informal origin should report a higher RS due to the community participation intrinsic in the production of their neighborhoods. Thus, we designed the study to address two research questions:

1. Does neighborhood origin have an impact on RS in low-income communities in Bogotá, Colombia?
2. If it does, what are the main factors of formal origin neighborhoods and informal origin neighborhoods that impact RS?

We base our analysis on primary data collected in 2017 from four formal origin and three informal origin low-income neighborhoods in Bogotá for a total sample of 531 participants.

3.1 Study Site and Context

In order to study low-income communities in Bogotá, it was necessary to use selection criteria that would guarantee variability and comparability. To fulfill this goal, the sample was drawn from neighborhoods identified by the city government as low-income through a stratification system (Fig. 1).

In Bogotá, a system of stratification was implemented by the city government in 1994 that required utility companies to bill customers based on neighborhood. The system included a subsidization strategy so that the wealthy would pay in excess of the actual cost of the services they received in order to subsidize the cost of services for the poor. However, the system had a significant impact on many aspects of urban life, such that it has become a marker of socio-economic and spatial classification.

The stratification system has six strata. Low-income citizens live in strata 1, 2 and 3, which together represent 87.7% of the city's population. We selected stratum 2 as the population of interest for the following reasons: First, this stratum represents 41.3% of the city's population. Second, although the neighborhoods are all low-income, there is variability in regard to the features of their built environments and in regard to neighborhood origin (informal vs. formal). Third, the neighborhoods are located throughout the perimeter of the city, thereby offering a variety of environmental and functional urban conditions. Bogotá's stratification system classifies dwelling plots across the city. Consequently, people living in those dwellings are also assigned to the corresponding stratum.

For this study, seven neighborhoods from Stratum 2 in the city of Bogotá were selected for the analysis, three of informal and four of formal neighborhood origin (Fig. 2). In selecting the neighborhoods, we considered the following criteria in order to provide a valid sample for examining the impact of built environment features on RS: neighborhood origin (formal/informal), variability of the built environments' features, and locations within the city.

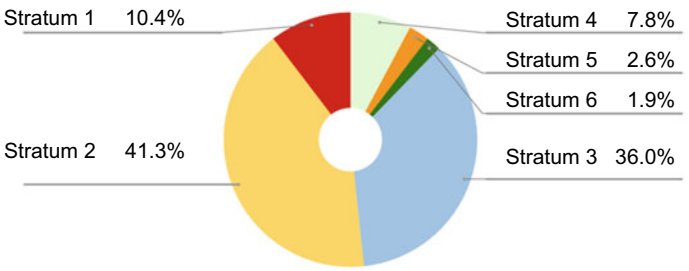

Fig. 1 Residential population per stratum in Bogotá

_	Neighborhood Name	N'hood Origin	Participants
1	Nueva Gloria	Informal	84
2	Santa Cecilia	Informal	85
3	Los Almendros	Informal	84
1	Ciudad Bachue I Etapa	Formal	74
2	Nueva Tibabuyes	Formal	75
3	Ciudadela El Recreo II	Formal	64
4	Osorio II	Formal	65
_	Total (n)		531

Fig. 2 Neighborhoods selected for the study

3.2 Methods

Research design This study relies on survey methodology to examine participants' RS and their perceptions of features of their residential environment in selected low-income households in Bogotá, Colombia. For this purpose, RS is measured as the combined index of the residents' responses to questions about their satisfaction with their respective dwellings (units), their neighborhood, and their community.

Instrument Data were collected through an instrument composed of distinct validated items to measure the RS construct. The survey consisted of the following sections: demographic information pertaining to variables from the Social Life Questionnaire (James 2014) (10 items) (Fig. 3), RS (3 items from the Social Life Questionnaire) (Fig. 4), and perceived environmental features (37 items from the PREQI) (Fig. 5).

The perceived environmental features section relies on the PREQI (Fornara et al. 2010), an instrument developed, tested, and validated by a group of researchers from Italy in a variety of urban environments across Europe, Asia, Australia, and South America (Bonaiuto et al. 2015). We used the short version of the PREQI, which consists of 4 general categories, 11 scales, 19 factors, and 62 items (Fig. 5). We used

1	Education	6	Enough money for health
2	Age	7	Household composition
3	Gender	8	Household size
4	Household financial situation	9	Time in neighborhood
5	Self assessed health	10	Identified community

Fig. 3 Demographic items. Social life questionnaire (James 2014)

1	How satisfied are you with being part of your community?
2	How satisfied are you with the place where you live? (house, apartment, room)
3	How satisfied are you with the environment where you live? (neighborhood)

Fig. 4 Residential satisfaction items. Social life questionnaire (James 2014)

Category	Scale	Factor
Spatial	Architectural and town-planning spaces	Building aesthetics Building density Building volume *
	Organization and accessibility of roads	Internal practicability External connections
	Green spaces	Green areas
	People and social relations	Security Discretion *
Human		Sociability *
	Welfare services	Education services Social health services
Functional	Cultural-recreational services	Sport services Socio-cultural activities
	Commercial services	Commercial services
	Transportation services	Public transport Relaxing/distressing *
	Pace of life **	Stimulating/boring *
	Environmental health	Environmental health
Contextual	Maintenance and care	Upkeep and care

Notes: ** scale not included in the study; * factor not included in the study.

Fig. 5 Perceived environmental quality indicators (PREQI). Fornara et al. (2010)

10 scales consisting of a combined total of 14 factors to keep the questionnaire within practical size because this paper is part of a larger study for which other data were collected.

The independent variables in the study are seven-point Likert-type scale measurements from the PREQI questionnaire for a total of 37 questions. These questions were compiled first by factor and then by scale to obtain a total of 10 PREQI variables (Fig. 6).

Site To study the effect of neighborhood origin on RS, we used a case study approach. A total of seven neighborhoods (three of informal origin and four of formal origin) were selected to guarantee that a range of physical and location characteristics within the city would be represented. Each block in each neighborhood was assigned

1	Architectural and town-planning spaces	6	Cultural-recreational services
2	Organization and accessibility of roads	7	Commercial services
3	Green spaces	8	Transportation services
4	People and social relations	9	Environmental health
5	Welfare services	10	Maintenance and care

Fig. 6 PREQI scales used in the study. From Fornara et al. (2010)

an ID number. With the use of an online randomizer tool, between five and seven blocks were selected in each neighborhood. A number of households was defined to survey from each block (10–15) to obtain a combined total of 65–85 participants per neighborhood. The final sample size across all seven neighborhoods was 531 participants.

All the neighborhoods included in the analysis are designated as Stratum 2 (low-income) in the city of Bogotá. This information is publicly available from the District Administrative Department of Planning (DAPD) in Bogotá and managed using Geographic Information Systems (GIS). The DAPD also provided information (graphic and numeric data) about neighborhood origin, which we used to define two groups of households: informal origin and formal origin.

Participants The participants recruited from the Stratum 2 neighborhoods in Bogotá represent a population of households living either in houses or apartments located in neighborhoods of informal or formal origin. Through a screening process, potential participants who were under-age were excluded from the sample, and the data were collected using a door-to-door/drop-off pick-up strategy. Details pertaining to the composition of the sample are given in Fig. 2.

3.3 Statistical Analysis

This section presents the analysis of the data intended to answer the questions posed in the section titled "The Study" about the effect of neighborhood origin on RS in Bogotá. The full sample (N = 531) was used to run the tests. We selected cases by neighborhood origin as required by the test.

From the total sample of 531 participants, 254 (47.8%) belong to informal origin neighborhoods and 277 (52.2%) to formal origin neighborhoods. The mean RS for the sample is 10.08 ± 2.28; the informal subset mean RS is 9.58 ± 2.61; and the formal subset mean RS is 10.55 ± 1.82. The data are normally distributed, as assessed by a Q–Q Plot.

3.3.1 Effect of Neighborhood Origin on RS

In order to find out whether there is a difference in mean RS between residents of informal origin neighborhoods and residents of formal origin neighborhoods, we ran a Welch *t*-test because the assumption of homogeneity of variances was violated, as assessed by Levene's test for equality of variances ($p \leq 0.001$). Data are mean ± standard deviation, unless otherwise stated. There were 254 participants from formal origin neighborhoods and 277 from informal origin neighborhoods. There were no outliers in the data, as assessed via a boxplot, and the RS scores for each level of neighborhood origin were normally distributed, as assessed by the Shapiro-Wilk's test ($p > 0.05$). Residents of formal origin neighborhoods had higher residential satisfaction ($M = 10.55$, $SD = 1.82$) than did those living in informal origin neighborhoods ($M = 9.58$ $SD = 2.61$), which constitutes a statistically significant difference: $M = 0.97$, 95% CI [−1.35, −5.75], $t(529) = -4.89$, $p \leq 0.001$.

Of the two kinds of neighborhoods under investigation, we expected the informal origin neighborhoods to score higher on RS because we hypothesized that for low-income people, community ties and social networks would be fundamental to the needs of everyday life (Addo 2016; Amérigo and Aragones 1990). Residents of informal origin neighborhoods usually share the same struggles, settle with extended family nearby, and develop a strong sense of pride in and belonging to the residential environment that they have built themselves (Lara 2012). However, we had expected higher satisfaction with community and neighborhood to result in overall higher RS for residents living in informal origin neighborhoods relative to those living in formal origin neighborhoods. Yet, our results do not support this hypothesis.

3.3.2 Examining Built Environment Features that Contribute to RS

The *t*-test revealed a significant difference in RS between those living in formal origin neighborhoods versus those living in informal origin neighborhoods, with residents in the former group enjoying significantly higher RS. In the next step, we focused on determining the features of the built environment that contribute to RS for the residents of each kind of neighborhood. We ran a Multiple Linear Regression (MLR) on informal origin neighborhoods and formal origin neighborhoods separately to compare the models and identify the variables that contribute to RS in both formal origin and informal origin neighborhoods. We used the backwards[1] variable selection method, as this analysis was exploratory in nature. Through this method, we were able to find the best fit for each group of participants (formal origin and informal origin) by choosing from all the environmental features examined (PREQI variables).

[1]Even though the backwards selection method is not usually considered valid because it relies on computer algorithms rather than theoretical input, in this case all the variables had already been validated in other studies as highly correlated with the dependent variable RS. The purpose was not to find the best predictive model of RS. Instead, the models highlight the differences and commonalities between the groups of interest.

3.3.3 Informal Origin Neighborhoods

The MLR was run to predict RS in informal origin neighborhoods from all the PREQI variables (10) using the backwards variable selection method. The results of the regression model indicated that five variables (PREQ_Upkeep, PREQ_Unsafe, PREQ_TranServ, PREQ_ArqPlan, and PREQ_OrgAccRoads) explained 51.2% of the variance in the mean RS for residents of informal origin neighborhoods (adj. R2 = 0.501, F(5, 229) = 48.002, $p < 0.001$). The regression coefficients and standard errors are presented in Table 1.

The residents of informal origin neighborhoods considered *Upkeep* (PREQ_Upkeep) to be an important contributor to RS. As per the PREQI, *Upkeep* has to do with the maintenance of streets, adequate signage, cleanliness, and the overall care taken of the residential environment. It may be that residents of informal origin neighborhoods hold *Upkeep* in high regard due to the extended time that it takes for such neighborhoods to materialize and the sense of belonging, pride, and care associated with informal origin neighborhoods (Richards et al. 2007).

In terms of security, perceptions of the relative safety or lack of safety of a neighborhood (PREQ_Unsafe) contribute to RS. Residents of informal origin neighborhoods pointed to the possibility of vandalism and of experiencing a dangerous encounter at night as defining elements of satisfaction (or dissatisfaction). Not feeling safe after a certain hour of the day in their own neighborhood limits people's freedom, which ultimately leads to changes in customs and in urban culture overall.

Transportation Services (PREQ_TranServ) is defined by the PREQI in terms of bus comfort, frequency of routes, and bus stop distribution across the neighborhood. It also includes how well the public transport system connects the neighborhood with other areas of the city. For informal origin neighborhoods, *Transportation Services* is a crucial aspect of RS because most of these neighborhoods have an underdeveloped infrastructure and/or are located in areas that are not yet considered part of the city (Camargo and Hurtado 2013). As a consequence, access to welfare (health, education) and recreational services is usually dependent on public transportation for residents of informal neighborhoods (Duarte and Rojas 2012).

Table 1 Informal origin neighborhoods (summary of multiple regression analysis)

Variable	B	SE_B	B
Intercept	−1.388	1.299	
PREQ_Upkeep	0.168	0.055	0.175*
PREQ_Unsafe	−0.164	0.057	−0.137*
PREQ_TranServ	0.158	0.051	0.178*
PREQ_ArqPlan	0.362	0.05	0.371*
PREQ_OrgAccRoads	0.14	0.041	0.197*

Note * $p < 0.005$; B = unstandardized regression coefficient; SE_B = standard error of the coefficient; B = standardized coefficient

The *Architectural and Town-Planning* (PREQ_ArqPlan) variable accounts for people's perceptions of two aspects of the environment: building aesthetics and building density. In the PREQI, this variable is used to examine perceptions pertaining to the "beauty" of buildings, how close together they are in the neighborhood, street width, and the overall spatial quality of the residential environment. This variable has the greatest effect on RS for informal origin neighborhoods, which means that the residents place a high value on the look, feel, and density of their neighborhood. A closer examination of building aesthetics and density in informal origin neighborhoods in Bogotá is warranted to more fully understand which architectural and planning characteristics residents value most.

Finally, the MLR model includes *Organization and Accessibility of Roads* (PREQ_OrgAccRoads) as a significant variable contributing to RS. As per the PREQI, this variable is used to examine residents' perceptions of how easy it is to move around their neighborhood by walking or cycling and how adequately it is connected to important parts of the city. For informal origin neighborhoods, this offers an insight into the availability and accessibility of alternative transportation modes given that most low-income people in Bogotá do not have a car such that they rely on public transportation, bicycle and/or walking to work, to school, and to access most of the other activities of daily life (Duarte and Rojas 2012).

3.3.4 Formal Origin Neighborhoods

The MLR was run to predict RS in formal origin neighborhoods from all 10 PREQI variables using the backwards variable selection method. The results of the regression model indicate that four variables (PREQ_Unsafe, PREQ_ArqPlan, PREQ_Green, and PREQ_RecServ) explain 19.8% of the variance in mean RS for residents of formal origin neighborhoods (adj. $R2 = 0.185$, $F(4, 244) = 15.028$, $p < 0.001$). The regression coefficients and standard errors are presented in Table 2.

For formal origin neighborhoods feeling *Unsafe* (PREQ_Unsafe) negatively contributes to RS. The sampled neighborhoods are gated communities, which by definition are intended to address precisely this matter of safety and security. However, residents still feel that they may face issues with vandalism and dangerous encoun-

Table 2 Formal origin neighborhoods (summary of multiple regression analysis)

Variable	B	SE_B	B
Intercept	3.625	1.51	
PREQ_Unsafe	−0.157	0.065	−0.139*
PREQ_ArqPlan	0.246	0.06	0.238*
PREQ_Green	0.165	0.059	0.177*
PREQ_RecServ	0.126	0.037	0.213*

Note * $p < 0.005$; B = unstandardized regression coefficient; SE_B = standard error of the coefficient; B = standardized coefficient

ters in their neighborhood, which means that this design "solution" contributes only marginally to addressing the problem.

The *Architectural and Town-Planning* (PREQ_ArqPlan) variable has the greatest impact of all the variables on the RS of formal origin neighborhoods. Given that the spatial features of these neighborhoods are the result of regulated, planned, and approved design and construction processes, the aesthetics and neighborhood/complex layout met with a high level of acceptance.

The variable *Green Spaces* (PREQ_Green) is designed to elicit perceptions of the quality, availability, and accessibility of areas for relaxation and contemplation. Formal origin housing developments are required to include green areas as part of the housing project (DAPD, Bogotá, nd), and residents see them as an important feature of their neighborhoods. Green spaces in formal neighborhoods can be public or private in nature. A closer examination of the nuances of residents' perceptions in this regard, therefore, is necessary.

Finally, the MLR model of residential satisfaction includes *Recreational Services* (PREQ_RecServ) as a significant contributing variable for formal origin neighborhoods. As per the PREQI, this variable accounts for the number, variety, and accessibility of sports facilities as well as the entertainment and/or cultural activities offered at venues designed for this purpose. Community centers and sports facilities are generally offered among the amenities in formal origin housing developments, which means residents of such neighborhoods generally expect them to be available.

4 Discussion and Conclusion

The analysis showed statistically significant differences between the mean RS of informal and formal origin neighborhoods. Yet, the explanatory power of the models differs greatly. On the one hand, RS was higher in formal origin neighborhoods (M = 10.55) but only 19.8% of the variation in RS was explained by the model. On the other hand, for informal origin neighborhoods (M = 9.58), 51.2% of the variation in RS was explained by the model. The fact that the best fit model found using the backwards variable selection method for each group showed such a large difference in explanatory power strongly supports the hypothesis that there is a difference in the perceptions of environmental features, which, in turn, contributes to RS in formal origin versus informal origin neighborhoods.

The considerable difference in explanatory power shown by the models (formal origin versus informal origin) suggests that for residents of each group different aspects of the residential environment contribute to RS. From the architecture and planning perspective, every variable of the final regression model of RS for formal origin neighborhoods (*Unsafe, Architectural and Town-Planning, Green Spaces*, and *Recreational Services*) are at the core of formal housing delivery processes. This could be interpreted as a good result, but the fact that it accounts for only 19.8% of the variance in RS is cause for concern. Given this result, it can be inferred that for this group other variables need to be considered in the model. We put forward

the argument that the variation in RS explained by the model for formal origin neighborhoods is low because of the standardization process embedded in formal housing delivery. In this regard, research has shown that standardized delivery models often result in developments with houses constructed of permanent materials and with infrastructure provided, but that these developments may lack character, giving rise to descriptions of them as sterile (Bond and Tait 1997).

Yet, given the greater explanatory power of the model of RS for informal origin neighborhoods at 51.2%, a closer examination of the nuances and potential differences between the three selected neighborhoods in this category might be beneficial to better understand the results. However, that direction is beyond the scope of the present study. It is interesting to find that of all the selected variables of the model, *Architectural and Town-planning* has the greatest effect on RS for this group. The three informal neighborhoods included in the sample differ from each other significantly in terms of physical characteristics. Yet, the residents consider physical characteristics to be quite important to RS. *Architectural and Town-Planning* as conceptualized in this study deals with building aesthetics and building density, two aspects most people would assume are best handled by experts. Yet, these aspects show a greater impact on RS in informal origin neighborhoods than in formal origin neighborhoods. It would, therefore, be beneficial for future research to address how residents conceptualize building aesthetics and building density in order to better understand their impact on RS.

Two variables are common to both models of RS: (i) *Architectural and Town-Planning,* and (ii) *Unsafe.* This is consistent with the literature that defines both the physical built environment and social aspects of residential areas as the overarching categories contributing to RS (Amérigo and Aragones 1997). The perception of being unsafe in formal origin neighborhoods can be interpreted as a failure of formal housing delivery for which safety has been and continues to be a focal concern. In Latin America, gated communities have become the common simplistic response to safety concerns (Coy and Pöhler 2002). In the case of Bogotá, the trend toward low-income gated communities is intended to match the residential features offered to affluent citizens under the assumption that doing so solves issues pertaining to vandalism and other crimes. However, given the low impact of the regression model for formal origin neighborhoods, the perception of being unsafe becomes less important in the context of all the variables used to explain RS for residents of these neighborhoods.

The perception of feeling *Unsafe* had more impact on RS for informal origin neighborhoods ($B = -0.164$) than for formal origin neighborhoods ($B = -0.157$). The fact that the variable *Unsafe* was important in both models of RS underscores the significance of social aspects as contributors to RS (Amérigo and Aragones 1997). Moreover, the greater contribution of this variable to RS in the informal origin neighborhoods as compared to the formal origin neighborhoods corroborates research that has established the importance of social factors in informal housing (Chavis and Wandersman 1990).

However, even though social factors are important, the fact that *Unsafe* contributed more to the model in informal origin neighborhoods indicates that participatory processes associated with the development of this kind of neighborhood in Bogotá does

not translate into a feeling of safety. As we did not specifically examine the process of settlement development, the relationship between informal housing delivery and safety requires further research.

The main take away from this study is that governments need to follow a nuanced approach to policy that seeks to improve sustainability of and satisfaction with housing in formal versus informal settlements. This study illustrates that a different set of factors (physical and social) contribute to RS in formal and informal settlements respectively. Furthermore, since the factors considered in this study explain RS in informal settlements better than those in formal settlements, this underscores the need for further studies of determinants of RS and sustainability in formal low-income settlements.

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Responsible Investment and the Disclosure of ESG Information in the Companies' Integrated Reports

Hong Yuh Ching

Abstract The objectives of this research are twofold: examine to what extension the environmental, social and governance information ESG are disclosed in the Integrated Reports of three industry sectors and whether there is difference in the disclosure between these chosen sectors. The vehicle of analysis is the Integrated Report and in its absence, the Sustainability Report. The disclosure reference model of sustainability proposed by Ching, Toste and Tardelli was used to examine which ESG information described in this model are present in the companies' reports. The sample consists of 15 companies of automotive, consumer goods and health care sectors. There were different levels of ESG information disclosure in the reports of the chosen companies, both in the dimension and in sectors. The disclosure in Corporate Governance dimension as well as in the consumer goods sector was less reported. The conclusions are: (a) there is still a long way to go by companies on the importance of disclosing ESG information; (b) one may speculate whether the low level of disclosure in corporate governance is due to lack of knowledge or disregard by the companies for this information; (c) the integrate reports are still being adopted in a shy way, given that the first release of its framework was in 2012. Finally, there is a concern about how socially responsible fund managers and responsible investors are making their investment decisions, as their primary source of ESG information should be disclosed in the Integrated Reports or Sustainability Reports.

Keywords Responsible investment · Sustainable investment · ESG · Integrated reports

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1 Introduction

Integrating environmental, social and corporate governance (ESG) policies and practices into a company strategy and its day-to-day operations is increasingly viewed by investors as relevant to their ability to realize long-term value (SSE 2015). Businesses looking to build long-term value are those that are anticipating and responding to the changing needs of their stakeholders, society and the external environment (Morrow and Yow 2014). Companies have been pressured to report their performance on sustainability and some efforts have been made to establish initiatives to guide them in that direction (Delai and Takahashi 2011).

Due to increasing demands for the integration of ESG by asset managers and the materiality of ESG metrics, this type of information is being used by these managers in the construction of their portfolios (Morrow and Yow 2014). Most large companies are providing sustainability information that is the basis for responsible investors to make decisions to invest in companies that are concerned with social and environmental aspects (Tuli 2013). This is called Responsible Investment (RI). This is an investment approach that explicitly considers the relevance of ESG factors and health in the long term and stability of the market as a whole (Principles for Responsible Investment PRI 2015). PRI recognizes that the generation of sustainable and long-term returns depends on stable, dynamic and well-governed social, environmental and economic systems.

Responsible investment is an investment strategy that aims to incorporate ESG factors into investment decisions (Principles for responsible investment 2015). For Arnold et al. (2012), the question of how these investors process relevant information contained in sustainability reports is of the utmost importance as ESG information has become increasingly relevant to capital market participants in their investment decisions.

This concept is also known as Sustainable Investment. In an article written in 2017 for www.morningstar.com (https://www.morningstar.com/articles/814953/what-exactly-is-sustainable-investing.html), John Hale states that sustainable investment is a long-term investment approach that incorporates ESG considerations into the investment process. According to this organization, there is a growing interest in sustainable investment, as many institutions and individuals seek to express their concerns about sustainability issues through their investments, just as they do with their purchases and in the workplace.

In the case of sustainable investment, the most commonly used strategy today is the Socially Responsible Investment (SRI). SRI is a long-term, investment-oriented approach that integrates ESG factors into the research, verification and selection process of securities in an investment portfolio. In the universe of investment vehicles incorporating ESG factors in asset management, 519 companies are registered, including mutual funds, equity funds, exchange traded funds or Exchange Traded Funds (ETFs) and closed-end funds, which represent US$ 1,74 trillion in ESG shares. The creation of SRI indices and the wide availability of ESG information for conventional investment analysts as a criterion for participation selection are some of

the evidence of SRI's growing impact on the investment market (The Forum for Sustainable and Responsible Investment 2016).

A trend to combine sustainability and financial reporting is emerging, the Integrated Report (IR). Integrated reporting is a concise communication on how an organization's strategy, governance, performance and prospects, in the context of its external environment, lead to value creation in the short, medium and long term (International Integrated Reporting Council, IIRC 2013). According to Laptes and Sofian (2016), the Integrated Report generally covers three fields that show how value is created, combining financial and non-financial information: sustainable development, social actions and environmental protection.

Socially responsible investors believe that by integrating ESG factors into the investment process, companies that will perform poorly will be eliminated. Excluded companies are engaged in unsustainable activities or practices, making them less profitable over time (Royal Bank of Canada Global Asset Management 2012).

From the ESG information, it is possible to verify how a company and/or sector treats the sustainability factors and how it reacts to them. In order to analyze this data effectively, a study is needed that can gather such information and confront them with safe parameters of sustainability measurement. In such a way that it can facilitate and make more efficient the decision process of sustainable investors. In view of this, the present study proposes to verify if the ESG information is properly reflected in the Integrated Reports or in the Sustainability Reports, in its absence, of three industry segments and if there is difference in the disclosure among these selected segments. The reference model of sustainability disclosure elaborated by Ching et al. (2016) was used to verify which ESG information described in this model is included in the companies' reports. This study can help investors and/or managers of socially responsible funds choose companies that have this information reflected in the Integrated Report, as well as draw attention to the use of this report. We contribute to the literature on responsible investment with this study.

2 Literature Review

This section will address responsible and sustainable investments, what are taken into account in these types of investments, their approaches and the Principles for Responsible Investment (PRI), then some of the main models of ESG disclosure are presented and, finally, discussion on the Integrated Report, its objectives and the framework.

2.1 Sustainable and Responsible Investment

Lydenberg (2013) begins with a sketch of the history of Sustainable Investment (SI), passes through Socially Responsible Investment SRI and ends with Investing

Responsible RI. The latter using the environmental, social and governance factors ESG and understood as the most current and most used corporate metrics of sustainability. Subsequently, with these developments in SI types, it traces the development of Corporate Social Responsibility (CSR) over time and the emergence of new techniques and concepts such as Integrated Reporting (IR). He then investigates who the responsible investors are, what they want and what kinds of ESG initiatives they expect from corporate managers to create, monitor, and report. This investment strategy refers to the practice of choosing actions based on environmental and social factors (Ziegler and Schroder 2010). To do so, such ESG information and initiatives should be reported in corporate reports, notably IR.

The link between ESG factors and investment performance was formalized by the United Nations in 2006 when it enacted the Principles for Responsible Investment (PRI), a set of practice standards offered for voluntary adoption by investors (Radu and Funaru 2011). The Principles are based on the conviction that ESG issues may be relevant to the financial interests of investors, affect the performance of investment portfolios and therefore are important for the Principles for Responsible Investment (2015).

Investors and fund managers are aware of the opportunities resulting from Socially Responsible Investment (SRI). Specifically in 2017, more than a quarter of the world's professionally managed assets—somewhere around US$ 22.9 trillion—are in some sort of sustainable investment, with US$ 8.7 trillion of that in the United States and US$ 12 trillion in Europe (Stanley 2018). In this context, global growth in sustainable investment is aligned with the emergence of literature specialized in the expansion of organizations that meet the environmental, social and governance (ESG) criteria in their strategies.

Responsible investment is fast becoming a predominant concern in the investment industry. The large growth in the number of investors who have adopted the Principles for Responsible Investment is only one of the most recent indicators of the industry's interest in integrating ESG factors in investment management (Price Waterhouse & Coopers 2015). In early 2016, global sustainable investment reached US$ 22.89 trillion, compared with US$ 18.28 trillion in 2014, a 25% increase. Previously, global sustainable investment assets grew 61% from 2012 to 2014. Still, almost all regions saw increases in their SRI assets relative to their professionally managed assets, with the largest increase seen in Australia and New Zealand (Global Sustainable Investment Alliance 2016).

There are several reasons for the worldwide growth in demand for ESG strategies, including the desire for greater transparency; institutional investors are looking for ways to understand the internal workings of a company beyond traditional financial analysis. Geographically, about two-thirds of the demand comes from Europe, where institutional investors often ask managers to disclose how they are integrating ESG into their share classes. In the first quarter of 2017, 79 new investors joined the PRI, bringing the total number of signatories to 1600 (UBS Asset Management 2017).

2.2 CSR and ESG Disclosure and Measurement Models

According to Scalet and Kelly (2010) the ESG movement has progressed over the decades, ranging from the analysis of a concept of responsibility to the development of specific measurement tools for assessing responsibility. The evaluation process requires the creation and collection of data, evaluation standards and a process of applying the data to the standards for the creation of specific classifications. Over the decades since the ESG deployment, several models have been developed with a focus on dissemination, implementation and measurement, some of them are listed below.

An analytical model, developed by Marques-Mendes and Santos (2016), allows a study of the strategic orientation of companies that adopt Corporate Social Responsibility CSR. This is made through the analysis of different types of integration of CSR into business strategies; different CSR strategic maturity levels; and the path needed to be followed by a company to achieve its full development as well as predict which initiatives have the greatest contributions to this end.

CSR continuity model assesses the level of corporate social responsibility. It is a multi-level hierarchy of criteria, which allows the stated corporate actions to be put on a "scale" of social responsibility (Nowosielska-Rojek 2014).

Hanke and Stark (2009) propose a conceptual framework for development of CSR strategies, based on considerations of legitimacy and sensemaking/sensegiving in companies. In this regard, the framework provides strategic options for classifying the CSR of the companies or their engagement.

In Singh et al. (2009), they provide an overview of twelve sustainability assessment methodologies and indices applied in the practice of policies. They conclude by stating that although there are several efforts to measure sustainability, only a few of them have a holistic approach that considers environmental, economic and social aspects.

Delai and Takahashi (2011) developed an ESG model based on eight known sustainability measurement initiatives, which are: Indicators of Sustainable Development of the Commission on Sustainable Development (CSD); Dashboard of Sustainability; Barometer of Sustainability; GRI; IChemE; Dow Jones Sustainability Index (DJSI).

The sustainability disclosure reference model developed by Ching et al. (2016) is based on the models and requirements of four sustainability indices: Dow Jones Sustainability Index, Index of Business Sustainability ISE, Frankfurt STOXX and Financial Times FTSE ESG. Its structure consists of three levels: Dimensions (Environmental, Social, Economic and Corporate Governance), Themes and Subtopics.

All of these models facilitate the implementation of the CSR/ESG and the investor decision-making process, but one has to be aware that unlike financial performance indicators, that are well-defined and well-structured, such as return on assets and return on investment, the sustainability performance indicators are quite heterogeneous. There may still be some trade-offs between the different metrics chosen, such as in cases where investors decide to reward certain companies that adopt new

environmental management practices, but are still polluting. Recognizing these trade-offs can help build stakeholder confidence in SRI and improve ESG implementation (Delmas and Blass 2010).

2.3 Integrated Reporting

The IIRC's mission is to provide an integrated framework for a globally accepted reporting that brings together financial, environmental, social, and governance information in a clear, concise, consistent and comparable format to help businesses make more sustainable decisions and enable investors and other stakeholders understand how a company's performance really is (Busco et al. 2014).

Thus, the IIRC seeks to correct major market failures by providing an approach that, if widely adopted, will allow investors to discern which firms are best positioned to create value, and which are not (Soyka 2013). Created in December 2013, the framework can be divided into two parts. The first shows the interrelationships between IR concepts in the process of value creation. The second part of the framework focuses on the requirements for an integrated reporting, which consist of guiding principles and content elements (Hurks et al. 2016).

The main objective of integrated reporting is to provide information about the resources and relationships used and affected by an organization, these resources are collectively referred to as "capital." They are categorized in the framework as: Financial, Manufacturing, Intellectual, Human, Social and relationship, and Natural Capital (International Integrated Reporting Council 2013). Integrated reporting is only the final step in a process or chain of integrated actions.

IR's primary intent is to provide an appropriate balance between flexibility and prescription, the IR framework is based on principles rather than rules based. The idea is to recognize the wide variation in the individual circumstances of different organizations, yet allowing a sufficient degree of comparability between organizations to meet the relevant information needs. For this reason, the IR Framework does not focus on measurement rules, disclosure of individual issues, or even the identification of specific key performance indicators (KPIs). Instead, the framework is driven by integrated thinking (Busco et al. 2013).

3 Methodology

The selection of industry segments was chosen by the authors for recognizing the importance of the social, environmental and economic impacts they can cause in the world through their activities. The segments are: automobile, consumer goods and health care.

Five companies were chosen for each sector, Volkswagen, Daimler, and BMW, Hyundai and General Motors (Automobile), Takeda, Bayer, Chugai, Mediclinic and

Novo Nordisk (Health Care), and L'Oréal, Truworths, Coca HBC, Diageo and Nestlé (Consumer goods). These companies were chosen for the representativeness in their segment and also for having issued the Integrated Report or at least the Sustainability Report in its absence. Initially the search for the Integrated Reports of these companies was done in the database of the IIRC website. When not available, the websites of the companies themselves were searched.

For the Takeda company's analysis, the sustainability report for 2017 was used, which was only available on the company's website. Bayer and Chugai's integrated reports for 2016 were only available on their websites. The Mediclinic and Novo Nordisk reports for year 2017 and 2016 respectively were already in the IIRC database. Regarding companies in the automobile segment, only sustainability reports were available on their websites and only for the year 2016. Integrated reports were not available.

Ching et al. (2016) sustainability reference model was chosen as the proxy due to its comprehensive structure, which allows for a coherent analysis of the various aspects of sustainability adopted by an organization. As mentioned before, the model is divided into three levels: Dimensions (environmental, social, economic and corporate governance), 23 themes and 60 subthemes that make up each dimension. The main objective of the model is to facilitate the decision-making process of investors because it recognizes the heterogeneity of the ESG data, fully addressing all aspects of sustainability and, through its structure, allows the comparison between organizations and sectors.

Thus, in order for a theme of a respective dimension in a given segment to be considered relevant, it should have half or more of the sub-themes reported by at least three companies in each segment. For example, Environmental Dimension, Air theme in the consumer goods segment, three or more companies reported two of three subthemes. An irrelevant theme is that in which the majority of subthemes were reported by none or until two companies. Likewise, in relation to the subthemes, those that were reported by at least three companies in each segment were considered relevant, and consequently an irrelevant subtheme is that in which the majority of subthemes were reported by none or until two companies. The reading of the integrated reports or sustainability reports of the selected companies in the sample was based on the definitions in the chosen reference model. For illustration, in the consumer goods segment, in the Social dimension, Working Practices and the sub-theme Training and Education, the following information was extracted from the reports: Diageo: "We support our employees through clear policies, competitive reward programs and development of opportunities"; Coca-Cola HBC: "Our new learning support application will enable us to make the knowledge even more available to employees by democratizing learning by accelerating development and helping them realize their potential"; Truworths: "more than R107 million in 2016 was invested in developing internal talent and creating opportunities for unemployed apprentices"; Nestlé: "Through the training and learning strategy, we ensure that learning goes hand in hand with career development and our approach 70-20-10 (in which 70% of development is on the job, 20% is via feedback and 10% is through courses and reading)"; L'Oréal: "The learning teams around the world offer technical

training and staff development programs including programs to help employees with integration".

When a quantitative data appeared in the report, this was also considered in our study. The following data were obtained from the companies as illustration: Volkswagen: 328,408,918 tonnes of CO_2; Hyundai: 2,544,847 tCO_2e (tonnes of carbon dioxide) equivalent); Daimler: Direct and indirect 2938 (in 1000 t); BMW: total inbound and outbound CO_2 emission in tones 1,427,399; GM: direct emission 2,003,265 CO_2 and indirect 5,799,436 CO_2.

4 Results and Discussions

4.1 Comparative Study of the Automobile Segment

In the automobile segment, the dimensions that had the greatest adherence in the sustainability reports were social and economic. In these two dimensions, the companies reported 100% of the themes in a relevant way (Table 1).

Among the subthemes of the social dimension, at least three companies in the segment reported 92% of them. In addition, at least four companies cited 18 sub-themes (out of 25). The sub-theme "public commitment" was the only one not addressed by the companies among the five sub-themes that make up the theme Human Rights. This item is about the organization making a public commitment to how the organization will deal with the human rights aspects relevant to the success of its operation.

In the Economic dimension, 100% of the themes were relevant to organizations in the sector, where at least three companies reported 80% of the sub-themes. However the sub-theme "crisis management plan" was the only one addressed by only one company. This item is part of the theme Investments and treats the organization to have a contingency plan to prevent, manage and mitigate a crisis that may affect its growth in the future.

The Environmental dimension had 89% of its themes addressed by at least 3 companies, and 19 sub-themes (out of 23) considered relevant by companies, where at least four companies addressed 17 sub-themes. Only one of the companies in their reports reported only two subtopics, "content" and "public availability". These two

Table 1 Adherence of the automobile segment to the model

Dimension	Total of themes	Adherence (%)	Total of subthemes	Adherence (%)
Social	10	100	25	92
Economic	3	100	5	80
Environment	9	89	23	83
Corporate Governance	1	N/A	7	71

Source Author

Table 2 Adherence of automobile companies to the model

Company	Environment dimension (%)	Social dimension (%)	Economic Ddmension (%)	Corporate governance dimension (%)	Total of subthemes reported (%)
GM	87	88	80	57	83
BMW	83	88	80	71	83
Volkswagen	91	76	100	43	80
Hyundai	78	76	80	57	75
Daimler	65	80	80	71	73

Source Author

items are part of the theme Environmental Policy and Management and deal with the content and how the organization will be available to the public.

The Corporate Governance dimension was the one that obtained less adherence by the companies of the segment, the subtheme "fiscal transparency" was reported by all the companies, since the subtopic "percentage of executives in the council" did not obtain quotations from the companies. Ching and Tardelli (2015) commented that the Board should have a sufficient number of non-executive members of the company capable of exercising a fair trial in situations that may create a conflict of interest.

Table 2 shows the level of companies that compose this segment and the adherence of these companies to the reference model. Those that had the highest adherence rates were GM and BMW. Volkswagen was the one that most addressed the environmental and economic dimensions. Daimler obtained a smaller approach to the topics in his reports (73%) but, together with BMW, obtained the highest number of reports in the corporate governance dimension and was the second with the largest number of citations in the Social dimension.

4.2 Comparative Study of the Health Care Segment

Table 3 shows the levels of adherence of the health care segment to the reference model. It shows the approach to the themes and sub-themes that make up each dimension of the model.

In this segment, the dimension with the highest index of themes and sub-themes reported by companies was Economic, with 100% of the relevant themes and sub-themes. It was also observed that in this dimension, at least four companies approached three subtopics (out of 5).

In the Environmental dimension, 89% of the themes were reported in a relevant way by the companies, and 65% of the sub-themes were cited by at least three companies, and 9 of them (out of a total of 23) were approached by four or five

Table 3 Adherence of health care segment to the model

Dimension	Total of themes	Adherence (%)	Total of subthemes	Adherence (%)
Economic	3	100	5	100
Environment	9	89	23	65
Social	10	80	25	64
Corporate governance	1	N/A	7	43

Source Author

companies. Seven subthemes of this segment were reported by one company, and of these subthemes, two were not addressed by any of them, such as "consumption of renewable sources" and "public availability". The item consumption of renewable sources is part of the Energy Theme and is about informing if the organization is consuming energy from renewable sources. This same item was also not addressed by companies in this segment.

In the Social dimension, 80% of the themes were reported by companies in which 16 of their subthemes (out of 25 were reported by the companies in this segment. Among them, at least four companies reported 13. In this dimension, nine subthemes were reported by only one or no company. Two companies did not report "public commitment" and corporate citizenship" subtheme. This last subtheme is part of the theme of Society and it is one of the ways in which the organization obtains legitimacy before society of how socially responsible it is. The public commitment item was also not addressed by companies in this segment.

The Corporate Governance dimension was the least addressed, all companies addressed the subtheme "fiscal transparency", and the subtheme "whistleblower program" was not mentioned by any of the companies in their reports. This program seeks to compensate an individual who voluntarily informs the Securities and Exchange Commission of the country about possible violations of federal securities laws. For more details, see https://www.sec.gov/whistleblower/frequently-asked-questions#faq-1.

According to Table 4, the company that obtained the highest adherence was Bayer, with emphasis on the Economic and Social dimensions. Takeda was the company that most reported the Environmental dimension and at the same time was the one that least addressed the Governance dimension. The company that best addressed the Governance dimension was Mediclinic. Chugai and Novo Nordisk were the companies that least reported in their reports.

Table 4 Adherence of health care companies to the model

Company	Environment dimension (%)	Social dimension (%)	Economic dimension (%)	Corporate governance dimension (%)	Total of subthemes reported (%)
Bayer	61	84	100	43	72
Takeda	70	60	80	30	62
Mediclinic	57	56	80	71	60
Chugai	52	44	60	57	50
Novo Nordisk	43	52	80	43	50

Source Author

4.3 Comparative Study of the Consumer Goods Sector

Table 5 shows the levels of adherence of the consumer goods segment to the reference model. It describes the approach of the themes and sub-themes that make up each dimension of the model.

In the consumer goods segment, the dimension with the highest percentage of themes and sub-themes reported was Economic, with 100% of the themes addressed by at least three companies and 80% of the subthemes reported in a relevant way. In this dimension 3 subtopics (out of 5) were cited by at least four companies.

In the Social Dimension, companies in the segment reported 70% of the themes in a relevant way. At least three companies reported 64% of the subthemes and 9 (out of 25) were reported by all companies. Three subthemes were addressed by only one of the companies, being "indigenous rights", "respect for customer privacy", and "sustainability performance by supplier". These three items are part of the topics Society, Product Responsibility and Supplier Selection and Evaluation respectively. The product liability item seeks to protect customer data regarding the potential impacts that products may have on customer health and safety. The third item deals with reporting to the supplier on what has or has not done about sustainability along the supply chain.

Table 5 Adherence of consumer goods segment to the model

Dimension	Total of themes	Adherence (%)	Total of subthemes	Adherence (%)
Economic	3	100	5	80
Social	10	70	25	64
Environment	9	56	23	48
Corporate governance	1	N/A	7	57

Source Author

Table 6 Adherence of consumer goods companies to the model

Company	Environment dimension (%)	Social dimension (%)	Economic dimension (%)	Corporate governance dimension (%)	Total of subthemes reported (%)
L'Oréal	74	76	100	57	75
Nestlé	61	80	80	14	65
Diageo	61	64	80	71	65
Coca HBC	43	64	80	71	58
Truworths	9	56	20	43	33

Source Author

The Environmental Dimension obtained 56% of the themes reported by at least three companies, of which 48% were sub-themes reported by the segment, where 9 subthemes (out of 23) were addressed by at least four companies, of which two were reported by the five companies. Eight subthemes were reported by only one or none of the companies, of which three had no citation by companies in their reports, such as "incidents of non-compliance with all applicable environmental legislation," "content "and" public availability." The first item is the only subtheme of the Compliance theme that focuses on potential incidents arising from non-compliance with environmental legislation. The other two items were also not reported in the other industrial segments.

The Governance Dimension was the one that obtained the lowest number of citations by the companies; however, two subthemes were reported by four or five companies. All companies mentioned "Transparency of the remuneration of top management". One company addressed two subthemes, and "percentage of board executives" was not addressed by any of the companies. This same item was also not addressed by companies in the automobile segment.

Regarding the individual adherence of the companies of the sector, Table 6 demonstrates the levels of adherence to the model. The L'Oréal Group was the one with the highest adherence index, with emphasis on the economic and environmental dimensions. Nestlé was the one that most touched on the social dimension in its reports, despite being the one that presented the least citations of the Corporate Governance dimension. Diageo along with Coca-Cola HBC were the most cited on the corporate governance dimension. The company that had the least number of citations in its reporting was Truworths.

5 Conclusion

The segment that most reported subthemes of the model was the automobile, with emphasis on the social and environmental dimensions. The health care was the second segment that presented more adherences to the model with 65% of the subthemes reported by the companies, with more citations in the Economic dimension. On the other hand, the consumer goods was the segment that least showed adherence to the model, addressing only 58% of the subtheme. Looking at the Economic and Social dimensions, they were the ones that had the highest number of reports by companies, while the dimension of corporate governance was the one that had the least citations regarding their sub-themes by the segments. Reports of the selected companies disclosure information on ESG factors, but in varying degrees of disclosure, both in terms of size and in sectors. See Table 7.

We can arrive to the following conclusions: (a) there is still a long way to go by companies about the importance of disseminating ESG information; (b) one can speculate if the low disclosure of corporate governance is due to the lack of knowledge or disregard by the companies for this information; (c) The Integrated Report is still being adopted by the companies in a timid manner. This is worrisome given that the first version of the framework is from 2012.

Finally, the contribution of this study was to facilitate the decision-making process in sustainable and responsible investments. However, given the quantity and quality of ESG information reported in this study, there is a concern about how socially responsible fund managers and responsible investors are making their investment decisions, since ESG information should be disclosed in the Integrated Reports or in Sustainability Reports.

The access and availability of company reports were the main limitations for the development of this study, in which there is no section for the automotive sector in the IIRC database. As a suggestion of future work, expand this study to more industry sectors and compare with the conclusions reported here.

Table 7 Adherence of the segments to the model

Segments	Environment dimension (%)	Social dimension (%)	Economic dimension (%)	Corporate governance dimension (%)	Adherence to the model (%)
Automobile	83	92	80	71	85
Health care	65	64	100	43	65
Consumer goods	48	64	80	57	58

Source Author

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Urban Spaces Sustainability. Applied Study to Curitiba's Central District—Brazil

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Abstract Curitiba's Central District is an active area, a centrality that has a concentration of metropolitan services and cultural offerings, with great access to public transport. It is undergoing constant changes in land use and occupation designed to lead to sustainability, social justice, ecological stability and economic prosperity. This analysis of the Curitiba's Central District is based on the inventory of the natural system, the anthropic system and the urban metabolism in the light of the Sustainable Development Goals—SDG-, specifically the Goal Nº.11 "Sustainable Cities and Communities". Curitiba's Central District, a center of historical origin recognized by legal norms, is undergoing urban renewal processes that can lead to sustainability in different aspects: the uncovering of urban rivers, as a water management and public space project, as well as the provision of new housing, public spaces and mobility services, along with the local supply of vital resources and better waste management. Central District is in the process of taking advantage of its symbolic and functional relevance to reinvent itself and reach the ideal of "Curitiba, sustainable city".

Keywords Cultural heritage · Urban environment · Urban mobility · Public space · Housing

1 Introduction: Sustainability of Urban Spaces

Urbanization is a phenomenon of interest in the context of a globalized world where much is determined by the decisions taken by cities, and where the metropolitan areas are the key geographic units in economic development that show a constant growth. The impact of globalization and urbanization is often seen in the areas of the city that are valued as cultural heritage. In the case of Curitiba, the cultural heritage area is an active and connected area—a centrality—that suffers changes in land use and occupation, related to commercial establishments that once were luxurious, and

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today are popular, as well as in the kind of residents: before families, today mainly students and seniors (Ultramari et al. 2014).

The re-qualification of historic centers implies a complex process of change. New uses, services and buildings need upgrading infrastructures by adapting existing systems or building new ones. This re-qualification is sometimes a result of urban renewal policies that can generate gentrification: expulsion of the traditional inhabitants because of the economic dynamics, in which the price of space rises due to commercial purposes, service provision and high-income housing; but can also be an opportunity for an approach towards sustainability.

Sustainability can be understood as living with equity within the limits of nature and requires a reduction of aggregate economic transfer (Wackernagel and Rees 2001), in the understanding that the economic system is part of the anthropic system, and this is immersed in the biosphere (Martínez-Alier 2001). On the other hand, sustainability has to do with the capacity of the territory to physically support human activities (Leal del Castillo 2004), historically human tragedies as a result of environmental and socio-environmental phenomena (droughts, floods, avalanches, cyclones, earthquakes, etc.) were the origin of studies about the environment (Osorio Guzmán 2011). We also recognize the importance of the contributions of urban ecology as a basis for analysis and proposals about sustainability of urban spaces, specifically the study of urban metabolism to understand the transformation of matter and energy in the city, in search of low entropy (Bettini 1998).

On the other hand, according to Klein (2018), from a cultural perspective, sustainability is recognized as a moral commitment to the collective environment expressed in the feelings of responsibility of the inhabitants with the landscape, first regarding structures and space, and secondly, regarding the constant transformation of its dynamic nature. In this case, it is understood that sustainability implies transformations towards social justice and ecological stability, based on a post-modern re-humanizing discourse, appropriated by the different fields of knowledge, which need institutionalization, as well as a strong citizenship (Osorio Guzmán 2011).

In the quest for sustainability in urban spaces from a cultural perspective, the challenge is to find a balance between transformations inherent to social evolution, and permanencies necessary for the continuities that give meaning to the experience, connecting it to the history (Klein 2018).

From the environmental perspective of sustainability, it is evident that large cities based on the current economic system generate air and water pollution, noise, heat islands and difficult access to healthy food (Camargo Ponce de León 2005). We occupy spaces with hydrological and geological systems that become threats to constructions and people. Access to vital resources as well as risk management in urban spaces have multi-scalar implications from the building scale to the neighborhood, the city, the metropolis and the planet scales.

Sustainable Development Goals (UN 2015) which should guide national policies, include inter-related and multi-scale issues. Objective No. 11 "Sustainable Cities and Communities" (UN 2015) focuses on the specific problems related to urban systems: adequate, safe and affordable housing; safe, accessible, sustainable transport; inclusive and sustainable urbanization; participatory planning and management; safeguard

of cultural and natural heritage; protection of people in situations of vulnerability; reduction of negative environmental impact (air quality, waste management); positive economic, social and environmental relations between urban, peri-urban and rural areas; national and regional development planning; integrated plans for inclusion, resource efficiency, mitigation and adaptation to climate change; resilience to disaster; sustainable and resilient buildings with local materials. The present approach emphasizes on cultural heritage preservation, urban environment, urban mobility, public space and housing, for Curitiba's Central District.

2 Legal Protection for the Cultural Heritage of Curitiba's Central District

The protection of cultural heritage obtained forums of constitutional importance in Brazil, becoming solid from a broader perspective of environment that includes natural and artificial heritage, and has a specific normative for urban assets.

The idea that cities generally emerge from a central core where trade exchanges and institutions of social influence (cultural, religious, and political) occur more intensively, is widely accepted (Barreto 2010). In the central core of urban areas, one often sees evidence of the passage of time and the changes that have occurred in the city, and it was no different in Curitiba. The Central District is located in the central core of the city, as well as most of the historic real estate of relevant value.

According to Monnet (2000), centrality can have at least the following symbolic and therefore patrimonial outlines:

(a) Centralised policy: the major political players and their central administration.
(b) Centralised economy: the headquarters of companies.
(c) Centralised trade: location of diverse stores and shops merchandizing products and services with some kind of exclusivity.
(d) Centralised accessibility: location in the system of traffic and transit of people and goods, clearly capable of directing the flow from the border to the urban core.
(e) Centralised sociality: location that originates in the interpolation of more than two of the mentioned dimensions, resulting in a frequency flow capable of defining and characterizing the representation of space as a socially mobilized image and discourse.

In this measure, the central area of Curitiba preserves the largest number of protected buildings in the city (one-*Paço da Liberdade*-as federal heritage, 47 as state heritage) in addition to other landscape, art and architecture items (IPPUC 2018), constituting a cause of human cohesion and imaginaries. On the other hand, a city is a physical phenomenon, existing in concrete form in a certain period and causing alteration in the space where it is located. The result of the holistic approach of considering the environment, whose conceptualization in Brazil is recent in the 1980s, is

undoubtedly complex. According to Hardt (2006), such characterization is identified with the structuring concept of city, composed of natural and cultural systems. Thus, Oliveira (2018) refers the understanding of territory and its amplitude, to the notion of landscape, defined as the relation between the support and the cover.

The legal protection of natural and human environments in Curitiba acquired at federal, state and municipal reliefs, is ample. The natural environment is a subject in the Federal Constitution (Chapter IV—Natural Enviroment, Art. 225) and in the Common Legislation (Law Nº 6.938, August 31, 1981—National Policy of the Environment). Artificial environment and urban environment are found in the Federal Constitution (Art. 30. It is the responsibility of the Municipalities: VIII, IX/Art. 182. § 1º, § 2º) and Common Legislation (Law Nº 10.257, July 10, 2001—Cities Statute; Law Nº 13.089, January 12, 2015—Metropolis Statute; Law Nº 14.771, December 17, 2015—New Revision of Curitiba's Master Plan: Art. 1º; Art. 17. II, V, IV; Art. 20; Art. 29. VI; Art. 68. II, III, IV, V, VI, VII; Art. 69. I, II, III IV, V, VI, VI, Art. 70. I, II, III, IV, V, Art. 72. III, IV, V, VI). Work Environment is defined in Federal Constitution (Title VIII—Social Order; Art. 193). Cultural Environment is include in Federal Constitution (Chapter III—Education, Culture and Sports; Section II—Culture Art. 215; Art. 216. I, II, III, IV, V § 1º) and Special legislation for the preservation of cultural heritage (Federal—Decree-Law Nº 25, November, 30, 1937; State—Law Nº 1.211, September, 16, 1953; Municipal—Law Nº 14.794, March, 29, 2016).

At this point, the public perception of Curitiba Central District is that it is a highly valued cultural heritage and it is fully protected by an existing regulatory framework. The legal guarantees made to preserve the tangible and intangible cultural heritage, are consolidated and interconnected by environmental teleology. The current questions are whether these assets can be evaluated collectively, how the community can be involved in their reinterpretation and enjoy a landscape that is valued. In the balance of the uses of space and its urban value, cultural heritage is essential for new economies, as tourism, and for the construction of new meanings between what is perceived and inherited from the past and what can be planned. The Central District is a small area of the municipality that contains a large sample of heritage related to the rest of the city.

3 Urban Rivers

Rivers are important elements in the landscape of many cities. The history of the occupation of a territory has a direct relation with the surrounding water ways that are used for supply, transport, communication, and agriculture. Many cities have their identity associated with the river that gave them origin: Paris and the Seine, Lisbon and the Tagus, Vienna and the Danube. However, during the 20th century, urban rivers were often treated with disregard, seen mainly as wastewater destinations. In 1957, the Thames was declared a dead river by scientists at the London Natural History Museum (Francis et al. 2008).

Curitiba is part of the Upper Iguaçu River Basin and has six sub-basins: Atuba, Barigui, Belém, Iguaçu, Ribeirão dos Padilha and Passaúna (Curitiba 2013). In Paraná, five Basin Committees operate and Curitiba is under the responsibility of the Alto Iguaçu and Alto Ribeira Tributaries Committee.

The Central District is located in the Belém River basin, which represents 20% of the area of the city. It presents a progressive loss of quality as it flows from its origin to the river mouth (Bollmann and Edwiges 2008). Belém river is 17.8 kms long. 7.2 kms are in the center of the city and the basin covers approximately 87.80 km^2 of drained area. It presents the highest index of water pollution among the rivers that bathe the city, caused mainly by sanitary sewage, solid waste and disorderly and irregular occupations (IAP 2009). The original soil of Curitiba was modified by urbanization decreasing the flow of streams during the dry season and increasing flooding during the rainy season (Curitiba 2017b).

Curitiba was founded at the confluence of the Ivo and Belém rivers, then the city spread over the floodplain areas. The first records of occupation report that it was frequently flooded (Curitiba 2017b). Belém river, once an important structuring axis of the urban layout, became an environmental and urban problem: it was rectified, channeled and urbanized in the last decades, polluted, and experienced increasingly worse floods (Duarte 2006).

In 1886, as a preventive measure for public health problems, the first Curitiba park was created, the Passeio Público (Curitiba 2013) with artificial lakes according to the modern engineering design of the time, transforming flooded areas into public spaces (Curitiba 2017b). It was an urban approach to control rivers, to prevent contagious diseases and to promote areas for urbanization (Duarte 2006).

In 1912 the river Ivo was channeled and the river Belém rectified. In 1920 Saturnino de Brito presented a preliminary study called *Saneamento Curitiba*, and in 1940 with the Agache Plan, the first basic sanitation plan for Curitiba, was elaborated (Duarte 2006). The denial of urban rivers, that once were references for the occupation of the territory became obstacles to economic development. Unfortunately, this was a common scenario in many Brazilian cities.

Regarding urban drainage, Curitiba has a general map of irregular occupations, flood spots and critical points. However, it is noted that there are no flood spots in the center, although that population suffers from urban drainage problems. The city has no survey of the places in the center of the capital that flood more frequently, but people already know the most problematic spots (Tavares 2012).

Belém river is disregarded, domesticated in parks and hidden as a sanitary sewer in the city center (Duarte 2006). Knowing that environmental quality is one of the fundamental aspects to improve the quality of life in cities, water management, especially of urban rivers, is essential in the search for more sustainable cities. Healthy rivers give more value to the cities and in the case of Curitiba Central District, streets that hide rivers, contribute to the loss of affective memory: rivers are now remembered by bad smells or floods. Within this analytical framework, the tendency of reopening of the rivers is clear as an attempt to rescue the river's interrelations with the city, exalting human responsibility to the environment and increasing the shared sense of responsibility among people. The group Solo Arquitetos (2017) designed the project

"Discovering the rivers", aimed at uncovering the Ivo and Belém Rivers. It explores different ways to approach the river and proposes public spaces for sports, cultural, gastronomic and contemplative uses. It remains still only a proposal.

River-city interrelationships, due to accelerated urbanization and lack of planning, often generates socio-spatial segregation and environmental problems. Urban rivers have gone from rectification to channeling in many metropolis, due to a sanitary view, now outdated, that channeling was the best solution for avoiding the contamination of the population with diseases related to sewage poured into the waters. This work understands that the relationship between natural and cultural heritage is intrinsic and that the behavior of urban life is crucial to the challenge of the future of cities to preserve vitality, safety and sustainability. Through the correct appropriation of public spaces, the city will arouse the sense of belonging in the population and consequently the valorization of its environmental and cultural patrimony. The influence that urban planning has on people's daily lives related to the quality of a city's public spaces and the presence of nature evidences the tendency to reopen urban rivers.

4 Housing Against the Deterioration of the Center

According to the demographic census data (IBGE 2010), the Central District has 23,360 domiciles, 96.27% apartments, 3.38% houses and 0.35% houses in private condominiums. It is also noteworthy that there are no informal residential occupations registered in the Central District, although there is a housing deficit of 1.60%—in contrast with all of Curitiba, which records 381 irregular occupations and a larger housing deficit of 5.34%. The Central District ranks third of the six neighborhoods with the highest percentage of vacant residences, that is, 13.6% of Curitiba's total. Noting this fact, the other five neighborhoods of this same ranking are close to the Center, which makes it clear that the problem of idle real estate ends up reaching a wider central region.

The age pyramid of the neighborhood reveals itself much narrower at its base than Curitiba's, thus demonstrating the existence of a very small number of children in the neighborhood. At the same time, the proportion of elderly—mainly women—and young people, between 15 and 24 years old, is significantly higher than Curitiba's (IBGE 2010).

In addition to data, we consulted a study of people's perceptions (Curitiba; IPPUC 2017). It lists the main points perceived by the population, on the positive side are those related to culture, commerce, collective transportation, job offers, as well as health and education issues. On the negative side, unfortunately appears a much larger list, the population identifies visual pollution, inaccessibility of sidewalks, chaotic traffic, the lack of quality public spaces, insecurity and violence, degradation of urban environment, and homeless. The lack of housing policies is considered one of the main problems. Linked to this, insecurity is also mentioned, resulting from the emptying of the streets during the non-commercial period.

Still from the population perspective, it is understood that the Central District attracts people for different reasons, resulting in great dynamics and an evident diversity observed also in its architecture, since the typologies are quite varied, from houses to skyscrapers.

The second biggest problem of Central District is the amount of homeless people. The central region where the neighborhood is located, leads the rankings with 670 homeless people, out of a total of 1715 in Curitiba (Piva 2016).

We conclude that, in relation to land use and occupation in Central District, the loss of residential use and the increase of commercial use and services contributed to the degradation of public spaces. An alternative proposal of new uses for idle buildings can be social housing. This would benefit a portion of the population, families with kids for instance, that could live close to urban services, enriching the demographic diversity and ensuring the appropriation of the urban space 24 h a day.

Many buildings of the central area today are underutilized and even abandoned. It is necessary to rescue the vitality of the Central District so that it is not active only during the day, proposing incentives that promote housing as a way to increase public safety and minimize the constant deterioration. Concerning the problem of the housing deficit in the central district, and the problem of buildings that are degraded or underutilized, we intend to heal both with a single guideline: a proposal for new housing in idle buildings what would also affect positively mobility, letting people live close to working, service and commercial areas.

5 Pedestrian Streets, Public and Alternative Transportation

The *XV de Novembro* street, also known as *Rua das Flores,* was the first pedestrian avenue in the country, inaugurated in 1972. Centenary buildings, tourist pubs and gardens characterize it. The street has been considered a protected cultural heritage by state law since 1974. The Federal University of Paraná historical building, the Guaíra theater, is one of the main tourist attractions of the street.

In *Praça Rui Barbosa* is located one of the main public transportation stations of the city and in the *Rua da Cidadania da Regional Matriz* there is a public building that offers institutional services surrounded by restaurants and a shopping center. One of the biggest problems in the Central District is violence. In 2017, the Central District was considered the most violent area of the city (G1 PR 2017). In the 90s, there was a demographic decline in the district that caused a significant decline in public spaces utilization at night, space deterioration and increased violence.

However, between 2000 and 2010, the Central District increased its population probably due to the following reasons: urban structure, services diversity, habitation prices, mobility and central zone revitalization. New proposals where launched, such as the Centro Vivo Project, the Marco Zero program and the Riachuelo e São Francisco revitalization.

The Central District has many collective transportation lines. Still, the municipal institution URBS demonstrates that the amount of passengers has been declining

since 2015. The indexes fell in 14% (7 million tickets) comparing 2017 to 2016 (RPC 2017). That reduction was due to an increase of the tickets prices. Other reasons related to the declining number of passengers are the migration to alternative modes of transportation and the economic crisis.

On the other hand, the number of bike paths has been increasing, and the installation of low speed lines in the Central District has been attracting attention. The first *Via Calma* (low speed line) in Brazil was inaugurated in 2014, having a 6.3 km extension, and it was created to enable the traffic sharing among drivers, motorcyclists and bicyclists. The maximum speed allowed is 30 km/h and the project plans to extend to other regions of the city (Curitiba 2015).

According to the IPPUC studies made in 2008, 2013, 2014, 2015 and 2016 demonstrates that the *Via Calma* installation was responsible for the cyclist's traffic increasing in 132% on *Sete de Setembro* street (Curitiba 2016). To the cyclists, beyond the new projects and alternative routes implantation, a new kind of technology has arrived in the city, a new bridge located in *Centro Cívico* district, has been installed over the Belém river with a power generator paving that is in the testing phase. The project is part of city hall plans and has resources from a Japanese technology company. The paving captures the vibration transmitted by the bikes and pedestrians that converts in enough energy to illuminate the traffics lights along the way. One of the project goals consists of increasing the safety on the bike paths. This kind of initiative may guide the planning and system improvements by using sustainable measures, which are capable to increase the life quality of people.

There is a recent return of activity in public spaces in the Curitiba Central district, after a period of progressive emptiness from the 1990s. It is interesting to evaluate the creation of proposals for the District's streets to be used as places of encounter and experience rather than just for mobility. Public spaces can contribute to the creation of links between the state and society, through different forms of use that strengthen citizenship. Public spaces also have the potential to serve as places that value the human-nature relationships towards sustainability. In terms of mobility, it is important that public authorities put into practice what is being planned, such as projected cycle paths, and to spread new technologies in the city that contribute to a sustainable environment. It is worth emphasizing the need to think of alternatives to stimulate the use of public transport, reducing traffic in the central area, as well as the emission of pollutants by the large number of automobiles.

6 Curitiba's Urban Metabolism and the Central District

This chapter reviews the systems related to Curitiba's urban metabolism of water, sewage, energy, food, building materials and solid waste, and the role of the Central District in them. Population and land use are key issues of this approach: the percentage of inhabitants of the municipality of Curitiba (1,751,907 inhabitants) that lives in the Central District (37,283 inhabitants) is just the 2.13%, but its population can multiply five times during the day with a floating population of ca. 200,000 people.

In addition, 38% of the formal economic establishments of the municipality are in the Central District (IBGE 2010).

The main sources of drinking water in Curitiba are the dams of Piraquara 1, Piraquara 2, Iraí and Passaúna, as well as Miringuava River. The treatment for human consumption is done in the water treatment stations-ETA- of Passaúna, Iraí, Iguaçu, Miringuava (ANA 2010). A lack of water supply related to climate change was documented by the inconstant presence and the decrease of surface waters (GWSE 2015). The increasing use of underground water—there are ca. 1000 wells in the 10 aquifers of Paraná (SANEPAR 2015) contributes to the extinction of these nonrenewable sources. In the search for alternative sources of water for human consumption, using pluviometric data for residential consumption in the Central District, it is possible to say that if rain water where collected in 50% of the area of the Center District, it would provide 92% of the current residential consumption (calculations by the authors).

In the Brazilian context, Paraná has higher than average rates of sewage collection and treatment. According to the Atlas of Sewage (ANA 2017), Brazil collects 61.4% of the sewage and Paraná 65%; Brazil average of sewage treatment is 42.6% and Paraná is 64%. In the case of Curitiba, the municipality has an installed sewage network in 75% of the municipality and about 60% of the buildings are connected to the network, the Central District is a critical area in this sense. The network was installed over already consolidated areas that still aren't connected, which causes direct discharges into the Ivo and Belém rivers and contributes to their pollution.

The Sewage Treatment Plant-ETE- Belém, located in Boqueirão, receives part of the municipal sewage of Curitiba, including the Central District network. It has capacity to receive 2520 L per second and to serve 500,000 inhabitants. In February 2018, a license was granted to operate a power plant fueled with biogas generated by the waste sludge from the ETE Belém. It is designed to generate 2.8 MW (which supply the consumption of 2000 popular dwellings) and will use 1000 m^3 of sewage sludge and 300 tons of organic waste/day. It is the first plant of its kind in Brazil (Ohde 2018). This type of plants could be installed in other ETE as an alternative and complement to hydroelectric production.

Paraná has eight hydroelectric plants connected to the national grid, the largest of which, Itaipu, supplies 15% of Brazilian electricity consumption and 75% of Paraguay's (Wikipedia 2017). The energy produced in Paraná would be able to cover 30% of Brazil's demand, a fact that is increasing, as the construction of four new hydroelectric plants was approved in Paraná: Baixo Iguaçu, Bom Suceso do Sol, Prudentópolis and Guarapuava (G1 2013).

However, let us remember the instability of water sources in the context of climate change, which validates the search for sources other than hydroelectric power plants in a prospective view. The Solar Energy Atlas of the State of Paraná (CIH 2017) demonstrates the potential of Curitiba for the implementation of solar thermal or photovoltaic panels. The direct normal irradiation in Curitiba is 1190 kWh/m^2 a

year, 43% higher than that of Germany, a country that uses the sun more than Brazil as a source of energy.

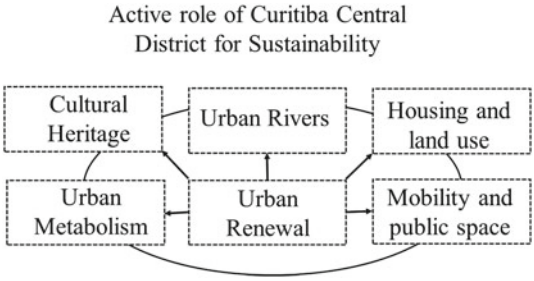
Curitiba has community gardens that are more than 30 years old; the city has 848 participating families and 410 thousand square meters of vegetable gardens. The Central District does not have communal gardens within its limits. It is worth mentioning a project in the vicinity, the Reference Center on Urban Agriculture and Creative Economy, to be installed in the area adjacent to the train yard, in the Pinhão Valley area, occupying an area of 9860 m^2 (Curitiba 2017a). The greening of the Central District could be made by including urban community gardens.

We refer to the mining and construction data to show that is possible to reduce the consumption of these resources if the Central District buildings are renewed, and that is necessary to insist on the possibility of using demolition debris as a raw material in the construction industry. Approximately 77% of the mining deposits in the Metropolitan Region of Curitiba-MRC- are concentrated in only 20% of the municipalities, mainly in Colombo, Campo Largo, Rio Branco do Sul, Almirante Tamandaré, Cerro Azul and in the south of Curitiba. The annual mining production in the MRC for 2004 represented gains of R$131 million, the exploitation of 21 million tons, of which 30% correspond to construction materials (Tribuna 2004) what implies important transformations in the landscape of the mining municipalities.

Curitiba has several solid waste collection and disposal services (IFC-WB 2015). The collection services are divided into services operated by the municipality, informal collection of recyclables and collection operated by the private sector. The Central District benefits from this system of collection and disposal of solid waste (there the collection occurs daily at night), however there are no collection points for recyclable or compost in the district (Rota da Reciclagem 2018), and on the visits there is evidence of the presence of many informal garbage collectors.

From the study, we can conclude that the active role of the Central District towards sustainability can emerge on policies, programs and projects that prioritize construction and renovation with ecological efficiency, such as water management, that includes the use of rainwater and the connection of new and existing buildings to the installed sewage network or the construction of a neighborhood scale system of water reuse along with rainwater treatment. Exploiting the solar energy potential of Curitiba is an alternative to the weakness of the hydroelectric system in a climate change scenario. We suggest the implementation of urban gardens as part of a greening program for local food production and composting of organic household waste. Urban renewal, reuse of buildings and recycling of debris to diminish environmental and landscape impact of mining is desirable, as well as waste management reinforcing recyclable routes and collection points.

7 Conclusion: The Active Role of the Central District Towards Sustainability



Synthesis diagram by the authors.

The urban renewal of historical centers, places of functional and symbolic relevance, as is the case of the Central District of Curitiba, constitutes an opportunity towards sustainability. Using an integral approach, the renewal of the Central District takes into consideration: its widely valued and legally protected cultural heritage; the recovery of water quality and the morphology of urban rivers historically hidden and polluted; the provision of social housing in idle buildings bringing families back to the center and avoiding its deterioration; the improvement of the public transport systems, bicycle and pedestrian roads; the design of a public space as a meeting place; as well as the efficient management of solid waste, and the self-supply of water, energy, food and building materials. The Central District can play an active role as a representative place for Curitiba's sustainability.

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Governance Contributions for the Revitalization of Urban Hydrographic Basins: Challenges and Perspectives for the Belém River Basin, Curitiba/PR

Demian da Silveira Barcellos, Ana Paula Coelho Schimaleski and Augusto Pimentel Pereira

Abstract The research presents governance as an instrument to improve the process of management of urban river basins in the municipal sphere, strengthening the involvement of stakeholders, including society, to consolidate and democratize the management process. Therefore, were identified contributions from the field of environmental governance for the recovery of urban watersheds, specifically analyzing the case of the Belém river basin in Curitiba, Paraná state, Brazil. Thus, from a documentary and bibliographical analysis, it was possible to verify some subsidies of experiences and studies (local, regional and international) for the recovery of urban hydrographic basins, elucidating perspectives and challenges for the management of the Belém River basin. Some perspectives were: (1) the creation of a cooperative or association for garbage collectors, improving the social status of this category and reducing the amount of waste; and (2) the creation of a subcommittee of the Belém river basin, which may result in more effective management of its problems and make the political involvement of the residents more apt. Some challenges identified were: (1) decentralization of environmental monitoring of the quality of the waters of the Belém River; (2) overcoming sectoral public policies; (3) greater environmental awareness and proactivity of society.

Keywords Environmental governance · Urban environmental management · Revitalization of urban watershed · Belém watershed

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1 Introduction

The process of urban growth, accentuated mainly after the Industrial Revolution, increased the pace of transformation of cities, causing spatial, economic and populational expansion. In Brazil, this reality was not different, since the urban population of the Brazilian population grew from 58 to 80% between 1970 and 2000 and, according to the last IBGE Demographic Census (Brazilian Institute of Geography and Statistics) done in 2010 (IBGE 2010), out of a total of 191 million people in the country, 84% were already living in urban areas. With the increase of population living in cities, there is a consequent increase in demand for the use of natural resources to meet human consumption, often in disarray with the capacity for ecosystem renewal.

Focusing on a more specific reality, in Curitiba, capital of the state of Paraná, there is the case of the Belém rivers basin, which has symbolic relevance within the local context. Despite this, it is verified that the environmental degradation of the basin is quite serious, since it is polluted and contaminated by domestic sewage and industrial effluents (Bollmann and Edwiges 2008). Public management of environmental issues in urban settings are traditionally peculiar. Such character comes from its interdisciplinary and interinstitutional characteristics, which brings with it the demand for reorganization and systematic restructuring. These, both from the point of view of administrative political practices and by the clamor for new patterns of proactive participation. These conditions, by itself, characterizes a panorama of advancement to urban environmental sustainability (Rosa et al. 2008).

Within this scenario, it is of great relevance for the continuity of the provision of good quality ecosystem services to the cities covered by the Belém River basin, that sustainable development and environmental management integrate the relationship between the use of natural resources, the construction of territoriality and management processes (Giaretta 2011). Thus, for the present research, governance is presented as a form of mediation between State, civil society and economic agents that, through the action of multiple actors and social power, extends the mechanisms of participatory democracy in opposition to the traditional perspective of centralized administration (Jacobi et al. 2015). In other words, governance, when related to environmental issues, acts as a way of governing natural resources through sustainable development strategies motivated by relevant actors.

Employing governance instruments focused on optimizing urban environmental management, it is possible to reconcile and integrate new forms of social participation through more democratic deliberative practices (Frey 2012). Such strategy can bring even more significant gains in the issue of mitigation of socio-environmental impacts, necessary to the analyzed reality. The high levels of pollution in the Belém river basin may be related, among other possible causes, to failures in the management of water resources, due to the inefficiency of the National Water Resources Management System (Bracht 2008). Thus, the main objective of this article was to identify the contributions of environmental governance to the management of water resources in the urban environment, presenting perspectives and challenges for the studied case.

2 Governance, Environmental Governance and Participation Networks

Among the authors who study governance and its forms of application, different understandings and conceptualizations are observed. Here, governance is considered from the point of view of its capacity for integration and connection motivated, mainly, by interinstitutional networks (Frey 2012). For the discussion of the relationship between governance and environmental management, this delimitation becomes essential, and can be observed throughout the research. Governance is a result of the actions of multiple actors structured in networks that bring the state closer to society and facilitate their interrelationships (Frey 2012). That is, it refers to the notion of social power that mediates between state, civil society and economic agents, expanding the mechanisms of participatory democracy, as opposed to the traditional top-down perspective of centralized management (Jacobi et al. 2015).

Environmental governance, which historically began in the mid-1980s, refers to ways of governing natural resources that, following the same conceptual framework as previously explained, involves different actors in a way that stimulates space for discussion of innovative management ideas (Jacobi et al. 2015). Environmental governance is related to sustainable development strategies motivated by relevant actors that go beyond government, such as civil society and the private sector (Frey 2012). The emergence of new environmental governance practices at various levels and scales was motivated by the growing recognition of one's own limitations in dealing with complex problems, such as environmental threats, both globally and locally. Its challenge, as a political-administrative practice, is to reconcile and integrate new forms of popular and social participation with practices of deliberative democracy (Frey 2012).

The standards of this governance can be modified if there is an effective implementation of the various instruments of participation, enabling new mediations between the State and civil society organizations and, thus, enhancing their democratic relations (Jacobi et al. 2015). These mediations can happen by means of a logical transformation of public administration management, opening space of more complex dialogue, increasing the degree of responsibility of the segments that always had asymmetrical participation in the public management. In this context, it is essential to consolidate practices of informal articulation and the formation of networks of actors that interact, exchange ideas and information continuously, collectively developing alternative proposals and strategies (Frey 2012). This participatory governance feature is essential to break the logic in which a sectoral policy view prevails (Jacobi et al. 2015). For example, the prevalence of these sectoral policies reduces the potentiality of effective changes, being linked to the difficulties and complexities of overcoming traditional management visions (Jacobi et al. 2015).

Governance arrangements can contribute to the reduction of negative externalities of public policies and also boost positive externalities through the integrated mobilization of economic, social, ecological and political sustainability (Frey 2012). In developed countries, environmental governance has been successful, adopting the

environmental management model based on "classic environmentalism", which is basically based on remediation of the developmental side effects (Frey 2012). However, the mitigation of such problems is directly related to the increase of the wealth of countries (Lee 2006).

This model has as elements the presence of qualified scientists capable of identifying problems threatening the stability of ecosystems and their respective causes. Added to these key actors, independent media, active citizens and engaged civil society agencies. A competitive and efficient political system for creating laws, regulations and resource allocation is also necessary. All this, inserted in a strong economy where those involved seek technological and mitigating solutions in order to maintain the quality of life of human beings and ecosystems (Lee 2006).

The model of environmental governance based on classic environmentalism has limits for its implementation in developing countries. According to Lee (2006), this model was only successful in countries that were already rich, when environmental awareness ascended in the 1970s. In poor countries there is a lack of planning and capital capacity that prevent the universalization of networks of capital-intensive infrastructures (Lee 2006). Even in the richer countries and with consolidated democracies, there are still restrictions on the distribution of environmental services, presenting problems at the institutional level (Frey 2012). In this case, the poorest communities in these countries still suffer from the precariousness of basic services, especially where economic liberalization is advancing and the retraction of the welfare state (Frey 2012).

Based on the characteristics of environmental governance, it is observed that the consolidation of informal articulation practices is crucial for the formation of networks of actors that develop alternative proposals and strategies. These articulated networks can support participatory or deliberative democracy and contribute to the advancement of environmentalist ideas within the framework of the political and economic systems of ecological citizenship in society (Frey 2012). Frey (2012) is based on the idea of Dobson (2009), considering it as a model where concerns and obligations for the common good are highlighted, and virtue and active participation in politics are essential elements for the search of a society where the notion of environmental justice prevails. In opposition to the liberal citizenship that neglects the citizen's obligations, highlighting only their rights before the State (Frey 2012). Regarding the act of building networks, that is, reconnecting institutions, democratic arenas of participation, sectors, people, among others, are the fears of the loss of power and control that leads to traditional hierarchies and verticalized structures and in the sectorization and functional separation. On the other hand, great potential exists for the fact that unique technologies facilitate and support the formation of networks as a new standard of social organization in the network society (Frey 2012).

3 Management and Governance of Water Resources

Water governance has, in general, been related to new social actors and government agents responsible for a good management of this natural good, as well as to the institutions, rules and procedures for decision making regarding the use of water resources (Campos and Fracalanza 2010). In Brazil, the legal framework for the beginning of water resources management is represented by the Water Code of 1934, which defined the property rights to use water resources for water supply, irrigation, navigation, industrial uses and energy production. Subsequently, the Federal Constitution of 1988 established the need to create a national water resources management system and define criteria for granting rights to its use. Nine years later, in 1997, the Law No. 9433, which established the National Water Resources Policy (Matos and Dias 2013), was sanctioned. This policy adopted some principles, such as the recognition of water as a public good, finite and vulnerable, endowed with economic value, as well as considering the river basin as a planning unit for decentralized and participatory management (Brazil 1997). According to Matos and Dias (2013), these reforms in the management of water resources allowed the participation of society, especially when recognizing the river basin as a planning and management unit, delimitation that requires the cooperation of all stakeholders within its scope.

In Brazil, urban water resources suffer from a dichotomy regarding the responsibility of their management (Bracht 2008). According to the Federal Constitution of 1988, continental waters are the domain of the Union and the States. On the other hand, it is also the responsibility of states and municipalities to "combat pollution in all its forms" (Brazil 1988). This same text can be found in the National Policy on the Environment (Law No. 6938/1981) (Brazil 1981). The National Water Resources Policy (Law No. 9433/1997) does not specify management responsibility in its legal text. Such generalization results in a difficulty of integration between the management of water resources, carried out by the State, and the management of land use and occupation, which is the responsibility of the municipality. This problem is clearly perceived in the entirely urban watershed of the Belém river, located in the city of Curitiba (Bracht 2008). In spite of this, the National Water Resources Policy has a strong water governance character, motivated mainly by the formation of river basin committees, based on the French model, whose objective is to promote the decentralization of water resources management (Campos and Fracalanza 2010). Thus, this governance presupposes the democratization of the process, considering that local society has a greater capacity to control political decisions at the local level than at the central level (Matos and Dias 2013).

In the United States, the United States Environmental Protection Agency (USEPA) promotes voluntary monitoring of water quality as an essential tool in assisting the environmental control of its rivers. This program has 1720 groups nationwide working for voluntary monitoring and associated activities (USEPA 2016). Volunteers are trained to monitor the conditions of local rivers, lakes, estuaries, wetlands and groundwater. Social participation in monitoring water resources enables community awareness of pollution problems, which helps to identify and restore problematic

sites, enhances engagement in the defense of its watersheds, and increases the quantity and availability of information on water pollution and water quality, an essential issue for the management of water resources. Voluntary monitoring has low costs, as gathering data and information involves collaboration among stakeholders, including academia, private industry, citizens, and local, state and federal governments (USEPA 2016).

4 Characteristics of the Belém River Basin

The water catchment area of the Belém river is part of the Iguaçu Basin, located in the eastern part of the state of Paraná. The Belém river crosses from north to southeast the municipality of Curitiba, passing through the central region of the city, capital of the state of Paraná (Fig. 1). The urbanization history of the Belém river basin began in the XVII century, more specifically from the year 1693, when the settlement existing in the region was elevated to the category of village, being called Vila Nossa Senhora da Luz dos Pinhais, which later would be called Curitiba (Curitiba 2016; IPPUC 2016). Until the year 1900 the area of the city did not exceed what today is the limits of the central region, but it was from the second half of the nineteenth century that a large population contingent migrated to Curitiba (IPPUC 2012), during which time, the basin covered an area of 87.62 km^2, which is equivalent to 20% of the total area

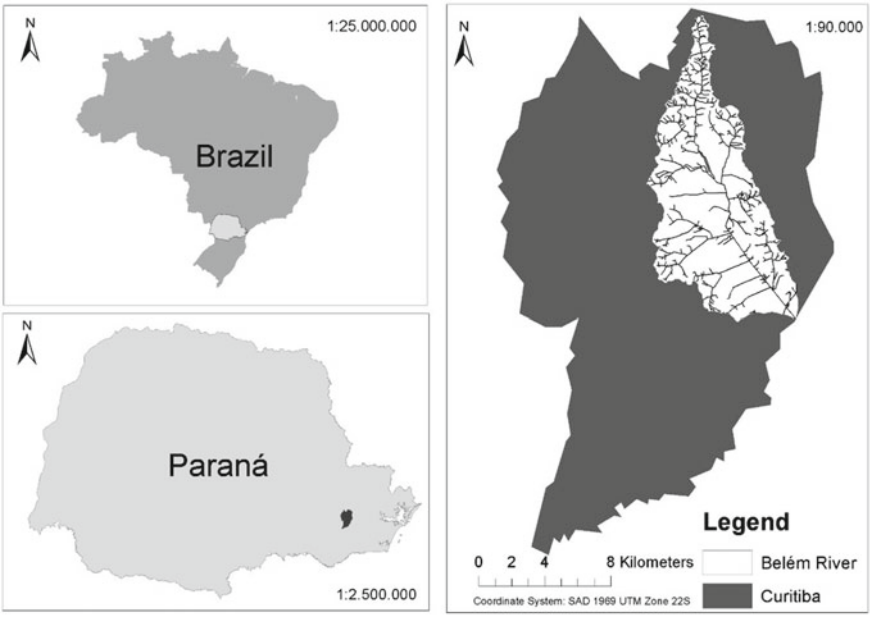

Fig. 1 Macro-location of the Belém river basin

of Curitiba, containing around 474 thousand inhabitants, who represent 27% of the municipal population (Procopiuck and Rosa 2015). Its main course crosses some sectors with greater demographic density in the upper and middle parts of the basin and with less dense occupation in its lower section (Bracht 2008).

Being urban through all its course, this river basin has serious problems of water quality resulting from the urbanization process characterized by population growth, uncontrolled use and occupation of the soil and inadequate exploitation of water resources, and the intense occupation hinders the capacity to carry out interventions for improvement of basin quality (Bracht 2008). Due to a set of point sources and diffuse sources of pollution, water quality deteriorates progressively from the springs towards its mouth, having as main contribution the launch of domestic sewage (Bollmann and Edwiges 2008). Garcias et al. (2014), also point to the importance of the contribution of diffuse pollution and informal waste, the first of which refers to waste from the release of materials used in everyday human activities and which may contain its highly toxic material compositions that are led to the river by stormwater galleries. Informal rubbish is those residues found in places that are not commonly imaginable, such as building roofs and hidden places that, in contact with the rain, are drained into stormwater galleries as well. Added to this is the inadequate disposition of the waste selected by garbage collectors who live near the banks of the river Belém, where in this case the material discarded by them is often thrown on the banks or directly in the river (Garcias et al. 2014).

The management of the Belém river basin falls within the attributions of the Alto Iguaçu and Tributaries Committee of the Alto Ribeira (COALIAR), a collegial body linked to the Paraná Water Resources State Council, which has normative, deliberative and consultative attributions regarding its area of jurisdiction (Hojda et al. 2015). Given the current characteristics, Hojda et al. (2015) states that the basin has a history of few decisions and a current weakened dynamics despite its importance and peculiar characteristics, with little discussion of projects and improvements to the basin in this committee. These considerations make explicit the lack of management of water resources in this basin, which has clearly delimited its problem in the literature, but with few decisive ways to minimize or mitigate the problem. A possible solution to this problem, advocated by Hojda et al. (2015), would be the creation of the subcommittee of the basin of the river Belém, within COALIAR. This proposal is supported by the examples of the Alto Tietê Committee and its subcommittees, the Rio das Velhas Committee and its nuclei, and the case study of five examples of urban rivers (Thames, Seine, Reno Cheong-gyecheon, Anacostia). These cases have undergone a process of requalification and now present positive scenarios regarding the feasibility of reversing anthropized scenarios, the approach and participation of society before and after the actions and the long-term planning that surpasses the "four years" commonly observed in Brazil.

5 Challenges and Prospects for the Belém River Basin

The studies already carried out on the Belém river basin reveal that the contributions of governance to its revitalization can be divided into two groups: perspectives and challenges. Both are still objectives and needs to be achieved. But while perspectives can be glimpsed because they have the means to reach them, the challenges are more difficult because they do not have a clear path for their realization. Therefore, the perspectives will first be discussed and then the challenges identified in the governance of the Belém River Basin case.

The two main agents of contamination of the waters of the Belém river basin are domestic sewage and solid waste (Bollmann and Edwiges 2008). Regarding solid waste, Garcias et al. (2014) emphasize the importance of "informal garbage"—those found in unusual places that do not receive much emphasis, such as cigarette butts, dust, wood, chalk and other organic materials. This type of solid waste pollution is an important aspect of diffuse pollution carried by drainage systems that directly interferes with the quality of the waters of the Belém river basin. However, in the case of solid waste contamination in the garbage that lives near the banks of the river is one of the main causes. Garbage collectors have an important social function for the city of Curitiba since they are responsible for collecting about 92% of the recyclable waste. Still, they sort the garbage by leaving the materials that have no value to them on the river banks, or even throwing them into the watercourse itself. In addition to water contamination, these residues are related to water-borne diseases, floods, silting, etc. (Garcias et al. 2014).

This environmental problem, according to Garcias et al. (2014), has interface with a social problem suffered by this category, which is disorganized, devalued and socially segregated. Thus, greater support for waste pickers, improvements in their living conditions and a more cohesive category are alternatives to considerably reduce the amount of waste dumped in the river and increase recycling. Garcias et al. (2014), suggests the creation of a cooperative or association for garbage collectors who, in addition to optimizing and organizing their work, can facilitate social assistance to this class. Therefore, this is an important perspective capable of improving the social condition of this category and mitigating the contribution of waste in the Belém river basin. Yet, this problem is specific to low-income urban settlements and, in addition, the Belém basin suffers from widespread governance problems, with a basin committee not very active, although the population shows an interest in the revitalization of the basin.

In the context of the Belém river, where there is a popular interest in the participation of actions to improve river quality, the study by Procopiuck and Rosa (2015) shows that about 80% of the population living in the area would be willing to participate in these actions, which are currently still insufficient. Endorsing this observation, Carvalho (2007) found something similar in this context, noting also the absence of channels capable of developing a dialogue and involving the population in the improvement of the basin. In this sense, Hojda et al. (2015) noted the inefficiency of the Alto Iguaçu and Upper Ribeira Basin Committee (COALIAR),

of which the Belém river basin is a part, in involving representatives of the residents and specifically addressing the problems of the basin. It suggests the idea that was also supported by Bollmann and Carvalho (2008), who defend that the creation of the Belém River Basin Committee can facilitate the negotiation of social and environmental conflicts. Therefore, the creation of the subcommittee of the Belém river basin is another important perspective for the basin, which can result in a more effective management of its problems and make the political involvement of the residents more apt. But beyond the prospect of improvement, urban water governance faces challenges that need to be overcome.

The social research carried out by Procopiuck and Rosa (2015) in the Belém river basin showed that about 89% of the population living in this basin understands that responsibility for conservation must be shared between the government and the population. Nevertheless, in the Belém river this has not happened in the planning, which includes the stage of monitoring, nor in the management. A contextualization of this fact occurs in the monitoring phase of water quality, which is essential both for planning and for the management of water resources. This phase is centralized by the local environmental agency, the Environmental Institute of Paraná (IAP). The Belém River has seven monitoring points that are part of the IAP sampling network, which are monitored three times a year (IAP 2009), although CONAMA Resolution No. 357/2005 (CONAMA 2005) requires at least six annual samplings. In addition, the Monitoring Program of the Belem River conducted by PUCPR in 2006 showed the need to monitor at least 23 points to obtain an adequate diagnosis in relation to the quality of the waters of this basin. These facts demonstrate the inability of the IAP to meet the legal conditions regarding the monitoring stage, even though it is one of the best structured Brazilian environmental agencies.

Decentralization of the environmental monitoring of the quality of the waters of the Belém River can be an interesting alternative that allows a denser monitoring network and an annual frequency of sampling that meets the environmental legislation. Even reducing the high costs that these monitoring campaigns have for IAP. The decentralization of the environmental monitoring of the Belém river is a prominent alternative, because it is an urban river that shelters a large part of the population of Curitiba. But a voluntary program of environmental monitoring of water quality, following the United States Environmental Protection Agency (USEPA) model, is still a major challenge for the Brazilian case and for the Belém river basin. successful environmental governance, such as that of developed countries, that is induced by a government with consolidated and organized administrative structures. In addition, the context of the Belém river basin is under the aegis of a water resource management system that is flawed in decision-making processes.

According to Bracht (2008), who specifically studied the case of the Belém river basin, it is influenced by failures of the national water resources management system. These failures mean that even the minimum that is established by the regulatory instruments is not effectively fulfilled. According to Bracht (2008), this occurs because the Federal Constitution of 1988 establishes that there are no more municipal rivers as determined by the former Water Code, in contrast, it defines that land use and occupation management is a responsibility municipal. This makes the manage-

ment of water resources more difficult, especially in urban areas, since the planning unit for this subject, as determined by the National Water Resources Policy, is the river basin. In this context, Bracht (2008) considers that the high levels of pollution in the river basin of the Belém River are related to these failures in the management of water resources. Thus, considering the national context and that of the Belém river basin, the overcoming of sectoral public policies is one of the emerging challenges in the management of water resources.

The sectoralization of public policies causes a conflict of competences between union, state and municipality, which directly affects the quality of the Belém river basin. However, besides the government, the proactivity of civil society is also an essential factor. From the standpoint of sustainable rainfall drainage, Bertolino et al. (2016) shows that, in addition to government structural measures, other individual population initiatives would also be needed. In the meantime, the government should provide a public rainwater drainage system that is less impacting to the hydrological cycle—with ditches, infiltration trenches, permeable floors, etc.—civil society must also contribute to this end. The use of rainwater, the use of permeable floors and green roofs are individual ways to contribute to sustainable drainage. But this is still a great challenge since the Brazilian population has low levels of environmental awareness and proactivity.

6 Conclusion

As observed throughout the work, the basin of the river Belém is currently in an advanced degradation process. The inadequate use of the basin over the years has made it polluted and contaminated, directly affecting the quality of life of the population of its surroundings and, consequently, the society of Curitiba in general. In this sense, the article sought to emphasize environmental governance as an important instrument to be used for the management of water resources in the urban environment. In the specific case of the Belém river, it was possible to identify some of the main perspectives and challenges related to management based on environmental governance.

Regarding the perspectives, it was observed that the consolidation of efficient management depends on a series of factors involved in governance, the main ones being: (1) the creation of a cooperative or association for garbage collectors, improving the social status of this category and to mitigate the waste input in the Belém river basin; And (2) the creation of a subcommittee of the Belém river basin, which may result in more effective management of its problems and make the political involvement of the residents more apt. With these alternatives, it is possible to aim at creating economic policies that ensure adequate quality of life and the enhancement of natural resources, appropriate environmental policies with efficient execution, qualified and forward-thinking residents, among others, always resulting from efficient governance.

Regarding the challenges presented, it was noticed that the main contributions of governance are related to: (1) decentralization of environmental monitoring of the quality of the waters of the river Belém, enabling a dense monitoring network and an annual frequency of sampling that meets the legislation environmental; (2) overcoming sectoral public policies; (3) greater environmental awareness and proactivity of society in general in applying alternatives that diminish the impacts caused to that basin.

The application of governance instruments emerges as a way of optimizing the management of water resources located in urban areas. Involving all those interested in the best use and conservation of these resources and subsidizing the public power in actions to regularize these spaces, mitigation of socio-environmental impacts and improving the quality of life of the municipal population as a whole. Therefore, it is understood that, with appropriate management tools, it is possible to reduce vulnerability and, at the same time, contribute to improving the quality of life and conscious use of the Belém river basin.

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Urban Management: Learning from Green Infrastructure, Socioeconomics and Health Indicators in the Municipalities of the State of Paraná, Brazil, Towards Sustainable Cities and Communities

Luciene Pimentel da Silva and Fábio Teodoro de Souza

Abstract The 2030 Agenda for Sustainable Development included universal access to health care and well-being. However, the massive growth of cities and the reduction of vegetated areas induced imbalances in the environment. Green spaces reduce environmental stressors such as heat waves, air and noise pollution. Nonetheless, late-year Reports by WHO-Europe demonstrated that there is some controversy about the benefits of green spaces. This paper discusses results of a pilot study involving socioeconomic data and built environment indicators, including green infrastructure, as well as morbidities of respiratory and circulatory diseases for the 399 municipalities of the State of Paraná, as well as a data mining approach to extract rules to associate morbidities with said indicators. Results showed high variability in the values of such indicators. Hierarchical tree analysis and non-hierarchical k-means technique grouped the same variables into two clusters, one of which formed only by the morbidities. Main component analysis resulted in four factors that explain about 70% of the variance of the original variables. The mining of associative rules was encouraging but further research is necessary, probably looking into other data extracts such as geography, age and gender. These outcomes may support urban planning and policies to enhance urban quality of life.

Keywords Green infrastructure · Respiratory diseases · Circulatory diseases · Paraná · Data mining

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1 Introduction: Urban Built Environment Indicators and Human Health

The built environment, mainly in urban areas, affects ecosystems, ecosystem services, human health and the well-being (Koren and Buttler 2006). Souza and Rabelo (2015), Cardoso and Souza (2017) and Souza (2018) have been studying, mainly in the metropolitan area of the city of Curitiba, Brazil, relations between air pollution and morbidity of respiratory diseases. They have been applying data mining techniques to extract modeling rules and obtained accuracies of up to 100% on predicting morbidities up to two months in advance. These studies may help advance urban environmental planning, air pollution control, and may improve public policies towards sustainability.

Green infrastructure is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, recreation space and climate mitigation and adaptation (EUROPEAN COMMISSION). These public spaces materialize in squares, parks and planned gardens; forest reserves and fragments of original or secondary forest; woods; afforestation of the streets; to name a few. Other innovative ways of inserting these green spaces in urban areas, especially with the function of controlling surface runoff and pollution, are also observed (Fletcher et al. 2014). Some examples are sidewalks that allow infiltration; wells and ditches for infiltration and bio-retention; and, green walls and roofs. There is a renewed interest in these green spaces in urbanized areas for a more comprehensive environmental perspective associated with urban management towards sustainable development (Kowaric 2013; WHO 2016, 2017). The positive externalities of the green infrastructure are strongly associated with psychological aspects and the mitigation of environmental stressors in urban spaces, such as air and noise pollution, and heat waves (Markevych et al. 2017; Nowak et al. 2018). These environmental stressors are related to human health, especially mental disorders, gradual hearing loss, respiratory and circulatory diseases.

Although there is a consensus on the positive externalities that vegetation exerts on environmental stressors in urban areas, the establishment of objective associative or quantitative relationships that relate green spaces to morbidities and mortality by urban diseases does not present sufficient scientific evidence, or is controversial. The extraordinary growth of urban populations during the twentieth century and the projections for the 21st century and the phenomenon of global warming are also responsible for the interest in positive and negative externalities of the approximation of the urban population to these green spaces.

There is evidence in the literature of the positive impacts of the presence of green spaces on human health, especially for relaxing, talking walks, doing physical exercise and socializing, which add benefits to both physical and mental health (Suppakittpaidarn et al. 2017). The green infrastructure also promotes the enhancement of spaces. Neighborhoods with more parks, squares and other green areas tend to have higher market values (Wolch et al. 2014). The issues of energy consumption in

urban centers and the increase in the frequency of natural disasters caused by climate change are also included in such studies.

Vegetation promotes the naturalization of urban environments, recovers the natural cycles of water, mitigates the phenomenon of heat islands, contributes to recovering the original rates of rainwater infiltrations, reduces runoff and promotes flood control. Obtaining associative or quantitative relationships between green spaces and health can indicate better ways to plan the urban space, promote more objective metrics for said planning, and contribute to better health and municipal management, with impacts on the quality of life and optimization of the use of public resources. However, associating and quantifying the importance of each of these factors alone or in groups is a great challenge (Suppakittpaidarn et al. 2017; Amato-Lourenço et al. 2016).

The purpose of this study was to evaluate qualitatively the association between socioeconomic and built environment indicators, including green infrastructure, and morbidities of respiratory and circulatory diseases in municipalities of the State of Paraná in the form of a pilot study.

2 Materials and Methods: Municipalities of Paraná, Data Sources, Data Mining

Study area Paraná is one of the 26 Brazilian States. It is composed of 399 municipalities of a total of 5570 in Brazil, and is located in Brazil's Southern region (Fig. 1). The total population in the state was 10,444,526 inhabitants in 2010 (IBGE 2010), the sixth in Brazil, which corresponds to about 5% of the total population of the

Fig. 1 The State of Paraná, Brazil, IPARDES. (IPARDES. Paraná in Figures. Available at http://www.ipardes.gov.br/index.php?pg_conteudo=1&cod_conteudo=3. Access on November 18. 2018.)

country. Of its total population about 85% live in urban areas. More than 40% of the total population of Paraná are concentrated in 10 municipalities: Curitiba, the main city [Latitude South 25° 25′ 40″, Longitude West 49° 16′ 23″ and altitude of 934 m (IPARDES 2018)], Londrina, Maringá, Ponta Grossa, Cascavel, São José dos Pinhais, Foz do Iguaçu, Colombo, Guarapuava and Paranaguá.

According to the KÖPPEN classification, the North, West, part of the Central and Southeast regions, as well as nearly all of the Southwest region of the State of Paraná are under subtropical climate (Cfa), with average temperatures under 18 °C in the coldest month, and above 22 °C in the warmest, with hot summers, infrequent frosts, and rainfall mainly in the summer, although there is no well-defined dry season. This is the case of the Municipalities of Londrina, Maringá, Cascavel, Foz do Iguaçu and Paranaguá. Meanwhile, about half of the Central, Southeast and South regions of the State are under temperate climate (Cfb), with average temperatures under 18 °C in the coldest month, fresh summers, with average temperatures under 22 °C, without a defined dry season. This is the case of Curitiba (main city), Ponta Grossa and Guarapuava (Alvares 2013).

The State of Paraná is the fifth largest economy of the Country. It is home to the Itaipu dam, which set a world record in power generation in 2016. Agribusiness is very relevant in Paraná and the dairy and meat production adds important industrial value to its economy. Paraná ranks among the top ten Brazilian exporting states. The municipal average Gross Domestic Product of Paraná was 26,058 BRL in 2015 (equivalent to about 6950 USD on November 15, 2018). The Human Development Index (HDI) was 0.749 in 2010, above the country's average of 0.699 (IPARDES; IBGE 2010).

Circulatory diseases are the main cause of death in the world. Although in Brazil rates have been decreasing in the last decades, it is still the main cause of death. In 2016, circulatory diseases (CID-10 IX) were the second cause[1] of morbidity in the State of Paraná. In relation to respiratory diseases (CID-10 X), the Southern region of Brazil presents the highest morbidity rates, and Paraná, one of the three states in this Region, generally presents the highest rates, in some years superseded by the State of Rio Grande do Sul. In 2016, respiratory diseases were the third cause of morbidity in the State of Paraná (Paraná 2017).

Variables and Data Sources Box 1 presents all variables applied in the study, their description and sources. The studies involved variables such as: demographic density (DD), gross domestic product (GDP), municipal Human Development Index (M_HDI), percentage of households with adequate sanitation (SNT), percentage of urban households in streets with trees (ARB), percentage of urban households in streets with urbanization (URB), number of vehicles (VHCLS), morbidity of respiratory diseases (RD) and morbidity of circulatory diseases (CD) per municipality in the State of Paraná.

These data are from National-reference databases such as the "IBGE@Cidades" of The Brazilian Institute of Geography and Statistics, The National Department of Transit of The Brazilian Ministry of Cities, and "TabNet/DATASUS" of The Brazilian

[1]The first cause of morbidity was pregnancy, childbirth and puerperium (CID-10 XV).

Ministry of Health. IBGE@Cidades synthesizes information about Brazilian States and Municipalities, including indicators, research reports, infographics and maps. These values are mostly based on or derived from the last census survey dating back to 2010. The number of vehicles is based on the number of licenses issued each year and includes all types of vehicles such as automobiles, buses, trucks, tractors, motorcycles, and tricycles. The morbidity data of respiratory diseases (CID-10 Chapter X) and circulatory diseases (CID-10 Chapter IX) were extracted from TabNet—DATASUS, and include both emergency and elective care in 2010 (by selecting all months).

"ARB", the percentage of urban households in streets with trees, surveyed in the 2010 census, was taken as the green infrastructure indicator. GDP was taken per capita. The rates per 1000 inhabitants were taken for vehicles and morbidity of respiratory and circulatory diseases.

Variables analysis The variables analysis was performed by calculating descriptive statistics such as the average, minimum, maximum, variance, standard deviation, standard error and Pearson's coefficient of variation, as well as the histogram for each variable. Moreover, the matrix of linear correlation was calculated and data mining techniques were performed by multivariate analysis. The multivariate analysis included two clustering methods, as well as the factor and main components searching.

The hierarchical tree diagram (dendrogram) and k-means were applied for clustering using Euclidian distances. Cluster analysis allows verifying which variables have the same characteristics, classifying them into different groups.

Factor analysis allows identifying new variables that result from the linear combination of the original variables values. This results in a reduced number of variables without loss of information of the original variable values. Given that "m" are components of "p" variables X ($m \leq p$), the main components (MC) that result from linear combinations of the original variables are given by:

$$\begin{aligned} MC_1 &= a_{11}X_1 + a_{21}X_2 + \cdots + ap_1X_p \\ MC_2 &= a_{12}X_1 + a_{22}X_2 + \cdots + ap_2X_p \\ &\cdots\cdots\cdots\cdots \\ MC_m &= a_{1m}X_1 + a_{2m}X_2 + \cdots + a_{pm}X_p \end{aligned}$$

The first main component (MC_1) is the one that best explains the variance of the original variables. The second component explains the maximum, not fully explained by the first component (MC_1), and so on. The main component "m", MC_m, is the one that contributes the least to explaining the total variance of the original variables, not explained by the previous components. The chosen main components were the ones whose eigenvalues together explained at least 70% of the original variables, described in Box 1.

Box 1 Variables Description

Name	Metric units	Description	Source
DD	Total population/km^2	Demographic density	IBGE@Cidades Census 2010
GDP	GDP/per capita	Gross domestic product (per capita) 2015	IBGE@Cidades
M_HDI	Index varies between 0 and 1.0	Municipal human development index	Compiled from ATLAS BRASIL (IBGE Census 2010)
SNT	%	Percentage of households with adequate sanitation	IBGE@Cidades Census 2010
ARB	%	Percentage of urban households in streets with trees	IBGE@Cidades Census 2010
URB	%	Percentage of urban households in streets with urbanization adequada	IBGE@Cidades Census 2010
VHCLS	Total/1000 inhabitants	Number of Vehicles per 1000 inhabitants	DENATRAN (2010)
RD	Total/1000 inhabitants	Morbidity of Respiratory Diseases CID-10 X	TabNet/DATASUS/Ministry of Health (2010)
CD	Total/1000 inhabitants	Morbidity of Circulatory Diseases CID-10 IX	TabNet/DATASUS/ Ministry of Health (2010)

Apart from these previous analyses, a first attempt was made to mine rules that would explain respiratory and circulatory morbidities through the socioeconomic and environmental variables, including the "ARB", the percentage of urban households in streets with trees, which was taken as the green infrastructure indicator. Morbidity levels were computed by considering terciles (low, medium, and high). The classification was based on the association rules algorithm "CBA", described in Liu et al. (1998). In the first step, the algorithm scans the whole data set to find a set of classification rules with strong support (union of input and output variables). Then, the algorithm applies this set of rules to predict morbidity and to validate the rules previously established. The result of the classifier validation is presented in a confusion matrix where the main diagonal shows correct classifications, and misclassifications are shown outside the diagonal. The correct classification rules measure the level of accuracy, which is given by the sum of the correctly classified samples divided by the total number of instances sampled.

3 Results and Discussion: Descriptive Statistics, Linear Analysis, Cluster Analysis, Factor and Main Component Analysis, Classification Models

Descriptive Statistics Table 1 shows the descriptive statistics for all variables. Except for M_HDI, all variables present a large range of variation, albeit rating some of them per 1000 inhabitants. The standard deviation of DD is greater than its mean, showing that DD is heterogeneous. The largest value of DD was 4.027,00, for Curitiba (the main city), while the smallest was equal to 3.31 for the municipality of Alto Paraíso, in the Northwest part of the State. The histogram (Fig. 2a) demonstrates that nearly 160 municipalities, out of 399, have demographic densities ranging from about 19 to 35 inhabitants per square kilometer. Considering the two most frequent ranges of DD, about 70% of all municipalities have demographic densities ranging from about 3 to nearly 35 inhabitants per square kilometer. If a threshold of DD is established as 35, above this value, municipalities' demographic density seems to be better distributed. The largest Pearson's coefficient of variation (PCV) is for demographic density (DD), followed by the percentage for sanitation (SNT), which is 84.08%. As expected, the smallest PCV value is for M_HDI.

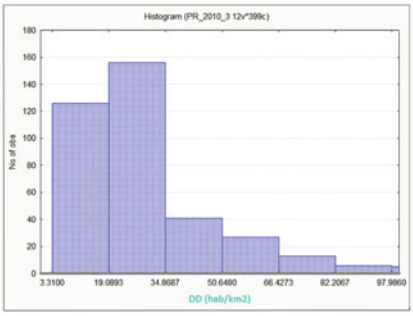
Regarding arborization (ARB), which is taken as the green infrastructure indicator, about half of the municipalities fall into the 90–100% class. The maximum arborization rate, 100%, was found for the municipalities of Arapua, Lobato, Miraselva, Santa Fé and Santa Inês, located in the Mid-North Mesoregion of the State of Paraná, and for Guaporema, Indianopolis and Nova Aliança do Ivaí, located in the Northwest Mesoregion of the State. These are all classified as small I[2] municipalities

[2]The Brazilian Institute of Geography and Statistics (IBGE) classifies Brazilian municipalities according to their total population into:

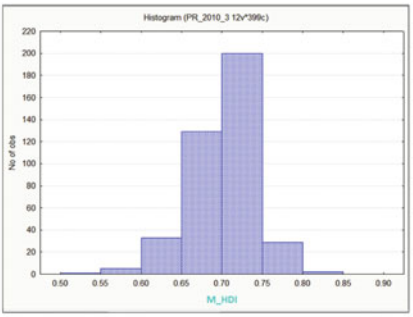
Small I. up to 20,000 inhabitants.

Table 1 Descriptive Statistics for all variables

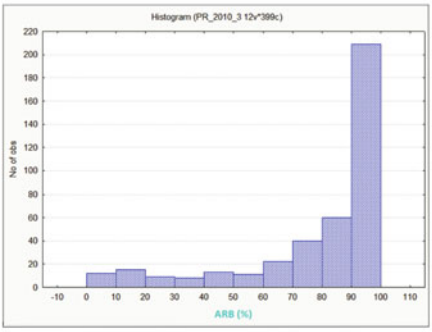
Variables	Valid N	Mean	Minimum	Maximum	Variance	Std. dev.	Standard error	PCV (%)
DD (inhab./km^2)	399	62.07	3.31	4027.00	57682.00	240.17	12.02	386.93
GDP (BRL)	399	26058.72	9904.09	114153.00	151145416.00	12294.12	615.48	47.18
M_HDI	399	0.70	0.55	0.80	0.0015	0.04	0.00	5.71
SNT (%)	399	32.42	0.60	97.20	743.00	27.26	1.36	84.08
ARB (%)	399	79.30	0.80	100.00	667.00	25.82	1.29	32.56
URB (%)	399	33.76	0.00	91.90	471.00	21.71	1.09	64.31
VHCLS (total/1000 inhab.)	399	390.46	47.14	712.40	9626.00	98.11	4.91	25.13
RD (total/1000 inhab.)	399	18.43	1.82	73.30	142.00	11.93	0.60	64.73
CD (total/1000 inhab.)	399	11.77	2.44	39.90	24.00	4.90	0.25	41.63



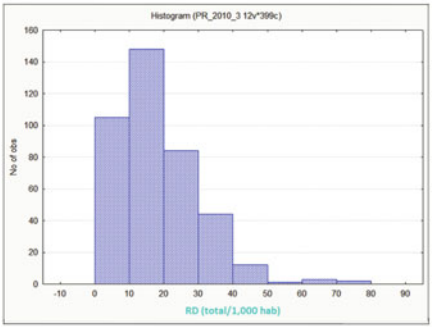
(a) Demographic Density (DD) inhab./km^2



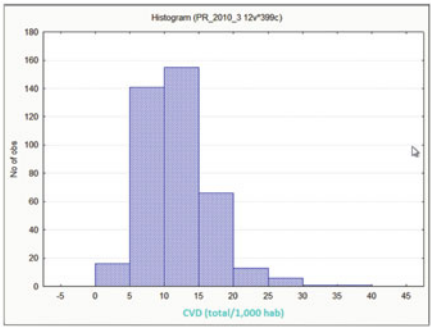
(b) Municipal Human Development Index (M-HDI)



(c) Arborization (ARB) in %



(d) Respiratory Diseases Morbidity (RD) per 1,000 inhab.



(e) Circulatory Diseases Morbidity (CD) per 1,000 inhab.

Fig. 2 Histograms. Socioeconomic, green infrastructure and morbidity indicators for municipalities of the State of Paraná

with less than 20,000 inhabitants. The municipality with the least arborization was Campina do Simão.

The total morbidity of respiratory diseases (RD) per 1000 inhabitants in the state is higher than that of circulatory diseases (CD). The maximum number of morbidities of RD per 1000 inhabitants is nearly double the morbidities of CD. Although PCV for both RD and CD are high, the standard deviation is not so high, and the histograms, Fig. 2d, e, shows a better distribution of values than for DD and ARB. For RD, nearly 250 municipalities present up to 20 cases of morbidity per 1000 inhabitants. Meanwhile, for CD, more than 300 municipalities present up to 15 cases.

Linear correlation Linear correlation was the first multivariate analysis performed. Before processing, the multivariate analysis variables were standardized. This avoided the influence of the magnitude and different measured units among variables (Vicini 2005). The whole matrix consists of 9 variables (as described in Box 1) and 399 instances (number of municipalities in the State of Paraná). There were no missing values. A linear coefficient near +1 or –1 represents a perfect positive or negative linear correlation, respectively. Table 2 presents the matrix of linear coefficients of correlation between indicators. The diagonal is always 1 (one) and shows the linear coefficient of correlation between the same variables. VHCLS and M_HDI showed the highest linear coefficient of correlation, followed by the one between RD and CD; in both cases it was positive. The higher the municipal human development index, the more vehicles; and the higher the number of morbidities of respiratory diseases, the higher the number of morbidities of circulatory diseases. The linear coefficient of correlation was negative between M_HDI and morbidities of respiratory and circulatory diseases.

The green infrastructure indicator (ARB) presented a negative linear correlation with DD: the more inhabitants per square kilometer, the lower the number of urban households in streets with trees. Meanwhile, it was positive between green infrastructure and morbidities of respiratory diseases: the greater the arborization, the higher the number of morbidities of respiratory diseases. Both RD and CD presented a negative linear correlation with sanitation and urbanization: the higher the sanitation and urbanization, the lower the number of morbidities of respiratory and circulatory diseases. It was unexpected that, although with a low value, VHCLS presented a negative correlation with the morbidities of respiratory diseases.

Cluster Analysis Figure 3 shows the dendrogram resulted from the hierarchal tree clustering analysis, built considering the single linkage of the amalgamation rule and Euclidean distance as the distance measure. The Y-axis and the vertical lines represent the unified groups by descending order of similarity. The lines along the X-axis indicate the distance between the formed groups. The dendrogram should be interpreted from the top to the bottom. Two distinct "branches" are observed in Fig. 3: Group 1 (G1), formed by DD, GDP, M_HDI, VHCLS, URB, ARB, SNT, and

Small II. Between 20,001 and 50,000 inhabitants.
Medium. Between 50,001 and 100,000 inhabitants.
Large. Between 100,001 and 900,000 inhabitants.
Metropolis. Above 900,000 inhabitants.

Table 2 Matrix of linear coefficients of correlation

Variables	DD (inhab./km^2)	GDP (BRL)	M_HDI	SNT (%)	ARB (%)	URB (%)	VHCLS (total/1000 inhab.)	RD (total/1000 inhab.)	CD (total/1000 inhab.)
DD (inhab./km^2)	**1**	0.11	0.26	0.27	−0.05	0.07	0.23	−0.11	−0.11
GDP (BRL)		**1**	0.38	0.23	0.06	0.15	0.37	−0.03	−0.09
M_HDI			**1**	0.3	0.29	0.43	0.75	−0.15	−0.07
SNT (%)				**1**	−0.17	0.07	0.27	−0.13	−0.11
ARB (%)					**1**	0.43	0.29	0.11	0.05
URB (%)						**1**	0.41	−0.13	−0.01
VHCLS (total/1000 inhab.)							**1**	−0.01	0.01
RD (total/1000 inhab.)								**1**	0.45
CD (total/1000 inhab.)									**1**

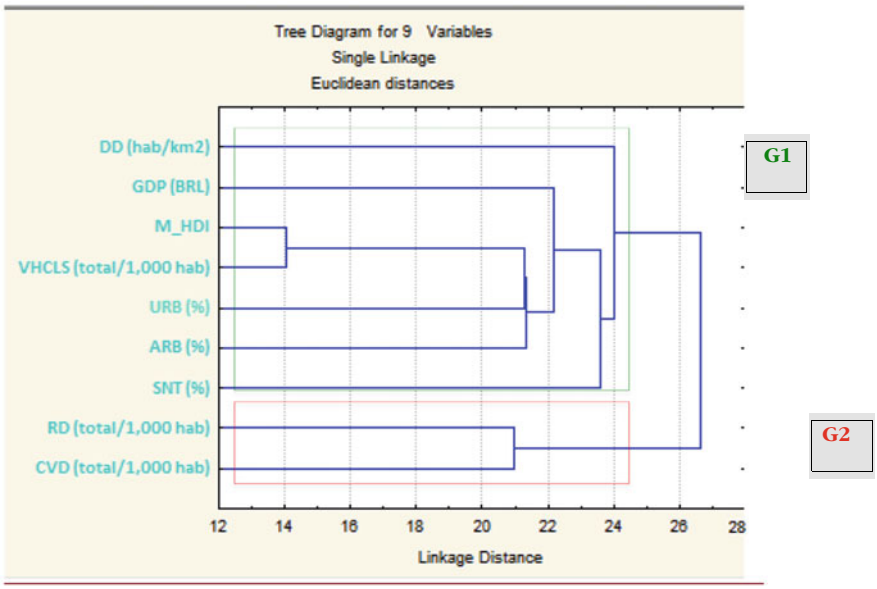


Fig. 3 Cluster Dendrogram

Group 2 (G2), formed by RD and CD. M_HDI and VHCLS are the variables that maintain the best similarity, as they pursue the least Euclidean distance. These two variables also presented the highest linear coefficient of correlation.

Table 3 shows that cluster G1 groups have the same variables as the dendrogram. As a result, these variables will be used as input for mining the classification model for RD and CD described in the "Data modeling" section.

Table 3 K-Means: Members of each cluster

Members of each cluster			
Cluster 1		Cluster 2	
Variables	Distance	Variables	Distance
DD (inhab./km^2)	0.90	RD (total/1000 inhab.)	0.52
GDP (BRL)	0.83	CD (total/1000 inhab.)	0.52
M_HDI	0.61		
SNT (%)	0.89		
ARB (%)	0.91		
URB (%)	0.79		
VHCLS (total/1000 inhab.)	0.63		

Factor and main component analysis Table 4 presents the results for factors 1, 2, 3 and 4. These explain 71.78% of the total variance of the original (standardized) variables. The first factor explained about 30% of the variance. The maximum number of factors was set to 9 (equals the number of variables). In Table 4, marked correlations (italics cells) are significant at $p < 0.05$. The highest loads in the first factor were for the municipal human development index and the number of vehicles per 1000 inhabitants. In the second factor, the highest loads were for morbidity of circulatory and respiratory diseases per 1000 inhabitants, and for arborization. In the third factor, the highest loads were for sanitation, arborization and urbanization, while, in the fourth factor, the highest loads were for demographic density and the gross domestic product (per capita).

Classification Models Box 2 presents the confusion matrix for the extraction of associative rules for morbidities of respiratory (a) and circulatory (b) diseases, respectively. The main diagonal shows the correct classification, and misclassification is shown outside the diagonal. The accuracy of the model (correct classification rate) is the sum of the correct classified samples divided by the total number of samples in the validation.

Regarding RD, the sum of the main diagonal ($61 + 26 + 105 = 192$), divided by the total number of instances (399) then multiplied by 100, gives the correct classification rate (CCR) of 48.12%. Then, the overall error is 51.88%. In the case of CD, CCR was equal to 47.12% and overall error is 52.88%. In both cases, the accuracy was less than 50%, which can be considered low, meaning the established rule would fail for more than half of the municipalities.

Regarding the association of morbidities of respiratory diseases and the green infrastructure indicator, two rules were identified (Box 3).

Table 4 Factor and main components

Variables	Factor1	Factor2	Factor3	Factor4
DD (inhab./km^2)	*0.39*	*0.36*	*0.28*	*0.63*
GDP (BRL)	*0.54*	0.08	*0.25*	*−0.64*
M_HDI	*0.87*	−0.06	0.04	−0.02
SNT (%)	*0.43*	*0.45*	*0.45*	0.04
ARB (%)	*0.4*	*−0.61*	*−0.41*	0.1
URB (%)	*0.62*	*−0.3*	*−0.38*	*0.17*
VHCLS (total/1000 inhab.)	*0.84*	*−0.17*	*0.14*	−0.03
RD (total/1000 inhab.)	*−0.21*	*−0.63*	*0.54*	−0.02
CD (total/1000 inhab.)	*−0.16*	*−0.64*	*0.51*	*0.16*

Box 2 Confusion Matrix for Morbidity of Respiratory Diseases Modeling

```
Overall Error: 51.88%
Confusion Matrix On Training:


(1)     (2)     (3)          < ---- Classified As
----    ----    ----
61      16      52           (1): RD_>_22
30      26      49           (2): RD_<_10
45      15      105          (3): 10_<_RD_<_22
```

Box 3 Rules for Arborization and Morbidity of Respiratory Diseases

```
Rule 3:
        ARB_>_96 = Y (A)
        SNT_<_12 = Y
        THEN  ->      Class = 10_<_RD_<_22 (B)
        (14.286% 52.632% 57 30 7.519%)

Rule 4:
        ARB_<_80 = Y (A)
        GDP_<_20000 = Y
        THEN  ->      Class = 10_<_RD_<_22 (B)
        (13.784% 50.909% 55 28 7.018%)
```

Results were similar for both rules, and also for the case of circulatory diseases. Taking rule 3 as an example, if arborization is over 96% and sanitation is below 12%, which is A, then morbidity of respiratory diseases per 1000 inhabitants lies in the medium tercile (10_ < _RD_ < _22), which is B. Of all times that (A) occurred in the database, (B) might also have occurred; therefore, this rule has a 52.632% (30/57 times 100) confidence. The best would be 100%. Support was 14.286%, which means that in 14.286% of all instances (57 times), A and B occurred together. Support is the result of (A ∪ B). And 7.519% of all instances (30 times) would be associated to the result of (A ∩ B).

4 Conclusions: Classification Models Support Planning and Public Policies for Urban Environment Towards Sustainability

This study demonstrated the potential of data mining techniques to extract information of fairly easily available municipal indicators, such as demographic density (DD), Gross Domestic Product (GDP), Municipal Human Development Index (M_HDI), percentages of households in streets with adequate sanitation (SNT), with trees (ARB) and with urbanization (URB), and also the number of vehicles (VHCLS) and morbidities of respiratory (RD) and circulatory (CD) diseases, responsible for high rates of causes of death and hospitalizations in the State of Paraná and in Brazil. This can help establish better urban management practices and reinforce some public policies.

The variable that showed the largest variability was DD and the one with the least variability was M_HDI. Most of the municipalities in the State of Paraná are classified as small, with up to 50,000 inhabitants, and 70% (about 280 of 399) of the municipalities presented DD equal to 3 to about 35 inhabitants per square kilometer. Meanwhile, the density of the largest cities in Paraná—Londrina, Maringá and Curitiba (main city)—was 306.52, 733.14 and 4027.04 inhabitants per square kilometer, respectively; whereas Rio de Janeiro and São Paulo, the largest in the country, counted 5265.82 and 7398.26 inhabitants per square kilometer, respectively, in the same census of 2010. This revealed the importance of the standardization of variables to proceed with the linear and other multivariate analysis.

Except for M_HDI and VHCLS, which presented a positive linear coefficient of correlation equal to 0.75, all the other coefficients were below 0.50. But some negative coefficients of correlation such as both morbidity rates with DD, GDP, M_HDI, SNT and URB were noticed. This might prove a return on investments in sanitation and urbanization. However, no significant linear correlation was observed between arborization and other variables, except with DD. This means there is a decrease in the number of urban households in streets with trees, as urban occupation density increases. RD and DD showed to be positively correlated. Also, the cluster analysis, both hierarchical (logic tree) and non-hierarchical (k-means), grouped both rates of morbidities in the same cluster, and the other variables in another cluster. It indicates that morbidities might be explained by such variables. Regarding the main component analysis, it was found that four factors explain 71.78% of the variance of the original (standardized) variables. The green infrastructure indicator (ARB) showed the best load in factor 2, aligned with RD and CD.

Although results of multivariate analysis were encouraging, the classification model, however, did not reveal rules with high accuracy and support. The analysis should be deeper, considering climatic variables, seasonality, sub populations, different ranges of ages and genders, or excluding highly correlated variables, as well as other hotspots to study urban management issues such as different mesoregions and metropolitan areas. Other modeling attempts might also involve extracting rules of the main components instead of the original variables.

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Using Public Deliberation and Environmental Issues Forums to Achieve the 2030 Goals for Sustainable Development: A Case Study in Missouri, USA

Christine Jie Li, Christine Costello, Sara Thuston and Bora Simmons

Abstract The majority of Climate Scientists agree that mean global temperatures have risen since pre-1800 levels and that this change is human caused. However, public opinion polling in the United States suggests many are not convinced, questioning the scientific consensus about climate change. To achieve the 2030 sustainable development goals, active participation of citizens, universities, and governments is necessary to move toward a climate-friendly, socially resilient and economically viable society. In collaboration with the Kettering Foundation, the North American Association for Environmental Education developed the—Environmental Issues Forums (EIF). The goal is to test EIF as a model for enhancing public deliberation and understanding on climate change, water, and energy. We conducted six forums at three study sites: the Columbia Public Library, the Calvary Episcopal Church, and the University of Missouri. This study addressed three research priorities: (1) participants' motivations for and perceptions of community-based forums focusing on climate change, (2) the effects of EIF forums and deliberation on fostering community-based solutions and sense of hope, and (3) what actions participants value to mitigate and adapt to climate change. The results suggest that participation in an EIF deliberative forum was an effective model to build a constructive conversation around community-based solutions.

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Keywords Deliberation · Climate change · Civic engagement · Sustainable development

1 Background

The majority (97% or higher) of Earth Scientists agree that mean global temperatures have risen since pre-1800 levels and that it this temperature increase is human caused (Cook et al. 2013; Doran and Zimmerman 2009; Oreskes 2004). However, among the public those that agree that the earth is warming due to human activities ranges between 16% among Republican conservatives, 38% among Republican moderates/liberals, 51% among Democratic conservatives/moderates and 77% among Democratic liberals (PEW 2012). Further, the public is far less sure that scientists agree that the "earth is getting warmer because of human activity" with only 30% of Republicans, 58% of Democrats and 45% of Independents answering "yes" to this question (PEW 2012). Closing the gap in understanding between expert and layperson about this important issue is critical for identifying solutions to managing both greenhouse gas emissions and adaptation response to climate change impacts. Further, Ding et al. demonstrated that misperception about scientific consensus is strongly associated with reduced levels of policy support and a belief that action should be taken (2011). Given that communication of facts alone has been shown to have limited impact on changing the minds of the public (Owens 2000), this forum takes the approach of creating dialogue and deliberation among non-experts. While many laypeople may still be on the fence about whether or not the climate is changing, many experts are directing efforts toward adaptation responses.

1.1 Civic Engagement Strategies

Engaging the public in solving environmental issues starts with community-based conversations. Jacobson et al. suggested five different types of outreach techniques as effective approaches to connect communities with conservation (2015). The five techniques include service learning, issue investigation, project-based learning, public participation in scientific research, and mapping. Strategies for civic engagement fall broadly into two categories: (1) those based on rationalist, 'information deficit' model, and (2) those owing more to a civic or deliberation model. The first category assumes that lay people are lack of knowledge in environmental issues and needs to learn how to prepare for risks: the public must be engaged in order to be better informed and converted to a 'more objective' view. The second category assumes that public perspectives might help not only to identify or implement solutions but to define, or reframe, what the problems actually are (Bulkeley 1999; Burgess et al. 1998; Jasanoff 1999; Macnaghten and Urry 1998; Thompson et al. 1998; Wynne 1996).

1.2 Deliberation Democracy

Deliberation democracy is a field of political inquiry that is concerned with improving collective decision-making. The deliberation democracy process values the openness that would allow people "to question assumptions about the roots and the character of environmental issues and the scientific understanding upon which analysis is based" (RCEP 1998 paragraph 7.22); alternatively, the community will remain effectively disengaged and disempowered. National Issue Forums and Kettering Foundation have developed a series of issue guides to promote public deliberation about difficult public issues. The issues guides cover a wide variety of topics, such as climate change, water, energy, safety and justice, higher education, and so forth. In collaborating with Kettering Foundation, North American Association for Environmental Education has developed a new initiative—Environmental Issues Forums (EIF). The first issue guide and program focuses on climate change—*Climate Choices*.

1.3 Hope Concerning Climate Change and Public Deliberation

To effectively engage people in problem solving and taking actions to address climate change, researchers studied the role of sense of hope and found that constructive hope had a unique positive influence on pro-environmental behavior (Ojala 2012). Given that many of the public deliberation programs are aiming to improve local civic capacity to solve critical issues through building stronger relationships, creating more productive decision making processes, and bolstering collaborative action, there is lack of research and evaluation studies that look at the effectiveness of deliberation process on fostering civic engagement competency and sense of hope. Thus, this study aimed at answering the following research questions.

2 Research Questions

1. What are participants' motivations and expectations for community-based forums, focusing on climate change?
2. What are the effects of EIF forums and deliberation on building hope regarding climate change? What do community members gain from participating in deliberative forums? To what extent does the deliberative forums affect participants' understanding and actions on climate change?
3. What actions do adults value the most to mitigate and adapt to climate change at the community level and personal level? What actions do youth value the most? Do youths think similarly or differently than adults on preference for action on climate change? How does this compare to climate change expert suggestions?

3 Methods

3.1 Issue Guide and Intervention Procedure

We used the *Climate Choice* issue guidebook for all five forums (National Issues Forums 2016). As suggested, the size for each forum was between 8 and 15 participants and each forum lasted 2 h. We followed steps suggested in the moderator guidebook with a neutral moderator and a discussion guide to presents several possible approaches to climate change to the group. The deliberation process focuses on three options: (1) Option 1—Sharply reduce carbon emissions; (2) Option 2—Preparing and protect our communities; and (3) Accelerate innovation. Option 1 suggests that we need to take aggressive action to reduce our energy consumption and other climate-changing behavior. Option 2 emphasizes that we should protect and prepare communities for the effects of climate change. Option 3 addresses that we must invest in rapid innovation to develop new, cleaner fuel sources, new ways to influence Earth's climate, and even new societal arrangements. Note that the forum does not create much room for debating anthropogenic activity induced climate change, rather the materials are intended to support discussion about what to do given that human activities have increased greenhouse gas concentrations to the point that the climate in changing. In deliberation, people examined the advantages and disadvantages of different options for addressing this issue, weighing these against the things they hold deeply valuable. The deliberative process involved the following steps.

1. Welcome: moderators introduced the program; participants completed the pre-forum questionnaire.
2. Ground Rules: participants and the moderators reviewed desired outcome and agree on ground rules.
3. Getting Started: moderators asked participants to take a few minutes to talk about their personal experiences with the issue and tell their stories. We asked people to describe how climate change is affecting them, their families, and friends. The moderators also showed the starter video provided by NIF that reviewed problems associated with climate change.
4. Deliberation: participants examined all the options and spent an approximately equal amount of time on each option. All thoughts and opinions were welcome. A note-taker was present to record key words on a large pad of paper or a white board for participants to view throughout the meeting.
5. Ending the Forum: participants reflect on what have been discussed.
6. Questionnaire: participants completed the post-forum questionnaire.

Table 1 EIF forums implemented in MO with specific locations, date, and type of participants

Study site	Forum locations	Type of participants	Date	Number of participants
1	Columbia Public Library	Adults	March 4, 2017	7
1	Columbia Public Library	Adults	April 18, 2017	12
1	Columbia Public Library	Adults	May 10, 2017	8
2	University of Missouri	Youth	July 12, 2017	11
3	Calvary Episcopal Church	Adults	Sept 24, 2017	8
3	Calvary Episcopal Church	Adults	Sept 25, 2017	13
				59

3.2 Study Site

We conducted total six forums in Columbia, MO from March to September 2017. We chose Columbia Public Library and Calvary Episcopal Church as our public forum sites because of its proximity to downtown Columbia to allow us attract a diverse audience. We also conducted a forum with a group of rising seniors from MO high schools who attended the Natural Resources Careers Academy in July 2017. The study followed the Institutional Review Board protocol at the University of Missouri (Table 1).

3.3 Evaluating Instruments

3.3.1 Survey for Adult Forum

The pre-survey had five questions: motivation (1 open-ended question), expectation (1 open-ended question), feeling (1 open-ended question), action (1 open-ended question), and hope concerning climate change (10 items). We used the Climate Change Hope Scale (CCHS) (Li and Monroe 2017) to measure the pre- and post-forum sense of hope among participants. The CCHS measured the hope with three factors: (1) collective-sphere willpower and waypower, (2) personal-sphere willpower and waypower, and (3) lack of willpower and waypower. The reliability and validity study indicated that the scale was reliable for use among high school students. The omega coefficient was between 0.75 and 0.83 for each of the three factors. The Cronbach's alpha was between 0.68 and 0.80 for each of the three dimensions. The post-survey

included five questions and a standard survey developed by National Issues Forums Institute (2015). The first four questions are open-ended on feeling, action, perceptions, and recommendation for the forum. The fifth question is the same set of 10 items on hope concerning climate change. We hypothesized the forum will increase participants' sense of hope significantly. The standard survey asked participants to rate from strongly disagree (1) strongly agree (5) on a set of policy suggestions (6 items), actions (9 items), and demographic questions (6 items).

3.3.2 Survey for Youth Forum

The survey for youth participants include 5 question from from American Teens' Knowledge on Climate Change (Leiserowitz et al. 2011) to measure the teens' prior knowledge about climate change the causes and consequences of climate change and the Climate Choices Participant Questionnaire (National Issues Forums 2016).

3.4 Data Analysis

For analyzing quantitative data, we used the descriptive and inferential statistics. We used the IBM SPSS version 24 to conduct the statistical analysis. We used percentage, mean, standard deviation, and dependent t-tests for comparing pre- and post-means on hope scores. We used a p-value of less than 0.05 for statistical significance. For analyzing qualitative data, we followed the steps suggested by Creswell (2007).

4 Results

4.1 Participants

Study site 1 served as pilot test study. Daniel Boone Library System delivered the invitation of climate change forums through their newsletter called *About Your Library* (n = 12,000). In total, we have recruited 27 adult participants in spring at study site 1 (Columbia Public Library), 11 youth participants by using *Climate Choices* in summer at study site 2 (University of Missouri campus), and 21 adult participants in fall 2017 at study site 3 (Calvary Episcopal Church). We administered the American Teens' Knowledge on Climate Change (Leiserowitz et al. 2011) to the youth group. In general, the majority of the participants believed that climate is changing and is mostly due to human causes. These groups had higher knowledge score than the national average, likely because these students applied to and were participating in an ecosystem conservation program. At study site 2, about 90% of the youth participants believed that climate change is happening. About 63% of them believe

that climate change is caused mostly by human activities. About 73% believe that most scientists think global warming is happening. All of them answered correctly on the definition of greenhouse gas effect (100%). On average, youth participants from study site 3 rated their knowledge about climate change is 3.17 ($SD = 0.54$; 1 = not at all informed; 4 = very well informed) prior to the forum. At study site 3, about 95% of the church participants believed that climate change is happening and about 42% of them believe that climate change is caused mostly by human activities. The majority of the church participants (85.7%) agreed that most scientists think climate change is happening. On average, participants from study site 3 rated their knowledge about climate change is 2.86 ($SD = 0.72$; 1 = not at all informed; 4 = very well informed) prior to the forum.

4.2 Motivations for Participation

We received 27 responses for the question "why did you want to participate in this climate change forum?" from adult participants. We examined the responses by using the intrinsic and extrinsic motivation (Deci 1971). All 27 responses fall into the intrinsic motivation in which they reported participating in the forums because they think climate change is an important topic; they come for its own sake rather than the desire for some external reward. Many people responded that they were there because they wanted to talk about how to find community-supported decisions, wanted to know what others thought. Because this is a voluntary event and adults have free choice to come to not to come, intrinsic motivation emerged as the driving force in this pilot phase. In general, people wanted to learn more about the issue, know how they work together with their fellow citizens to make a difference, and stay informed about local initiatives. People commented on:

- "I wanted to learn about climate change and local responses to the issue."
- "Voice concern of climate change and be active in the community."
- "I am curious to know my fellow citizens ideas and to work toward a community supported decision."

4.3 Expectations for Forums

We received 26 responses on the question "what did you hope to get out of the forum?" Participants wanted: (1) information on different ways to make a positive impact personally ($n = 8$); (2) information and data on climate change ($n = 7$); (3) information on how others feel about climate change ($n = 5$); (4) contact to new people and ideas about climate change ($n = 4$); (5) how to influence people to act in sustainable ways ($n = 3$); (6) to be more familiar with climate change initiatives in

the community ($n = 5$); (7) information on effects of climate change in farming in Columbia ($n = 1$); and, (8) not sure ($n = 1$).

4.4 Complex Feelings

When asked, "What is your feeling when you hear about climate change?" participants held complex feelings and the majority of them commented that they feel anxious about this issue but would like to take actions to address it (Fig. 1).

- "I am anxious because of the amount of inertia in society for climate, but also hopeful because of human problem solutions potentials."
- "I feel frustrated by the level of apathy in our government and society, but I am hopeful that I and others will be able to effect change in this community."
- "When I hear about climate change, I often feel overwhelmed and hopeless. It is such a huge overarching issue that feels impossible to solve."

After they participated the forums, most people felt that it is still a huge issue but they have more information and tools to help. They felt better and more optimistic that active discussion is occurring ($n = 21$). Some people still felt the same ($n = 6$).

- "I feel better and more optimistic that people are thinking about this."
- "I feel more familiar with difficult options on climate change."
- "I feel like it is a problem we can fix."

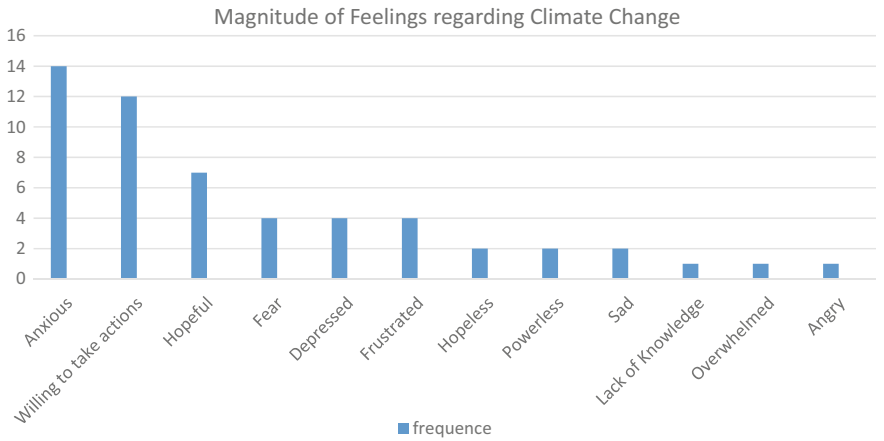

Fig. 1 The frequencies of different types of feelings emerged in the survey ($n = 26$, adults)

4.5 Collective Discussion Matters

Participants from all study sites commented that the deliberation process was very informative and they gain new insights and perspectives by listening to each. The discuss helps participants to not only gain a deeper perspective on the actions but also critical weigh them for pros and cons.

When asked, "Have you tried anything to address climate change in your home or community?" About 78% of them have already taken actions (recycle, bike, less consumption, energy efficient home, compost, not eat meat, volunteer, garden, buy organic and/local, and new technology). About 22% of participants have not be able to articulate anything but they are willing to make changes needed and needed information on what to do on the pre-forum survey.

On the post-forum survey, when asked, "Would you be willing to try anything new to address climate change in your home or community?" about 90% of participants said that they learned and are willing to try new things while one person responded that he/she is already doing what he/she can in the current time restrictions. The new actions include both personal level (solar power, unplug, participate in groups, energy audit, and reduce personal energy usage) and community level actions (sponsor a local event for climate change education, support and advocate for local climate policy).

4.6 Increase in Sense of Hope

We measured the sense of hope by using the Climate Change Hope Scale (CCHS) developed by Li and Monroe (2017). The range for the score is from 10 (minimum, strongly disagree) to 70 (maximum, strongly agree). At study site 1, we received 23 completed pre- and post-forum responses for this section and observed an increase on the mean score from pre-forum ($mean = 57.08$, $SD = 5.82$) to post-forum ($mean = 59.35$, $SD = 6.29$). At study site 3, we received 19 completed pre- and post-forum responses and observed an increase on the mean score from pre-forum ($mean = 52.31$, $SD = 11.80$) to post-forum ($mean = 56.11$, $SD = 10.47$). We used dependent t-tests to determine whether or not the increase is statistically significant. Table 2 show the mean differences on the statements from CCHS. Results show that the participants moved from slightly agree to agree on the statements that they think the society will be able to address climate change and they know what to do to help solve the problem. The increase is not statistically significant at $p = 0.05$.

Table 2 Comparison between pre- and post-mean score on the CCHS at study site 1

Statements	Mean[a] on Pre-Survey[a]	SD[a]	Mean[b] on Post survey[b]	SD[b]
1. I believe people will be able to solve problems caused by climate change	5.85	0.91	5.96	0.92
2. Even when some people give up, I know there will be others who will continue to try to solve problems caused by climate change	6.39	0.98	6.47	0.79
3. If everyone works together, we can solve problems caused by climate change	6.47	0.84	6.34	0.77
4. I am willing to take actions to help solve problems caused by climate change	6.60	0.65	6.56	0.78
5. I believe more people are willing to take actions to help solve problems caused by climate change	5.08	1.53	5.47	1.44
6. I know that there are things that I can do to help solve problems caused by climate change	6.13	0.86	6.21	0.79
7. I know what to do to help solve problems caused by climate change	4.60	1.4	5.52	0.89
8. Climate change is beyond my control, so I won't even bother trying to solve problems caused by climate change	6.34	0.88	6.04	1.06
9. Climate change is so complex we will not be able to solve problems that it causes	4.86	1.76	5.56	1.50
10. The actions I can take are too small to help solve problems caused by climate change	4.69	1.74	5.17	1.52
Total	57.08	5.82	59.34	6.29

Note
[a]$N = 23$ participants completed pre-survey on CCHS statements
[b]$N = 23$ participants completed post-survey on CCHS statements

4.7 Follow up Interview Results

We conducted follow up interviews with participants (response rate = 20.1%; $n = 10$) to further understand the impacts of the forums after 3 months. The results were split into two parts: (1) comments related to the forum process itself and (2) comments related to climate change action.

4.7.1 Comments Related to Deliberative Process

Participant 1 felt the content was well-balanced, had good visuals, and had good handouts. He liked that it was a small, intimate group (around 12 people). He felt everyone was able to speak and be heard because it was a small group. Participant 2 has a personal interest in climate change and believes it is an appealing topic. He thought the forum was OK and very informative. Attending the forum did not affect his feelings about climate change, but he claims it was very nice to talk to other concerned citizens. He feels discussion is positive. The forum added support to the direction he is already going regarding his feelings on climate change. It reinforced his current actions. Participant 3 attended the forum because she has personal interest in climate change and is very passionate about the subject, and affecting change. She thought the forum was great, and enjoyed the people who presented-she thought it was very informative. She suggests using microphones, because it was difficult to hear at some points. Being new to the community, she believes it is important to know how much the community cares, and she was happy with the results. Participant 4 decided to attend the forum because she felt helpless and shocked after the ongoing American political situations where there were cuts to the EPA and other events going on at the White House. She wanted a place to talk about the future and climate change. She enjoyed the forum, and thought it was a friendly atmosphere. She was in a group that was dominated by a few people, and wanted to be able to speak more. She suggests either a group moderator or procedure to ensure that everyone who wants to speak would be able to speak. She is willing to make big lifestyle changes in order to adapt to climate change. Participant 5 attended the forum because she is interested in climate change issues. She is an environmental activist. She enjoyed the forum, claiming it was a good community gathering of sharing ideas and talking to one another. She liked the Q & A setting. She claims she did not learn any new information regarding climate change, seeing that she is already an environmental activist.

4.7.2 Comments Related to Climate Change Action

Participant 1 believes that change happens when awareness spreads and the community is educated on the facts. He cared about the environment before attending the forum, and after cares the same amount, but now it is more at the forefront of his

attention. He believes we need representatives from the city to participate and be good leaders, and devote more resources to affect change-possibly with more education of the community. He claimed to be very optimistic about climate change, hoping that awareness spreads. He worries that until people are educated on the subject, nothing can change.

Participant 2 believes the most important action on climate change is mitigating public policy. He believes the community should be investing money and time into reducing our output of greenhouse gases so that we can "live without guilt." He claims he has a high willingness to change in order to adapt to climate change. He believes the community should be a leader in recognizing that climate change is human caused and that we need to be as aggressive as possible in educating and steering the community in the right direction. The City of Columbia council should integrate CO_2 and greenhouse gas emissions reductions in the annual job review for city operations. The City of Columbia initiated a city-wide Climate Adaptation and Action Plan since 2017. He is personally willing and optimistic about change, but after watching Al Gore's "An Inconvenient Truth," he is very pessimistic. He believes it is an inevitable reality.

Participant 3 believes that personal actions are the most effective action on climate change, with each person in the community taking action and making considerate choices. She is personally willing to make small and extreme changes in order to adapt to climate change. She believes that personal behavior and mindful decision making is important. For example, saying no to plastic bags and instead using reusable bags at the grocery store. She mentioned she would enjoy meeting more people in the community, if there was such an opportunity. She would like to see more interest group meetings, with more people coming together or more events held. She is overall very optimistic regarding climate change-she believes in people, especially people of the Midwest. As more people are educated on the subject of climate change, more people will start to care.

Participant 4 believes the most important adaptation to climate change is the community reducing its dependence on fossil fuels at a systematic level. At a personal level, she believes in making lifestyle changes like using less electricity and using shared transportation. She claims that the city needs to look at community needs that are area specific, while remaining sensitive to marginalized populations. She is optimistic about the future regarding climate change, but some days feels more realistically pessimistic. Current events and news shift her attitude towards climate change. She also mentioned "An Inconvenient Truth," and her concern about the population's capacity and will to do things and change. She is very optimistic regarding today's technology and research. Overall She enjoyed the forum, but concluded that everyone there was "preaching to the choir," and in order to affect change, we need to reach audiences that do not show up at forums, and educate these people.

Participant 5 believes that the most important aspect of fighting climate change is communicating with neighbors. It must be a group effort, and therefore the word needs to get out to the entire community. When asked about willingness to change and adapt to climate change, she claimed she is very willing to make big lifestyle changes. She wants for and is encouraged by the city council in committing to reducing carbon

emissions by 100% by 2050. She is currently working to reduce her carbon footprint in the home and at a personal level. Overall she is hopeful regarding climate change. Due to recent events and phenomena such as hurricanes put climate change in the media, which is helpful to the cause. She is hopeful that there will be change.

4.8 Adult and Youth Comparison on Climate Policy

Adult and youth participants hold very similar viewpoints regarding how they view the proposed climate change policy and action items (Tables 3 and 4). Both adult and youth strongly agreed that we should give companies incentives to develop technologies that reduce CO_2 emissions even if that means government interfering in the private sector. Both groups somewhat agreed that we should require states to lower their carbon emissions to meet federal standards, even if this eliminates some jobs and harms communities that rely on fossil fuel industries. Both groups less favor use zoning, building codes, forced relocation, and insurance rules to keep people from living and building in vulnerable areas like waterfronts, even if this would restrict what people can do with their land. However, youth and adult did not agree with each other on building levees, rebuild water systems, roads and transit to protect against flooding, even if these changes mar the landscape, and provide only limited protection ($t = -0.277$, $df = 23$, $p < 0.05$). Youth preferred more mitigation policy while adult preferred more adaptation strategies. Youth strongly agree that schools should teach children about the causes, consequences, and potential solutions to climate change and government should establish programs to teach Americans about climate change ($mean = 4.82$, $SD = 0.60$). Both groups strongly agreed that since the US is one of the world's largest greenhouse gas producers, it should take the lead in reducing emissions of CO_2. They somewhat agree that climate change will cause damaging changes for "my community and me in my lifetime." The majority somewhat agree the statement: "It's not possible to curb CO_2 emissions without much stronger governmental regulation and enforcement." They somewhat disagreed that taxpayers should not have to bail out people who choose to live in areas likely to be affected by sea level rise, wildfires, flooding and other problems caused by climate change. They both somewhat disagree with we should rely innovation and adaption—not regulation to address climate change. They both somewhat disagree that taking action to deal with climate change will seriously harm the US economy.

5 Discussion

From the six forums from three different sites, participants had considered EIF as an informative model and they appreciate the opportunity to talk aloud the issue in a safe space. The opinion leader from the local church played in an instrumental role in helping researchers recruitment participants.

Table 3 Comparison between youth and adult group on proposed climate policy

Statements	Mean[a]	SD[a]	Mean[b]	SD[b]	*t*-value
Give companies incentives to develop technologies that reduce CO_2 emissions EVEN IF that means government interfering in the private sector	4.45	0.69	4.21	0.89	0.74
Require states to lower their carbon emissions to meet federal standards, EVEN IF this eliminates some jobs and harms communities that rely on fossil fuel industries	4	0.89	4.36	0.63	−1.17
Increase the use of electric vehicles and redirect highway funds to create bike lanes, car-free zones and pedestrian-friendly neighborhoods, EVEN IF these actions will take a long time to produce any significant cuts in carbon emissions	3.91	0.94	4.29	0.61	−1.20
Encourage communities to build independent power grids and increase local agriculture EVEN IF it makes power and food more expensive	3.73	1.00	3.86	1.03	−0.31
Encourage Americans to use less energy by taxing fossil fuels, EVEN IF this burdens poor Americans by increasing the costs of necessities and commuting to their jobs	3.27	1.19	3.93	0.92	−1.56
Use zoning, building codes, forced relocation, and insurance rules to keep people from living and building in vulnerable areas like waterfronts, EVEN IF this would restrict what people can do with their land	2.82	0.75	3.5	1.16	1.69
Ease the rules for bringing new "green" technologies to the market EVEN IF there's a chance they could harm human health and safety	2.73	0.90	2.93	1.07	−0.49
Invest in finding new scientific methods to modify the climate EVEN IF the outcomes and negative consequences of such "geoengineering" are unknown	2.64	0.92	2.5	0.94	0.36
Build levees and rebuild water systems, roads and transit to protect against flooding, EVEN IF these changes mar the landscape and provide only limited protection	2.45	1.03	3.64	1.08	−2.77*

Note
[a]$N = 11$ Youth participants
[b]$N = 14$ Adult participants

Table 4 Comparison between youth and adult group on proposed climate actions

Statements	Mean[a]	SD[a]	Mean[b]	SD[b]	*t*-value
Schools should teach children about the causes, consequences, and potential solutions to global warming	4.82	0.60	–	–	–
Our government should establish programs to teach Americans about global warming	4.55	0.93	–	–	–
Since the US is one of the world's largest greenhouse gas producers, it should take the lead in reducing emissions of CO_2	4.27	1.19	4.79	0.43	−1.50
Climate change will cause damaging changes for me and my community in my lifetime	4.09	0.94	4.43	1.09	−0.81
It is not possible to curb CO_2 emissions without much stronger governmental regulation and enforcement	3.82	0.87	3.71	1.07	0.26
Taxpayers should not have to bail out people who choose to live in areas likely to be affected by sea-level rise, wildfires, flooding and other problems caused by climate change	2.82	0.98	2.36	1.01	1.15
We should rely on innovation and adaptation—not regulation—to address climate change	2.73	1.10	2.42	0.94	0.73
Taking action to deal with climate change will seriously harm the US economy	1.82	0.87	2	1.04	0.46

Note
[a]$N = 11$ Youth participants
[b]$N = 14$ Adult participants

The feedback was very positive as all of the responses like the open discussion, the quality of the guidebook (*Climate Choice*), the presenters, and the safe space to talk openly and express their concerns. They found that the discussion was helpful and examples were inspiring.

- "I liked the sharing of ideas on how climate change affects us and what we can do."
- "The information provided was easy to digest and discuss; I like the active discussion."
- "I appreciate the space to talk openly and express our concerns."

When asked, "How we can improve the forum?" participants would like (1) more suggestions for concrete action items to take place in the local area; (2) more time and follow up opportunities to for the region.

- "I would give more action items and discuss more attainable goals than just the 3 vague options. It would be better to discuss what we can do now, not just possible future options."
- "I would like to see more suggestions for concrete action to take place in Columbia."
- "I would give the booklet as a pre-reading material."

5.1 Recommendations

The EIF forums were initiated at three different sites and the majority of participants were white and Caucasian. While the researchers announce the forum through public library newsletter and other public venues, they were not able to reach out to a diverse group that holds different opinions on climate change. In future, researchers would like to reach out more church groups in the hope to reach out to more diverse ethnicity group. Researchers would like to contact church leaders from African American, Asian American, and Latino Churches. Researchers found that the congregation leaders play an instrumental role in defining a successful recruitment of participants. In reaching out to an ethnicity diverse group, language could be a barrier to host the forums as some church group will prefer use languages such as Spanish and Chinese. Researchers highly recommend the EIF lead team to consider translating the issue guide and video materials in other languages.

6 Conclusion

Environmental Issues forums allow the researchers to initiate an applied research process through deliberation and dialogue among citizens from local communities. The forums were effective at building participants' understanding, critical thinking,

and willingness to take personal and collective actions. The deliberation process is a successful model in building citizen competencies and enhancing social capita among local participants. Participants view the discussion is very informative and engaging. They expressed strong interests in holding the forum at their communities and help spread the word. The researchers would like to focus on engaging different type of participants, such as teachers, farmers, policy makers, K-12 students in using EIF *Climate Choice* as a model.

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Empowering Communities to Drive Sustainable Development: Reflections on Experiences from Rural South Africa

Rudi Pretorius and Melanie Nicolau

Abstract There have been several initiatives to address poverty and inequality since the dawn of democracy in South Africa in 1994. These initiatives are part of South Africa's National Development Plan, which aligns well to the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs). In terms of its mandate to engage with communities, the Department of Geography of the University of South Africa (Unisa) has been involved with the development and application of a community-based asset programme to empower people to drive their own sustainable development. This paper provides a critical reflection of the experience gained with the implementation of this programme in the villages of Koffiekraal/Brakkuil (Northwest Province, South Africa), with direct Unisa involvement from 2012 to 2016, and monitoring since 2017. The paper focuses on two initiatives of community empowerment identified during a community workshop in 2012, namely tourism and handicraft with Unisa subsequently providing comprehensive skills training. While focussing on the SDGs relevant to these two initiatives (No Poverty; Zero Hunger; Quality Education; Gender Equality; Decent Work and Economic Growth), this paper identifies the reasons why some intervention strategies were more successful than others and how strategies were subsequently adapted. Based on this experience, guidelines are presented that can be used during implementation of similar strategies towards community-based sustainable development, in different contexts and communities.

1 Introduction

In the publication "The Future We Want", which documents the outcomes of Rio+20, the clear verdict is that poverty reduction (preferably eradication) presents the single largest challenge faced by the world (UN 2012). Consequently the quest for sus-

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tainable development presupposes poverty reduction (Liu et al. 2015), and as such features prominently as the first Sustainable Development Goal (SDG1)—'End all poverty everywhere' of the 2030 Agenda (UN 2015). In this context a generalised view of poverty reduction applies, referring not only to income poverty, but also covering matters such as education, health, water and sanitation (i.e. multidimensional poverty), as expressed in SDG1 to SDG7 (Liu et al. 2015).

In South Africa significant progress has been made in addressing the challenges of poverty, unemployment and inequality since a democratically elected government came into power in 1994 (Fofana et al. 2018). Instrumental to this progress is South Africa's National Development Plan 2030 (NDP), that specifically aims at significantly reducing poverty, unemployment and inequality in South Africa by 2030 (National Planning Commission 2011). The NDP aligns well with the Sustainable Development Goals (SDGs). Dhlamini (2017) points towards the convergence between these two frameworks on matters related to people, prosperity, peace, planet and partnerships (the five P's). Despite the progress achieved to date, there is agreement that several issues have not yet been dealt with satisfactorily. Of concern is that vulnerable groups (women and children) continue to experience acute poverty (Fofana et al. 2018), while inequality continues alongside persistent high rates of unemployment and low rates of participation in the labour force (Statistics South Africa 2015, 2017).

1.1 Links Between Community-Driven Change and Sustainable Development

South Africa's NDP subscribes to the principle of community-driven change and development, thus advocating that the improvement of capabilities of communities through education, skills development and self-employment will put them in a better position to improve their lives (National Planning Commission 2011). Considering the historical context of human rights violations, inequalities and spatial underdevelopment in South Africa, development initiatives that focus on community-driven change, seems the appropriate way to go (Patel 2015). From this point of view, the traditional way of working with communities namely to identify problems and needs in communities and to design interventions for them may be unsuitable, whereas an alternative approach with a focus on strengths, assets and capabilities appears to be the preferred route to go (Nel 2018).

With reference to the achievement of sustainable development at community level, Shiel et al. (2016) point towards the important role that Higher Education Institutions (HEIs) can potentially play within communities in terms of engagement with stakeholders and facilitation of capacity building, thereby fuelling community-driven change. This type of involvement falls within the core area of outreach, which has developed to a significant impact area of HEIs regarding the sustainable development agenda (Findler et al. 2019). Broadly, speaking sustainability related activities

by HEIs in communities embrace two areas of application (Shiel et al. 2016). The first involves sustainability teaching and learning, with the context provided by communities. The second involves the identification, promotion and implementation of projects aimed at sustainable development in communities.

1.2 Aim, Methodology and Value of Chapter

This chapter addresses the sustainability drive by HEIs, with focus on the potential of the core area of outreach to contribute to community-driven change and development. With a critical reflection on a sustainability focussed community engagement project of the Department of Geography, University of South Africa (Unisa), the chapter contributes to the evaluative research on the role of HEIs in capacity building for sustainable development at community level, referred to by Shiel et al. (2016). The reflection on the Unisa project adds a further dimension to the outreach drive that often focuses on communities within the physical reach of HEIs (Ibid). In reality, spatial boundaries are becoming less important, and increasingly replaced by flexible, dynamic flows of knowledge (Ylikoski and Kivelä 2017). Illustrative is the case of Unisa, an open, distance and e-learning (ODeL) institution, with its outreach having a less static meaning and extending to communities that are not necessarily close to the main campus.

The outreach project of the Department of Geography comprised of a community-based asset programme (2012–2016) to empower the Koffiekraal/Brakkuil communities (Northwest Province, South Africa) to drive their own sustainable development. This chapter shares the framework for this engagement, critically reflects on successes and challenges and provides implementation guidelines for similar projects. The tourism and handicraft projects, initiated during a series of participatory community workshops in 2012, serve as mini case studies. Data collection took place during the initial participatory workshops and thereafter the different project phases. Various forms of data are available, including observations, interviews with and feedback from community members and participants and other forms of evidence, including reports, articles and artefacts. The authors made use of thematic assessment in order to support the critical reflection with concrete evidence.

2 Empowerment of South African Rural Communities Towards Sustainability

2.1 Community-Driven Change for Sustainable Development

Community-driven change, as proposed within the NDP and supported by Nel (2018), implies sustainable and inclusive change for many rural South Africans.

This approach provides rural communities with the opportunity to raise themselves out of poverty and improve their own quality of lives and in this way take ownership of developing their communities towards the objectives set by the SDGs. By advocating community-driven change, each community member has the responsibility to work with government and civil society to ensure that they introduce initiatives to reduce poverty and inequality in their own communities. The authors of this chapter suggest that if change is initiated and driven from inside the community, sustainable development is possible as the process would inculcate community ownership, a sense of pride, and a sense of belonging within one's own community.

2.2 The Role of HEIs in South Africa

The Higher Education Act of 1997 transformed higher education in South Africa from a highly segregated system to a single national system that had to serve both the individual and collective needs of society. Staff at HEIs in South Africa now had to focus their pursuit in three ways, namely teaching and learning, research and community engagement. The Act describes community engagement as any initiative of academics in HEIs to apply their teaching and research skills in the communities they serve. By introducing the community engagement component as a responsibility of all academics in South Africa, the 1997 Act call upon all HEIs to demonstrate their social responsibility by making available its expertise and infrastructure that would address the specific needs and wants of the South African community (South African Council of Higher Education 2010).

2.3 Community-Based Asset Programme of the Department of Geography (Unisa)

With the HEI's mandate of community engagement a group of geographers from Unisa partnered with a non-profit organisation (NPO) to share their expertise, skills and knowledge in communities that wished to drive their own sustainable development. This partnership and interaction with a number of rural communities across South Africa, led to the development of the Community Asset Mapping Programme (CAMP)—an empowerment tool to facilitate community-driven sustainable development in rural communities. CAMP consists of a number of processes designed to assist communities to make a mind shift from a traditionally disenfranchised community into a community of empowerment and control (Fig. 1).

The workshop format allows a creative and participatory way to engage all participants while working in smaller teams. The participants are taken through a practical sixteen-step process (Fig. 1) of exercises that are designed to make them aware of the skills and talents they possess, as well as the physical and economic assets that the

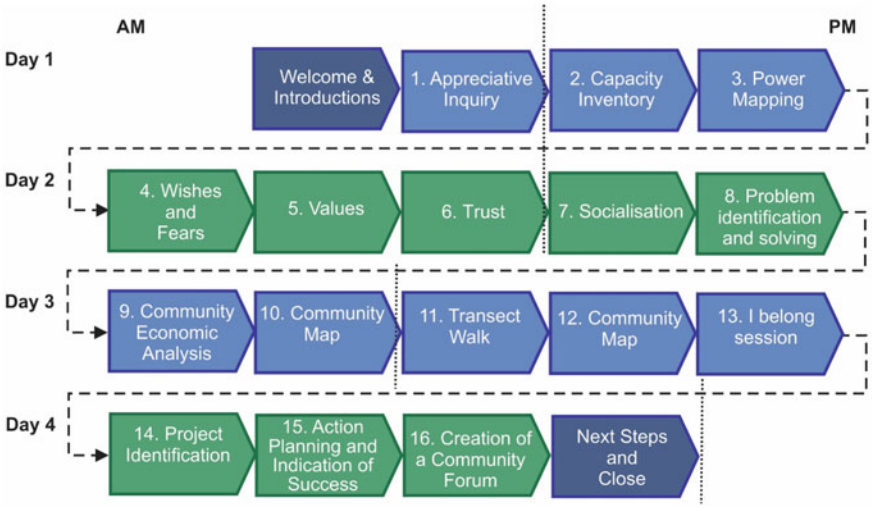

Fig. 1 Community asset mapping programme (Nicolau 2013)

community as a whole possess. The workshop also helps the community to identify their hopes and fears and assist in building trust between participants. The intention of the workshop is to enable communities to switch their thinking from 'this is what we lack' to 'we are richer than we realised'. The final processes of the workshop are twofold, namely, identifying a number of entrepreneurial opportunities that the participants could consider and for the development of their own indicators of success. After the workshop, the NPO assists participants with financial grants and support to develop and register their entrepreneurial projects, while Unisa provides the required skills training specifically related to the skills required for the identified project. Direct interaction between community, NPO and Unisa takes place through sharing of expertise, skills and knowledge after the workshop and this could last up to 2 years. This is followed by a 2-year period, when the external partners (NPO and HEI) interact with the community to assist them to monitor their own progress towards driving their own sustainable development. During the monitoring period, additional skills training as identified by the community is sometimes provided, but this is done in such a way that the community does not become dependent on external support in their drive towards sustainable development.

3 Case Study: Application of CAMP in Koffiekraal and Brakkuil

3.1 Study Area, Community Involved and Contextual Background

The case study considered in this chapter, namely Koffiekraal and Brakkuil, are two rural villages located in the Moses Kotane Municipality within the Bojanala Platinum District of North-West Province, South Africa. Both these villages link historically to the Bahurutshe (a chiefdom in the North West Province), with a timeline dating back to the 1850s (Mpotokwane 1974). The two villages are traditionally led by the Bahurutshe-Boo-Mokgatala traditional authority that has jurisdiction over an area of 40,000 ha of communal land and about 50,000 people, largely relying on subsistence farming for their livelihood.

Koffiekraal covers an area of 5.42 km^2, has an estimated population of 4282 people and 1088 households, while Brakkuil covers an area of 3.46 km^2, and has an estimated population of 2329 people and 623 households (Big 5 Community Tourism Forum n.d.). The two villages are geographical neighbours and there is a high degree of synergy between them. Setswana is the common home language. Females and female-headed households are dominant and this reflects in the female population demographic of 52.3%. An estimated 14.2% of the population in the villages have completed their formal schooling, while 29.3% of the population have no formal schooling. Less than 2% of the households have flush toilets or piped water, while the majority of households have electricity for lighting, but most households still use wood as fuel for cooking. Internet usage is low, as 92.7% of the population have no access to the internet. Over 50% of the population in the two villages are unemployed and rely on social grants as their major source of income (Statistics South Africa 2018). The spatial infrastructure linking the communities to the nearest town (Zeerust) is poor and public transportation is limited and costly. Access to the villages is via a tarred road, but within the villages, the road network is predominantly dirt roads.

3.2 The Application of CAMP

The four-day CAMP workshop (Fig. 1) in the village of Koffiekraal was attended by 76 community members from Koffiekraal and the neighbouring village of Brakkuil in August 2012. The attendees were representative of the community in terms of gender and across all age groups over the age of 18 years. The Bahurutshe-Boo-Mokgatala Traditional Authority provided the authors with the relevant permission to work in the community for the period 2012 to present.

After going through the workshop, and with due consideration of their inherent social, human, economic and environmental assets, the participants from Koffiekraal and Brakkuil identified a number of entrepreneurial opportunities that could stem the high unemployment rates and lay the foundation to facilitate community-driven high impact sustainable change in their communities. The community identified a number of opportunities to empower themselves and to drive their own sustainable development. Two of these opportunities were entrepreneurial in nature (namely community-based tourism and handicraft) and presented in this chapter.

3.3 The Tourism Project

The project trigger was the interest expressed by participants during the initial CAMP workshop to form a community-based tourism group to create self-employment opportunities. Table 1 provides the action plan developed by them during the last day of the workshop (Fig. 1). Staff of the Department of Geography (Unisa) then developed and implemented a training intervention in 2013 that aimed at transferring knowledge and raising the awareness amongst the group of interested community members of the potential of their local area for community-based tourism. Thereafter two smaller groups emerged, one for each of Koffiekraal and Brakkuil that had the opportunity in 2014–2015 to test the village tours they developed from the knowledge gained during their initial training. These groups merged in 2015 to form the BIG 5 Community Tourism Forum.

Table 1 Action plan—Koffiekraal/Brakkuil community-based tourism group

Future change project	Action steps required	Local assets available	Outside assistance needed	How will the group measure their own success
Create employment opportunities by creating a community based tourism company	Develop a business plan and learn about tourism	• Local culture • Local food • Seleke park • Old buildings • Historical cemetery • Game farms • Surrounding area (Madikwe) is a tourist destination	• Training as tour guides • Help to establish a business • Open a bank account	Tour guide company that employs local people. Tourists will visit the village and spend money in the village to help the community become wealthy

Source Developed by participants of the CAMP Workshop in Koffiekraal on 14 August 2012

3.3.1 Development/Skills Training Phase

A variety of strategies during the training phase were utilised to get participants interested in and excited about the possibilities of community-based tourism. These included the use of video clips, marketing material, tourism maps and case studies of community-based tourism projects. In this way, they received the necessary guidance to identify potential resources for tourism in their own area, thus realising the value of what is available to them. In this regard the "Six H" framework of tourism (adapted from Smith n.d.)—"Habitat, Hospitality, History, Heritage, Humans and Handicraft"—was very useful and repeatedly used to make connections with local examples.

Classroom activities included sessions for sharing expectations about the training and a workbook that had to be completed, covering topics as forces of attraction for tourists, marketing and packaging of tourism products and operational considerations. The application of all training within a local context formed the purpose of the learning interactions. To support classroom activities, a number of walks in and around Koffiekraal/Brakkuil allowed the community members the opportunity to identify a possible tourist attractions and participants could act as guides and provide information on their history, culture and environment. In addition, participants were able to join a field trip to a local tourist destination, so that they could get a real-life experience what it is like to be a tourist.

Comments of participants illustrate the impact of the training on participants (Nicolau et al. 2018): "I didn't know that what we have can be important to the world", "We have ourselves and things around us", "I learned that we can use things around us to develop ourselves and making a living out of it", "… when the time is right I can get involved in this field …", "My brain is touring now. I want to know more about tourism", "The community can make their own business to entice people to come to your place". In total 23 participants completed the training phase and received Unisa attendance certificates in March 2014.

3.3.2 Application/Implementation Phase

Following the training, ten community members from Koffiekraal and Brakkuil expressed interest to continue and use their newly gained knowledge to create village tours for their respective villages. Over the period 2014–2016, staff of the Department of Geography help develop and conduct trial runs of village tours, which aimed to capacitate the group to provide fully-fledged village tour packages as part of a self-employment initiative. To this end a forum, the BIG 5 Community Tourism Forum, was created to provide structure for planning and execution of activities. The trial runs aimed to develop an authentic tourism experience and experimented with options as visits to historical graveyards, traditional cuisine and entertainment, traditional living spaces, remains of historic architecture, community food gardens and trees with traditional value.

Each of the trail runs were followed by a feedback session during which staff of the Department of Geography provided forum members with feedback on positive aspects, challenges and opportunities for improvement. A number of domestic and international tourists also took part in the trial runs, which provided valuable feedback from the perspective of real tourists. The following serve as examples of the type of feedback obtained (Nicolau et al. 2018): "… getting a great view of the culture …", "… completely different to anything we know …", "… interesting because it is a mixture of so many different things …" and "… a truly authentic experience …".

During 2015–2016, the groups from the two villages started to cooperate more closely, thus providing more synergy and cohesion among forum members. In 2016, the trail runs developed to the point where it became clear that enough experience has been gained to take the village tour concept into the public domain. To ensure sustainability further training followed, targeting aspects as communication, project management, budgeting and bookkeeping, before the launch of the Koffiekraal/Brakkuil village tours in November 2016.

3.3.3 Critical Reflection

Although participating guests in the trial runs of the village tours were positive, several challenges were experienced during development and implementation (Nicolau et al. 2018). Some of these, as the reliability of locals providing entertainment and transport, are logistical and should be possible to address through planning and coordination, but might in practice always cause some uncertainty. Due to the lack of reliable 3G and internet coverage, communication between the Department of Geography and forum members remained challenging though out the project and sometimes had to wait until the next site visit. This aspect constrains operational aspects as planning and booking for tours, while the poor transportation infrastructure makes it difficult and costly for forum members to access products required for catering.

A more challenging concern, as perceived by the authors, was the apparent lack of confidence of forum members while presenting attractions to visitors. Despite the training interventions and trial runs of tours, this aspect did not improve and manifested until the launch of the tours. This can be ascribed to the challenges forum members experience when speaking in English with visitors, combined with the limited knowledge/insight of the younger forum members into the history of the villages. Although some matters therefore still require attention, the forum members value their engagement with the project—in terms of personal growth and the goal to provide a sustainable community-based tour (Nicolau et al. 2018). Their activities are reflected on their Facebook Page (BIG 5 Community Tourism Forum 2016), which serves as platform for future initiatives.

3.4 The Handicraft Project

During the initial CAMP workshop in 2012, an inventory of the skills of community members was compiled during Session 2 (Fig. 1). The existing skills of the participants included handicraft specifically related to textiles, clothing, fashion and crafts. The development of these skills into an entrepreneurial opportunity was expressed by a group of participants and during sessions 14 and 15 (Fig. 1) they critically evaluated the option of the creation of employment opportunities for community members with similar skills (Table 2).

3.4.1 Development/Skills Training Phase

To provide the participants with the required skills to assist them in developing their handicraft skills into a business, the Department of Consumer Sciences (Unisa) provided skills training through numerous short learning programmes aimed at developing the participant's competencies in textiles, clothing, crafts and jewellery (using paper beads). The hands on skills training took place in a classroom situation in the community on a monthly basis over a period of 18 months, after which the fifteen participants received certificates of attendance from Unisa in March 2014.

Table 2 Action plan—Koffiekraal/Brakkuil handicraft group

Future change project	Action steps required	Local assets available	Outside assistance needed	How will the group measure their own success
Development of an handicraft business that will provide employment to community members	• Setup project team • Establish guiding principle group interaction • Undertake a full skills audit of potential group members • Undertake an asset audit of available local assets • Develop a business plan	Variety of skills related to sewing, embroidery, knitting and crochet Sewing machines	• Start-up funding • Development of a business plan • Logistical support • Formal training in textiles and handicraft	We will measure the success of the project by the jobs we create for the people and the number of contracts from outside the community to provide handicrafts

Source Developed by participants of the CAMP Workshop in Koffiekraal on 14 August 2012

3.4.2 Application/Implementation Phase

After the training, six participants from Koffiekraal and Brakkuil expressed the need to form a collective, the NPO assisted the group with the development of a business plan, and this resulted in the formation of the "*Basadi Multi-Talented Rural Ladies of Madikwe*" in 2013. The group received a donation of five sewing machines from Unisa, and the NPO found a donor that provided match grants for the group to purchase more sewing machines and equipment. During 2014, the group had a number of opportunities to sell their handicraft outside of their respective villages, including selling their handicraft at the monthly craft market at main campus of Unisa; a contract to make rag dolls; and a number of contracts from multi-nationals to sell their jewellery made from recycled material. They were also able to sell their handicraft during the village tours of the BIG 5 Community Tourism Forum to a number of domestic and international tourists.

To ensure the financial sustainability of the group, the NPO provided much needed training in terms of budgeting and bookkeeping. In February 2014 the positive impact of the individual participation in the group were reflected in the comments of the members of the group—"I wake up in the morning, and I know have work to do and this makes me feel good", "I am so proud, the shop in Zeerust sold my jewellery!", "I now know I can make my own money and use this to feed my children", "I am making clothes and selling them to the community, and I think we should go to the lodges near Zeerust and find out if we can make uniforms for their staff".

3.4.3 Critical Reflection

Following the initial success of the handicraft group, matters relating to trust started to negatively impact on the relationships between the group members. Initially the trust issues related to financial matters and this highlighted an inherent negative interpersonal relationship between two members of the group. This development affected the group and their ability to work as a team to honour the contracts they had received to provide handicrafts. Despite attempts from the NPO and Unisa to mediate the situation through a trust workshop, the relationships between the members of the group had reached a point, where the group could no longer function as a collective and the group disbanded by the end of 2014. Since 2014, the individual members of the group have continued to produce their handicraft and are selling their goods within and outside their respective villages. In this way, the household income of each of the individuals is supplemented by the income of their handicrafts. Despite the failure of the group, the authors are of the opinion that the skills training initiative of the handicraft group was not wasted, as the individuals were capacitated with skills that they can use to generate self-employment and generate a modest income into their respective households.

4 Assessment of the Role of the Projects to Empower Community Participants to Drive Sustainable Development

The purpose of both the tourism and handicraft projects that resulted from CAMP, was to develop entrepreneurial opportunities that would provide employment and income for the largely unemployed populations of the two rural villages and in this way contribute to addressing the SDGs related to No poverty, Zero Hunger, Quality education, Gender equality, Decent work, and Economic growth. In this regard, the tourism and handicraft projects demonstrated similarities and differences in terms of their development, implementation, challenges and successes, as highlighted in this section.

The handicraft group consisted of members of the same gender, while the tourism group was a mixed group. The age differentiation between the two groups varied, with the handicraft group having the biggest difference in ages. In both groups, the age differentiation presented problems in the implementation of the respective projects. In the opinion of the authors, this reflected the culture within the villages, with youngsters expected to show respect for their elders. This sometimes impeded the success of the respective projects.

During the training phases of the respective projects, more success were achieved in the handicraft group. The authors speculate that the reason for the relative success of the handicraft group could be the product of their training. The handicraft group received training that had an immediate tangible outcome and group members could immediately attach a monetary value on a concrete skill learnt by selling their products. The training for the tourism group was more abstract and less tangible and the reality was that the group members found it challenging to grasp what the tourism industry is about, as most of them had never participated in any tourist activity prior to their training.

The training for the handicraft group was more regular, while the training of the tourism group was more ad hoc due to the availability of the academics. The initial successes of the handicraft group allowed the group to start selling their products to community members and as they were immediately able to generate an income from their training, they were more motivated to pursue the project and training. On the other hand, the tourism group could not immediately generate an income from their training and had to wait until implementation before financial benefits would materialise.

Finally, both groups developed trust issues in terms of their respective projects, the handicraft group eventually disbanded due to lack of trust with each other, while the tourism group inherently struggled with aspects related to confidence and trust in themselves to act as tour operators and to market the village tours that they developed as tourist attractions.

While the two projects presented in this chapter experienced successes and challenges in their implementation, the authors are of the opinion that community engagement initiatives of academics in rural areas through the implementation of CAMP

Fig. 2 Traditional dancing and handicraft during a village tour in 2015

can play a major role achieving the SDGs and the realisation of the NDP objective to eradicate poverty by 2030 in South Africa. In support of this assertion, the reader can view the numerous successes of the various skills training initiatives in Koffiekraal over the last seven years, as showcased in Fig. 2 and by the YouTube videos as listed in Table 3.

Table 3 List of YouTube videos related to the tourism and handicraft projects

Date published	Title of video Length of video URL	Short description
2012/11/07	Community tourism 7.34 https://www.youtube.com/watch?v=ojbigW3y_Gk	Informational video on the vision and planning for the community tourism project for Koffiekraal
2013/07/14	April training 2013 9.02 https://www.youtube.com/watch?v=0Uy1Hn2TnK8	Informational video on progress in the various training projects in April 2013
2013/10/01	Skuinsdrift update August 2013 4.48 https://www.youtube.com/watch?v=aL7vSdlqc6A	Informational video of the training in the various projects in 2013
2013/12/20	Skuinsdrift community tourism development 2013 5.51 https://www.youtube.com/watch?v=haO0ri_goXY	Informational video of the training phase of the community tourism project, covering the 6 H's of tourism
2013/12/22	Crafts and textile training 2013 4.53 https://www.youtube.com/watch?v=B3jcuZ7osJs	Informational video on the training and activities related to the handicraft project during 2013

(continued)

Table 3 (continued)

Date published	Title of video Length of video URL	Short description
2014/06/18	UNISA completion of 2013/2014 skills training, North West Province 5.07 https://www.youtube.com/watch?v=l6Afk-v0w3s	Informational video on the training that followed on the initial CAMP workshop in 2012 and the certificate ceremony in March 2014
2015/08/13	Tourism update 2015 3.34 https://www.youtube.com/watch?v=ooXsqlWmcIw	Informational video on the progress with the community tourism project in 2015—preparation of marketing material, trail runs of tour, profiles for members, etc.
2015/10/28	Heritage day village tour 2015 3.34 https://www.youtube.com/watch?v=fDrn4ZEFNK8	Informational video on the heritage day village tour in Koffiekraal in October 2015
2016/01/24	Koffiekraal community tourism promo video 5.01 https://www.youtube.com/watch?v=JYyJLCayJYU&t=17s	Promotional video to show the viewer what to expect when they go on the Koffiekraal community tour

5 Lesson Learnt and Guidelines for HEIs Engaging with Communities to Work Towards Sustainable Development

One of the most important constraints experienced in the community engagement initiative of Koffiekraal was the time available for academics to focus on consistent and sustainable interventions, while they have to cope with a significant workload in terms of teaching and other key performance areas. This constraint was exacerbated by geographical distance as the communities are located about 240 km from the Unisa Science Campus location in Florida, Johannesburg. Due to challenges experienced with internet connectivity and access in especially the rural parts of South Africa, communication between the community members and the university posed many challenges. As a result, many activities, including planning and preparation, were delayed until site visits took place, which significantly affected the programme and the pace of progress. When selecting communities for outreach, the aspect of distance, time and cost is therefore an important practical consideration and if not accounted for, can later on lead to project failure.

Related to the issues posed by practicality and logistics, the authors recommend that HEIs partner with NPOs as they often have a mandate to effect and monitor change in communities on a regular basis. As such, a partnership will safeguard continuity that is a requirement for sustainable change in communities. Experience

showed that partnerships between HEIs, NPOs and communities could be three to five years, and it is critical that an exit plan is drafted when the project commences to ensure that mutual dependencies do not develop.

Any interaction of HEIs within communities should be transparent and academics must ensure that they clearly explain any intentions to share their experience in their research and tuition. HEIs should be cautious of creating expectations in vulnerable communities and just as importantly, they should guard against creating unrealistic expectations. Within the context of community-driven change academics must be very careful not to impose unnecessary knowledge onto a community and should only react to the requests from communities for specific skill training interventions. HEIs should not impose their agenda on the community, rather the academics must be mindful that the drivers of success are the members of each community and not the academics with their own personal research and/or tuition agendas.

6 Limitations of Research and Future Initiatives

The authors acknowledge the limitations associated with the case study format of this research and the qualitative nature of the reflective methodology as applied in this chapter. The obvious advantage of this methodological approach lies in the rich, in-depth descriptions, based on the authentic voices of community members, whereas such depth is more challenging to achieve when typical quantitative approaches are used. Generalisation of results is possible with similar reflective assessments of the role of CAMP to drive sustainable development through a bottom-up approach in a number of other communities as well. Due to the contextual nature of this research, the realities associated with outreach will always differ from community to community, and results obtained in a specific community will never really be universally relevant, although lessons learnt can provide valuable pointers to other researchers also active in this field. Future work would involve application of CAMP in other communities as well, bearing in mind the lessons learnt up to know, and in this way build a community of practice and on the experience gained thus far.

7 Conclusion

The authors would like to express the hope that the research reported in this chapter will assist rural communities of South Africa in driving their own sustainable development. At the same time, CAMP could play a major role in the realisation of the NDP objective to eradicate poverty in South Africa by 2030. The development of CAMP as a tool to accomplish this and related objectives within the field of geography realises the author's belief that the application of this programme within the contemporary South African society could contribute to a better life for all. The illustration of the role of HEIs towards the attainment of the SDGs through the application of CAMP

in the rural villages of Koffiekraal and Brakkuil, with several achievements form the basis of this chapter. To this end, processes such as CAMP can play an important role to drive change especially in a country where change has not been the result of community initiatives but rather driven politically in a top down approach.

Since 1994, the government has done much to try and reduce inequalities through social programmes, however persistent inequalities and high levels of poverty has increasingly meant that business and civil society have to become more active in social and community change projects. This forms a fundamental premise of CAMP, namely that a number of external stakeholders need to partner with communities in order to facilitate sustainable roots driven change that can alleviate the levels of poverty in communities. Each of the stakeholders would have different reasons for their interactions within particular communities; however, CAMP specifies that external stakeholders' own agendas may never overshadow the particular communities' pre-determined indicators of success. It is also crucial that the relationship between communities and external stakeholders is not one that results in a dependency relationship between themselves and the communities.

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Education for Sustainable Development

Proposals for Teacher Training in the Face of the Challenge of Educating for Sustainable Development: Beyond Epistemologies and Methodologies

Mari Regina Anastacio

Abstract The predominant educational matrix based on unconstrained progress, individualism and competition needs to be reinvented so that it can contribute effectively to sustainable development. In this sense, the role of higher education institutions as trainers of local and global leaders is considered fundamental, along with the role of university teachers who are mediators of learning and great influencers. Thus, this article intends to reflect the ontological dimension on the programs of teacher training higher education, in view of the need to review mental models regarding actions aimed at effective sustainable development. Based on a foundation and a set of reflections, the importance of adding ontological aspects to teacher trainings, as well as the intellectual and methodological aspects, in which the following elements emerge: methodological congruence; multidimensionality of being; multidimensionality of relationships; attention to the unveiling of 'power from within'; meaningful learning; solidarity and civic culture; learning spaces; access to truths; heterogeneous plural practices (transdisciplinarity); wisdom and imagination; acting in teams; collective intelligence; group dynamics; world of youth; designer of learning environments.

Keywords Teacher training · Education for sustainability · Transdisciplinar education · Ontological aspects · Complex thinking

1 Introduction: The Roots of the Evils that Plague Humanity in an Unsustainable Long-Term Scenario

The diverse systemic challenges that present themselves in the contemporary scenario have invaded all life on the planet and translate, among others, into unlimited growth within a finite planet, in the excessive power of corporations, in a parasitic

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financial system, in the tendency to monopolize the knowledge and the imposition of a monoculture of minds.

In the face of the many serious economic, social, political, cultural, spiritual, environmental and geopolitical problems that permeate contemporary society and life on Earth, and the results that have been obtained, it seems that, in general, as humanity, we have not been able to comprehend the root causes of such challenges.

Thus, it is important to reflect on some of the possible roots of the contemporary challenges, since we are trying, as humanity, to act with palliative measures on the effects exposed to the surface. It is important to understand that what has been presented in terms of reality is the result of the structure that sustains it and the type of soil and environment that nourishes it through the roots, which ultimately starts to feed the effects that become visible.

According to Russel (1992), Scharmer (2010, 2014), Weil et al. (2013) and Capra (2004), the aspects that challenge the current situation are only symptoms of deeper causes related to the way we perceive realities.

The essence of the evils that afflict us is in our mind: we try to change the outer world, instead of worrying about changing our mental attitude. We live a "cultural trance," addicted to the material world and hypnotized by a materialist stance that makes us believe that outer well-being is the way to inner realization. Thus, we become an explorer consciousness and, instead of 'human beings', we become a human "having" and "doing" that functions as machines with set habits. Beings marked by selfishness, competition, and the fear of the future, which makes us resistant to change, without noticing that most of the things we fear are illusions of our mind (Russel 1992).

Weil et al. (2013, p. 15) call *normose* "the set of habits considered normal and that, in reality, are pathological and lead to unhappiness and disease." Or, put another way, the force that makes us resist the change of opinions, behaviors, attitudes and pathogenic habits endowed with social consensus and executed without their authors being aware of the pathological character of their acts. In a way that all, normose constitutes a form of alienation. Such aspects brought to the macro context, make evident a psycho-sociological process that threatens life on the planet Earth. Therapy for the contemporary crisis, according to Weil et al. (2013), begins when we become aware of *normose* and its causes.

It is thus verified that the metamorphosis required in the age of destabilization that we are going through, and the signing of a new time, invites us to transform our worldview of reality. In other words, the paradigms that govern our reading of reality need to be revised. In addition, we need to look at the roots, values and beliefs, invisible aspects that manifest in the world and that create individual and collective realities in the form of concrete effects.

The dynamics of the contemporary world leads us to the need to look at the realities from an ecosystem perspective, considering the complexity and consequent interdependence of human and nonhuman phenomena in the planetary context. Thus, the challenges we are being called to face will only be transposed through a systemic understanding of life, which requires addressing the development of complex thinking in the educational field.

Within the concept of complex thinking, the transdisciplinary approach is found in the field of education. And within this, the view that educational processes and teacher training should consider not only the epistemological and methodological dimensions, but also include the ontological dimension. Such a position reflects the understanding that to produce a new educational model more compatible with the demands of the contemporary world, it is necessary to act on a deeper level related to changing basic assumptions of 'beings' reference.

2 Complex Thinking and the Transdisciplinary Approach as a Possible Path in the Field of Education

The difficulty of understanding the contexts and thinking the necessary interpellations in complex contexts, ends up producing a state of blindness, becoming, according to Hathaway and Boff (2012), a kind of alienation, unconsciousness and irresponsibility that paralyzes, dulls the spirits, disconnecting us from each other and weakening the bonds of life in the planetary dimension. In particular, Morin (2007) warns that the more the problems become multidimensional, the more difficult it becomes to understand and transcend them.

By referring to complex thinking (Morin 2001, 2007), the cultural trance (Russel 1992), the tensions that threaten planetary survival (Hathaway and Boff 2012) and the concept of *normose* (Weil et al. 2013) these authors emphasize the importance, in the contemporary world, of understanding the realities of the problems that afflict humanity and life on the planet.

Reading a complex world is only possible from a complex worldview. For Wilber (2003), simplistic and monocular solutions are not capable of bringing about transformation in the contemporary scenario, since the solutions need to be looked from the prism of complexity of relations of nature and society.

Complex thinking allows communication between different knowledges serving as bridges. Its purpose is at the same time to highlight the challenge of uncertainty and to gather, contextualize and globalize the elements present in a given phenomenon.

Morin (2007, 2003) points to the mutilating pathology of contemporary thought as the major responsible for the barbarities we see. For him, complex thinking makes it possible to civilize knowledge, as it presents us with a type of thinking that allows the ethics of reconnection and solidarity.

Morin (2001) presents a set of principles that education must strive to effectively contribute to a new educational paradigm that is more compatible with the needs of the contemporary world, namely: **blindness of knowledge: error and illusion**—refers to the need to avoid, or at least to soften, through the examination of the nature of knowledge, the error and illusion present in the process of understanding reality; **the principles of relevant knowledge**—the importance of developing skills to organize knowledge not in isolation, but establishing relationships between the whole and the parts in order to contextualize the information so that they have more effective

meaning; **to teach the human condition**—which is at the same time biological, physical, psychic, cosmic, cultural, social and historical, and in this sense recognize as the essential object of all teaching the unity and the human complexity; **teaching the earthly identity**—brings the reflection on the care not only to conquer progress, but the survival of humanity by raising awareness of the need to civilize and be supportive with Earth; **facing the uncertainties**—the education of the future must include the teaching of uncertainties and the preparation of minds for the unexpected; **teaching understanding**—it is fundamental to teach mutual understanding as a vital assumption for humans to continue to exist; **and the ethics of mankind**—education must work in the minds of the citizens of Earth-Motherland who carry a triple reality: of being at the same time individual, part of society and part of the species.

Nicolescu (1999a, b), Weil et al. (1993), Crema and Brandão (1991), Morin (2001, 2003, 2007), Moraes (2010, 2012), Moraes and Batallosso (2015), D'Ambrosio (2010, 2012), Petraglia (2015), Behrens (2012, 2015), among others, present in their works indications of how educational institutions and educators can promote the global education of individuals and the impacts that an integral formation can generate in other spheres of life, not only human, but of the planet. The aforementioned authors consider that the transdisciplinary approach can elicit answers to the comprehension and the experience of complex thinking, as well as to help in understanding and acting on the complex problems present in the field of education and in human society.

For Morin (2005), the way to get to know the real for the theory of complexity is transdisciplinarity, given its condition of going beyond the disciplines, forming links that collaborate with each other and transcend the boundaries of the discipline, constructing a metavision about men, earth, the arts, life and the cosmos.

According to Brandão and Magalhães (2012), transdisciplinarity is a different way from the conventional way of daring to think and creating knowledge that invites to bond the multiple dimensions of human experience and the diversity of looks regarding knowledge: the rediscovery of the body, the confidence in the senses, the sensibility, the desire, the affection, the creative imagination, the amorosity and the multiple intelligences.

Education in the transdisciplinary perspective cannot be merely intellectual and act only on the mental level; it needs to be permeated with sentiment and ethics so that the resulting actions are life producers. Knowledge must be linked to wisdom and imagination, which presupposes valuing not only critical thinking about realities and their contexts, but also the ontological dimension of 'beings'.

In addition to the formal content of objective order, transdisciplinary education, like any other, has a hidden curriculum, which translates into the attitudes of educators (in tune with the principles of transdisciplinary education) and the methodologies adopted by them. A proposal that requires from educators changes involving emotional aspects, interpersonal relations and revision of personal values, in an ontological context, besides the change of frames of intellectual reference. As we can see in the next section.

3 The Training of Teachers in the Scope of Higher Education from the Transdisciplinary Approach

The predominant educational matrix based on unconstrained progress, individualism, and competition needs to be reinvented so that it can contribute positively to the great leap that humanity is being called upon to undertake. This raises the need for reflection on the current circumstances of educational systems at the global and local levels and the role of higher education in the context of the contemporary scenario.

Such a scenario points to the fact that education needs to be visionary, transformative and capable of instilling in the learning beings a new way of thinking, feeling and acting on life, on the realities in which they are inserted. Instead of becoming mere reproducers of a conduct that has proved unsustainable for the maintenance of planetary life.

Thus, it is necessary to reflect on how education has been acting in the minds and hearts of the learners and to what extent, in which aspects, it is contributing to a broader understanding of realities—a crucial element to achieve as humanity, to achieve success in the collective enterprise for planetary survival and evolution.

However, before touching the learners, it is necessary to find the educators, those who act as mediators of the learning processes in the field of formal education. These aspects lead us to reflect on teacher training programs focused only on the epistemological and methodological elements of the intellectuals, as well as on the relevance of considering in these formative processes the ontological bias, a dimension in which lies the possibility of evoking a more profound transformation—of minds, hearts and actions—that can radiate.

It should be emphasized that within the transdisciplinary conception, such dimensions are forged in a single fabric in constant integration and feedback. However, for didactic purposes they can be presented as follows:

(a) epistemological dimension—focused on the faculty of 'Thinking' and related to the theorists (intellectuals and technicians) that base the teaching practice in the various fields of knowledge and in the field of education in terms of teaching and learning;
(b) ontological dimension—focused on the faculty of 'Feeling' and related to the human development of the educator in the dimensions of relationship with himself, with others, with the world and with the transcendent. The aim is to produce meaningful learning with the aim of contributing to the educator's ability, in his/her educational practice and personal life, to present, as far as possible, coherent and congruent attitudes between thinking, feeling and acting in the perspective of a transdisciplinary approach.
(c) methodological dimension—focused on the 'Acting' faculty and related to didactic processes in harmony with transdisciplinary education.

Moraes (2012) reminds us of the importance of having clarity in the educational process of a transdisciplinary character regarding the connection existing between the epistemological, methodological and ontological dimensions. Because,

> Without this ontological and epistemological clarity, without the understanding of the logical relations interpenetrating the constitutive dimensions of life, be it physical, biological, social, political, cultural and spiritual, it is difficult to work on the proposed theme, Transdisciplinarity and Education. This is because the ontological explanations present epistemological ramifications and bring with them a set of procedures and strategies in which a certain type of reasoning, logic, world understanding and a vision of how reality is manifested predominates. Thus, any current system of thought affects all these dimensions, the practice arising from this applied logic, as well as the resulting political and social vision. In this way, it becomes easier to understand that transdisciplinary thinking, nourished by the complexity present in the different manifestations of life, connects ontology, epistemology and methodology. (Moraes 2012, page 77)

When speaking of ontology, it is important to make explicit that the conception of ontology adopted here is based on contemporary ontology. The word ontology, of Greek origin, is formed by the terms ontos (to be) and logos (study) and means "study of being". Ontology is considered as a part of philosophy that studies the reality, the existence and the nature of the being, also known as the science of the "signification of the being as being" in its fundamental relations.

In the book *Between us: essays on alterity*, Lévinas (2004) retakes the problem of ontology by philosophy, remembering that until then it was forgotten. In criticizing philosophical literature for oblivion, the thinker approaches the term in its contemporary version. In this version, the understanding breathes again the air of its source, which resides in the dialogues of Plato and in the metaphysics of Aristotle and confers the credits of the contemporary approach of the ontology to Husserl and Heidegger, when they conceive the possibility of the contingency and the feasibility, which presupposes the understanding of being not only by the intellectual attitude, but by the involvement of all human behavior. Ontology is the whole man in his needs, his affections, his science, his social life and his work.

For Lévinas (2004), the main contribution of the new ontology, or contemporary ontology, appears in its opposition to classical intellectualism, recognizing that:

> To understand the instrument is not to see it, but to handle it; to understand our situation in the real is not to define it, but it is in an affective disposition; to understand being is to exist. All this is indicating, it seems, a rupture with the theoretical structure of Western thought. To think is no longer to contemplate, but to engage, to be encompassed in what one thinks, to be on board - a dramatic event of being-in-the-world. (Lévinas 2004, 23)

Ontology as a form of access to truth in the transdisciplinary conception, indicates that the teaching act needs to be deeply understood by the being which is the teacher. Not only in terms of apprehension of knowledge, but of a being who acts in the world with vision and concrete attitudes in tune with the presuppositions of transdisciplinarity.

It seems relevant not only to critically reflect on the context of global and local systemic socio-environmental problems and their impacts on education, but also to observe the conditions and the locus of human beings that make up any and all social systems in their multidimensional aspects. And in this sphere, construct solutions so that education, from the attention to the process of development of the "inner potency" of individuals, can effectively contribute to the transition process in which

we find ourselves as humanity. Transformation needs to be driven at some point in the system, and it is not possible to aid in the transformation of learners without the effective transformation of educators.

Thinking about the formation of educators to act in the context of higher education requires training that contemplates the epistemological and methodological dimensions in an ontological context in which the ontological conception is related to the development of the "being that is the educator" in the intrapersonal, interpersonal, extrapersonal and transpersonal. According to Anastacio (2012), these aspects presuppose:

(a) intrapersonal—represents the consciousness of unity and the construction of a more harmonious relationship of the person with him or herself;
(b) interpersonal—represents the work that aims at harmony with the people with whom one interacts in the closest circles and the attitude of respect for the incredible diversity and richness of expressions of the human family;
(c) extrapersonal—presupposes the development of a consciousness of equality, not of superiority, in the face of planetary diversity, the consciousness of unity with all things and the sense of communion with realities;
(d) transpersonal—in this dimension there is the call to the spiritual mission of education, understood here as the full unfolding of human potentialities—which implies the proper relationship of being with oneself, with others, with the world and with the awareness of the sacredness of life.

Pineau and Patrick (2005), thinkers who defend the transdisciplinary approach, inspired by Rousseau (1712–1778), when they present what Rousseau considers to be the three fundamental masters of education (the own person, others and things), they propose the tripolar theory considering the transdisciplinary view of training. The theory defended by these authors presupposes that a process of transdisciplinary formation needs to be worked out from three complementary axes or levels of analysis: self-formation, training in the relation with oneself (personalization); hetero-formation, training in relation to others (socialization); and eco-formation, training in relation to the environment (greening). It is also emphasized that the most common in training processes in the educational context is the hetero-formation, which comprises formative processes usually marked by the appropriation by others of the training of the subject.

In order to better clarify the relationship between ontology (in the way understood here), transdisciplinary education and self-formation, we will turn to Galvani (2002), when he states that, in order to occur a transdisciplinary formation, it is necessary to reverse the axis of educational action to develop self-formation as an inner approach to education, understanding that self-formation constitutes the power of the subject over their formation; In other words, the subject develops an original awareness in the interaction with their environment. Such awareness requires considering the plurality of reality levels of the auto (self) and formation concepts, since it is constituted by the movement of reflexive awareness and feedback on hetero-formative and eco-formative influences.

In light of the above, some elements that may be present in teacher training are presented below, considering the assumptions of the transdisciplinary approach and contemporary demands. These elements are presented without the pretension of having them as unique, and of exhausting the possibilities existing in formative processes for teachers of higher education.

(a) methodological congruence—congruence between the assumptions of the transdisciplinary approach and the methodology used;
(b) multidimensionality of being—perceiving oneself, teacher, and instigating learners to recognize their multidimensionality: physical, emotional, relational, mental, creative, environmental, political and spiritual;
(c) multidimensionality of relationships—perceiving oneself and instigating learners to recognize the multidimensionality of intrapersonal, interpersonal, extrapersonal and transpersonal relationships, with which they will always be involved;
(d) attention to the unveiling of the "power from within"—acting in itself and contributing to the evolution of the consciousness of their students by stimulating the transformation of frames of reference with a view to the search for liberation (not alienation and not numbness);
(e) meaningful learning—promoting learning that can penetrate deep into the person's existence, going beyond the simple accumulation of facts and being able to generate transformation in their way of being and acting;
(f) solidarity and civic culture—awakening the "power from within" in an ecosystemic way, so that egocentric attitudes can be transformed into feelings of love and acts of compassion that allow the students to be respectful and open to differences. Always with a political purpose and focused on peace and social justice;
(g) learning spaces—considering the expansion of classroom space to produce learning. Not to limit social transformation to the classroom, expanding the learning for a transforming action with political intention and in the service of the reconstruction of the world;
(h) access to truths—recognizing, as Aristotle, the complementary importance of the various possibilities for working the truths that are not limited only to science as *episteme*, but also to art or the capacity to produce (*techne*) and practical wisdom (*phronesis*), a science capable of advancing towards a theoretical wisdom (*sophia*) and able to intuit the sources of intention (*nous*);
(i) heterogeneous plural practices (transdisciplinarity)—considering the diversity of sources of access to truth, which presupposes adopting knowledge and methodologies not exclusive to science, but also of the arts, traditions, philosophy, among others;
(j) wisdom and imagination—focusing on the development of wisdom and the promotion of imagination instead of focusing predominantly on the production and systematization of theoretical knowledge;
(k) acting in teams—considering the complexity and the necessary multifunctionality of the educator, it is considered necessary to act in teams. Even for the

richness of knowledges present in a group of learners and that can be put into service of such group (educators and learners);

(l) collective intelligence—considering at the same time individual learning and access to collective intelligence in a collaborative way through generative dialogues;

(m) group dynamics—understanding the functioning of groups to facilitate coexistence and make the most of the learning opportunities emanating from the diversity of situations that emerge from collective interaction;

(n) youth world—seeking to be attentive to the dynamics that involve the young age group in order to better interact and potentialize their capacities;

(o) designer of learning environments—aiming at the transposition of the condition of "teacher" to the condition of designer of environments for mediation of learning. Considering the need not to transmit preformatted knowledge, but to contribute to the development of the students' autonomy and creativity. This aspect requires the educator to be creative in structuring learning situations in diverse contexts, mixing theories, forged experiments to generate experiences—thinking about the concept of experience Josso (2010), which translates into the reflection on a given experience—inside and outside the institutional physical space.

The set of themes presented aims to bring some indicatives from the theoretical framework of the transdisciplinary approach, considering that these can be understood within a formative proposal under different prisms, whether in terms of contents, cross-cutting themes, guiding principles, methodologies, among others.

It should be stressed that the methodological proposal should allow the teacher in the training process to try out the 'transdisciplinary methodology'.

4 Conclusion

In view of the above, it is argued that the most adequate educational perspective to achieve success in the collective undertaking of planetary metamorphosis, to which we are called as a species, will be the one capable of promoting transformative learning in individuals and collective individuals. That is, capable of transforming premises, values and beliefs. That is, a perspective capable of altering the frames of reference that are proving inadequate to planetary sustainability, considering that planetary survival, in essence, depends on it, on the human capacity to perceive the complexity of phenomena and to learn for the roots of attitudes and transform them in a positive way. Thus, the conception of transdisciplinary education is presented as a perspective that would allow to encompass several of the aspects listed in this study.

But where and how to begin the metamorphosis in the face of the double-locking paradox, as Morin (2006) reminds us? How to transform people without transforming institutions, and how to transform institutions without transforming people?

Transformation needs to be leveraged somewhere in the system. According to Morin (2006), reform will emerge at a peripheral and marginal point of the system, from a minority perhaps misunderstood or even persecuted, until it is diffused and strengthened; that is, in order for the metamorphosis to happen, a "revolutionary engagement" will be necessary (Bauman 2001).

This study argues that the educational system is one of the points in the set of structuring systems of society with great revolutionary potential—not the only one, of course. And within this system, that transformation must be initiated by institutions of higher learning because, by nature, they constitute spaces of dissemination. In this case, not only because of the indication that is commonly attributed to them of dissemination of knowledge. This is of paramount importance, but in the contemporary context it is necessary to go further, fostering the awakening of people's wisdom and imagination, not the automated reproduction of the current normotic system.

It is essential that these institutions become spaces that allow people to reach higher levels of understanding about relationships with themselves, with others, with nature and with the cosmos. That they are capable of transforming premises (beliefs and values) incompatible with the clamor of the new times in premises compatible with the possibility of earthly survival.

I also believe that in higher education institutions, this process should begin with teacher training and the promotion of collective engagement with the knowledge of the various segments of society, on the central and most critical issues that afflict humanity—aspects that cause the university to assume a truthful and strong commitment to social transformation.

The formation of higher education educators must be aligned with the effective demands of contemporary society, based not only on the epistemological and methodological dimensions, but also ontological dimension in the formative processes. This involves, among others, the way in which the "being" perceives the "realities" and acts in the world, which presupposes, in a first instance, the understanding of "being" by the "being" itself.

The perspective defended here requires that teachers, besides an *episteme* and a methodology, adopt an ontology that involves a worldview and attitude to the realities in line with the transdisciplinary principles—which dismisses, on their part, going beyond the intellectual comprehension of a theory and a set of teaching techniques.

Moraes (2012, p. 82) affirms that new theoretical and epistemological contributions are needed to help ecologicalize the ontology, that is, the relationships of being with its reality, to better understand the relations between subject and object, as well as the methodological aspects related to the pedagogical practices adopted in education.

From the conception of education defended in this study, and considering even the principles brought by Morin (2001), the following elements are presented to the training of teachers of higher education: methodological congruence; multidimensionality of being; multidimensionality of relationships; attention to the unveiling of 'power from within'; meaningful learning; solidarity and civic culture; learning spaces; access to truths; heterogeneous plural practices (transdisciplinarity); wisdom

and imagination; acting in teams; collective intelligence; group dynamics; world of youth; designer of learning environments.

The intention of the propositional reflections presented is not to establish a complete and closed curriculum of what should be the formation of higher education teachers. Even because ready-made recipes do not exist in complex social contexts. Each individual and institution has their dynamics and their own moment, and the way the proposed elements will emerge will be affected by such constraints.

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An Enhanced Data-Analyses Method for the Graphical Assessment of Universities' Sustainability Image (GAUSI) Instrument: A Case Study in Federal University in Brazil

Gabriela Nicolino and Sergio Ricardo S. Barros

Abstract Universities can play a powerful role in the construction of a sustainable future through the education of next generations and by setting an example to society. According to the Higher Education Sustainability Initiative Declaration, universities bear responsibility to integrate sustainability strategies, research, teaching and campus practices. Thus, higher education institutions are positioned as key drivers for achieving the Sustainable Development Goals from the United Nations' 2030 Agenda. The Graphical Assessment of Universities Sustainability Image (GAUSI) instrument is a marketing tool, developed to incentivize and guide the incorporation of sustainability into universities' management. The GAUSI instrument presents how sustainable practices on campuses can build value to universities' image and reputation. This paper presents an enhanced data-analyses method developed for the GAUSI instrument, applied in a case study with students from the *Universidade Federal Fluminense*, in Rio de Janeiro. The objective is to allow a more accurate and visual assessment of investment prioritization in sustainability initiatives on campuses. The prioritization is based on the initiatives with greater contribution to an institution's sustainability reputation and overall attractiveness to stakeholders. The method applies the Paraconsistent Annotated Logic to process qualitative data, collected through a Likert scale questionnaire. The case study results provide UFF with an action-oriented outcome on how to prioritize, engage and advance sustainability initiatives on campus. It concludes that sustainability can add value to the university's brand image, while providing a more efficient tool for managers, administrators and marketing professionals.

Keywords University sustainability · Green marketing · Paraconsistent annotated logic · Sustainable development · Sustainability research

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1 Introduction: The Role of Higher Education in Achieving a Sustainable Future

On September of 2015, as the United Nations celebrated its seventieth anniversary, the organization publicized a new and ambitious agenda for sustainable development, meant to build on the Millennium Development Goals and to complete what these did not achieve. The declaration "Transforming our world: the 2030 Agenda for Sustainable Development" promoted the agenda for global action for the subsequent 15 years.

With a broad and comprehensive understanding of sustainability, the 2030 Agenda recognizes that eradicating poverty in all its forms and dimensions is the greatest global challenge and an indispensable requirement for sustainable development; hence, resolving to:

> end poverty and hunger everywhere; to combat inequalities within and among countries; to build peaceful, just and inclusive societies; to protect human rights and promote gender equality and the empowerment of women and girls; and to ensure the lasting protection of the planet and its natural resources. We resolve also to create conditions for sustainable, inclusive and sustained economic growth, shared prosperity and decent work for all, taking into account different levels of national development and capacities. (UN 2015, p. 6)

With unprecedented scope and significance, the 2030 Agenda consists of 17 Sustainable Development Goals (SDG) and 169 associated targets, which are integrated and indivisible. The SDG (Table 1) balance the three dimensions of sustainable development: economic, social and environmental, envisioning a world in which every country enjoys sustained and inclusive economic growth, with sustainable consumption and production patterns, respectful to the use of natural resources (UN 2015).

Effective public, public-private and civil society partnerships are key to achieve the Social Development Goals. Governments, organizations and companies have much to build on their previous experiences and, by aligning strategies, institutions can effectively work to transform society's current production and consumption patterns into sustainable ones.

Institutions, regardless of nature, have the responsibility to incorporate sustainability into management practices, to minimize their impact on the environment and society. It is essential and basic that institutions commit to the efficient use of natural resources and waste prevention, reduction and recycling, demanding the same in their business supply chain (UN 2015). In Goal 12, further crucial targets are exploited as necessary to sustainable production and consumption patterns, such as food waste reduction, environmentally sound management of chemicals, promotion of renewable energy sources by rationalizing inefficient fossil-fuel subsidies and, finally, to integrate sustainability in companies' reports.

Goal 4 addresses the educational disparity issue faced worldwide. The overall commitment of Goal 4 is to see that inclusive and equitable quality education at all levels is provided to all people, irrespective of sex, age, race, ethnicity or disabilities. Furthermore, education should ensure the teaching of sustainable development

Table 1 Agenda 2030 sustainable development goals

Goal 1	End poverty in all its forms everywhere
Goal 2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3	Ensure healthy lives and promote well-being for all at all ages
Goal 4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5	Achieve gender equality and empower all women and girls
Goal 6	Ensure availability and sustainable management of water and sanitation for all
Goal 7	Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 10	Reduce inequality within and among countries
Goal 11	Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12	Ensure sustainable consumption and production patterns
Goal 13	Take urgent action to combat climate change and its impacts
Goal 14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17	Strengthen the means of implementation and revitalize the global partnership for sustainable development

Source United Nations (2015)

knowledge and skills. This might include, among others, the education for sustainable lifestyles, human rights and gender equality; the promotion of a culture of peace and non-violence; and the appreciation of cultural diversity (UN 2015).

Although the Agenda 2030 urges several stakeholders, in addition to Governments themselves, to take action toward sustainable practices, it only subtly addresses the role and responsibility of educational institutions in this scenario. This issue was much deeply debated in the United Nations Conference on Sustainable Development (UNCSD), held in Rio de Janeiro in 2012. The UNCSD was commonly known as Rio+20, a follow up conference to the 1992 United Nations Conference on Environment and Development (UNCED) or ECO-92. The objective was also to assess the progress and renew the commitment to sustainable development, as a way to ensure the promotion of an economically, socially and environmentally sustainable future for present and future generations.

The UNCSD resulted in the renowned declaration "The future we want" (UN 2012), with clear similarities to the Agenda 2030. Heads of State and Government and high-level representatives' signatories recognized that poverty eradication, changing unsustainable and promoting sustainable patterns of consumption as the most urgent challenges to be addressed for sustainable development. It is also constantly stressed throughout the declaration the need for intrinsic balance between economic stability and growth, the promotion of social equity and the protection of the environment, namely, a green economy in the context of sustainable development and poverty eradication.

A framework for action and follow-up was elaborated, consisting of several thematic areas and issues as poverty eradication, food security, water and sanitation, energy, oceans and seas, health, employment and many others. One of these areas specifically addresses Education, concerning the right to quality education at all levels for all and the capability to:

> prepare people to pursue sustainable development, including through enhanced teacher training, the development of sustainability curricula, the development of training programmes that prepare students for careers in fields related to sustainability, and more effective use of information and communications technologies to enhance learning outcomes. (UN 2012, p. 44)

Therefore, it is essential that educational institutions integrate sustainable development into education, by teaching and adopting good practices in sustainability management. Moreover, Universities and higher education institutions, particularly, should promote and incentivize research and innovation for sustainable development in every field, forming professionals able to advance national sustainable development objectives (UN 2012). So, on the occasion of the Rio+20, the Higher Education Sustainability Initiative (HESI) was established by a group of UN partners, including the Executive Coordinator of Rio+20, UN DESA, UNEP, UNESCO, UN Global Compact. HESI consisted of the signature of a common declaration for sustainable development, where institutions agreed to support five basic actions:

- Teach sustainable development concepts, as a part of the core curriculum across all disciplines, also being encouraged to provide sustainability training to professionals and practitioners.
- Encourage research on sustainable development issues, to improve scientific understanding and to enhance the development, adaptation, diffusion and transfer of knowledge and innovative technologies.
- Green the campuses, by working on the institution's environmental footprint, supply chains and catering services practices, sustainable mobility options for students and faculty, waste minimization and recycling programs, thus encouraging more sustainable lifestyles.
- Support sustainability efforts in local communities, for better quality of living, resource-efficiency, social inclusiveness and smaller environmental footprints.
- Engage with and share results through international frameworks, in order to exchange knowledge and experiences and to report regularly on progress and challenges (UNESCO 2012).

2 The Graphical Assessment of Universities' Sustainability Image (GAUSI) Instrument

The GAUSI instrument is a quantitative research tool to collect primary data. It is a marketing research tool designed to assess a university's perceived commitment to sustainability practices, illustrating its image as a sustainable institution. The GAUSI instrument has a particular data-analyzes method, constructed to create a prioritization criterion for the sustainability initiatives which the University should engage, based on the improvement of the institution's attractiveness for the interviewed stakeholder groups (Nicolino 2016).

Once the stakeholder group for the research is defined, the GAUSI interviewing method involves three steps: to assess which sustainability initiatives are perceived as (1) the initiatives more important for sustainability; (2) the initiatives more relevant in deciding which university to attend/work; and (3) the initiatives their university is more committed to. The results obtained through these three steps denotes what constructs the ideal image of a sustainable university; plus, what represents a competitive advantage in the higher education environment; finally compared to how the institution's commitment to sustainability is perceived. This method of comparing different answers to a single questionnaire list was inspired by the work of Terkla and Pagano (1993), who proposed a list of semantic differential response options for assessing universities' characteristics.

2.1 The GAUSI Questionnaire

The questionnaire (Table 2) is composed by a list of sustainability practices, sided by a classic five-point Likert scale: strongly disagree (SD), disagree (D), neutral (N), agree (A) and strongly agree (SA). On the questionnaire, respondents assess their level of agreement to three different stem statements:

(1) *Sustainable universities should be strongly committed to*:
(2) *When deciding at what university to attend, I find these initiatives important*:
(3) *I feel my university is strongly committed to*:

The questionnaire's list is composed of 23 sustainability initiatives, specifically designed to concern universities' management. The items are categorized into Assessment and Reporting (A&R), Education and Research (E&R), Campus Operations (COp), and Community Outreach (COr), complying with the principles proposed by the Higher Education Sustainability Initiative Declaration (UNESCO 2012). This list was inspired in Nejati and Nejati's (2013) instrument to assess universities' perceived engagement with sustainability initiatives. The list was adapted and reordered to fit the purpose of the GAUSI instrument.

Table 2 List of universities' sustainable practices for Graphical Assessment of Universities' Sustainability Image (GAUSI)

	Item		SD	D	N	A	SA
1	Regular sustainability audits on campus	A&R	( )	( )	( )	( )	( )
2	Sustainability audits of the surrounding community	A&R	( )	( )	( )	( )	( )
3	Creating a written statement of the university's commitment to sustainability	A&R	( )	( )	( )	( )	( )
4	Creating written statements of each department's commitment to sustainability	A&R	( )	( )	( )	( )	( )
5	Incorporate social/environmental responsibility concepts into all relevant disciplines	E&R	( )	( )	( )	( )	( )
6	Policies for hiring and promoting faculty based on their knowledge of and work in sustainability	E&R	( )	( )	( )	( )	( )
7	Supporting students who seek environmentally and socially responsible careers	E&R	( )	( )	( )	( )	( )
8	Requiring potential social/environmental impact analyses of research conducted on campus	E&R	( )	( )	( )	( )	( )
9	Arranging opportunities to study campus and local sustainability issues	E&R	( )	( )	( )	( )	( )
10	Incentivizing participation in socially/environmentally friendly activities	E&R	( )	( )	( )	( )	( )
11	Aiming for self-sufficient campus operations	COp	( )	( )	( )	( )	( )
12	Reduction of university's ecological footprint	COp	( )	( )	( )	( )	( )
13	Optimized and sustainable campus land-use	COp	( )	( )	( )	( )	( )
14	Intelligent and sustainable campus building planning	COp	( )	( )	( )	( )	( )
15	Usage of renewable and safe energy sources, like solar panels	COp	( )	( )	( )	( )	( )
16	Reutilization of campus waste	COp	( )	( )	( )	( )	( )
17	Environmentally and socially responsible purchasing practices	COp	( )	( )	( )	( )	( )
18	Consulting students/faculty/employees' opinions on campus sustainability issues	COp	( )	( )	( )	( )	( )
19	Easy transportation to, from and between campuses	COp	( )	( )	( )	( )	( )
20	Organizing social and environmental community outreach programs	COr	( )	( )	( )	( )	( )
21	Encouraging participation in social/environmental volunteer activities around the community	COr	( )	( )	( )	( )	( )
22	Creating/sponsoring green community centers to benefit the local environment	COr	( )	( )	( )	( )	( )
23	Partnerships with government, non-governmental organizations, and industry working toward sustainability	COr	( )	( )	( )	( )	( )

Source Nicolino and Barros (2016), p. 203

3 A Case Study Applying the GAUSI Instrument in a Federal University in Brazil

This study was conducted within *Universidade Federal Fluminense* (UFF), a federal university located at the city of Niterói, Rio de Janeiro, Brazil. UFF was created in 1960, out of the conjunction of several federal and state higher education schools already existent in the city (Monteiro and Azevedo 2009). For its history, there are different campuses spread through the city of Niteroi, blending into the city community. The university is structured with three major campuses, which concentrate most schools—*Campus Gragoatá*, *Campus Praia Vermelha* and *Campus Valonguinho*—and some complementary isolated units within the city and in the countryside of Rio de Janeiro state.

Second largest campus of UFF, with over 3000 students, the *Campus Praia Vermelha* houses the Schools of Engineering and Architecture, and the Institutes of Physics, Computer Science and Geoscience. The campus architecture was conceived so a central square connects all its buildings, which are aligned east-west, optimizing sun lightning and ventilation in the campus. Parking lots are located on both east and west entrances, with access to the main public roads, but preventing circulation of privet vehicles inside the campus. Internal service roads connect the buildings and were projected to not intersect with pedestrian circulation routes. All buildings can be reached through the pedestrian pathways and are walking distance from each other (Monteiro and Azevedo 2009).

Due to the great dynamic of knowledge and people circulation inside the campus, and the vast diversity of higher education courses, the *Campus Praia Vermelha* was considered adequate for investigating the institutional image of the *Universidade Federal Fluminense* regarding its commitment to sustainability.

3.1 Sampling, Interviewing and Data Tabulation

For the purpose and viability of this study, Environmental Engineering and Environmental Science bachelor students were selected as the interviewed study group. These graduation courses provide students with a higher sensibility and awareness to sustainable development, which is believed to make them simultaneously more engaged with the research and more critical at the university evaluation.

Respondents were selected through convenience sampling, according to their presence in class, with no previous probabilistic intention regarding age, gender or entrance year in the university. This no-probability sampling method is commonly used in questionnaire application studies, due to the respondents' willingness and availability to participate (Anderson et al. 2011). This could induce results prone to bias, although no student in this study refused to participate.

A printed questionnaire was applied in classes attended by both Environmental Engineering and Environmental Science students. An introduction of the study and

brief explanation of the questionnaire's dynamic was required before initiating the interviews. Following, there was no interviewer-respondent interaction and students completed the questionnaires individually. Each application session demanded from fifteen to twenty minutes. In total, three sessions were conducted, with 80 students interviewed.

Additionally, a weblink was provided to absent students interested in the research. The digital questionnaire was hosted at the SurveyMonkey platform, where 56 extra students participated. The responses were analyzed regarding the individual sustainability initiatives, and concerning the A&R, E&R, COp and COr categories for a clearer overall understanding of the strengths and weaknesses of the university's sustainability image.

A total of 136 students were interviewed. According to UFF's Transparency System (https://app.uff.br/transparencia/inscricoes_por_curso), there are 117 active students in the Environmental Science bachelor course and another 381 in the Environmental Engineer bachelor. This provides this study with a total statistic population of 498 students, which represents a 6% margin of error, with 90% confidence level.

The interviewed group was composed by of bachelor students from both the Environmental Science and the Environmental Engineer degrees (Fig. 1), representing 81 and 19% of total interviewed students respectively. Their entrance year at the university varied from 2011 to 2018 (Fig. 2).

The balanced variety of entrance year of the respondents provides a representative interpretation of the institutional image of UFF. This image is composed by perceptions ranging from freshmen students, with an outsider perspective and high expectations for the university, to graduating students with a vast experience through all difficulties and highlights of their university years at the institution.

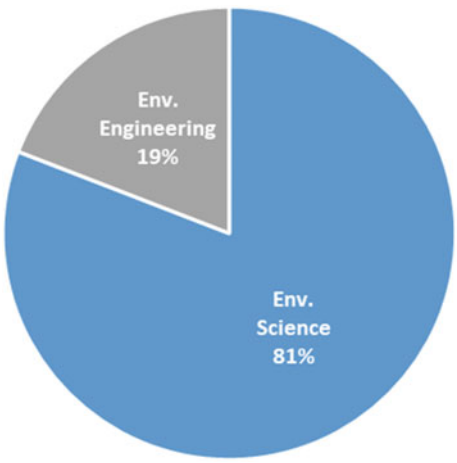

Fig. 1 Bachelor's degree of respondent students

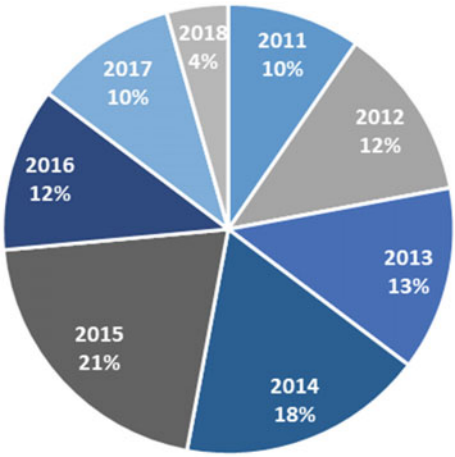

Fig. 2 Entrance year respondent students

3.2 Proposed Data-Analyses Method: Prioritization Criterium

For the prioritization criterium, results are analyzed separately for each stem statements (1), (2) and (3), which allows to observe the divergency in responses to the same sustainability initiative. The data relates to the answers considering the Likert scale: strongly disagree (SD), disagree (D), neutral (N), agree (A) and strongly agree (SA). To avoid controversy in valuing the Likert scale as an ordinal or interval scale, the collected data is interpreted by calculating the level of agreement to each item of the questionnaire, through the Paraconsistent Annotated Logic (PAL), as Sanches et al. (2011) proposed to be applied in qualitative analyzes with Likert scale.

The items of the questionnaire are interpreted as prepositions (p), to which respondents assess their level of agreement to the stem statements. To each preposition (p) a Disagreement (Dp) and Agreement (Ap) are calculated, generating an overall Level of Agreement (LAp). These values are calculated using the data from the questionnaire, where:

i. $D_p = SD + D + \frac{N}{2}$

ii. $A_p = SA + A + \frac{N}{2}$

iii. $LA_p = 100 - \left[100 : \left(\frac{A_p}{D_p} + 1\right)\right]$

The LAp value varies in an interval of [0; 100]. The calculation for the indicator LAp does not consider unanswered questions, thus there is no need to discard incomplete questionnaires. The same mathematical principle can also be applied

to the categories A&R, E&R, COp and COr of the questionnaire, known as factors in the Paraconsistent Logic, therefore calculating their own Disagreement (DF), Agreement (AF) and overall Level of Agreement (LAF).

As results are analyzed separately to the stem statements (1), (2) and (3), to each item of the questionnaire is calculated the respective level of agreement LAp1, LAp2 and LAp3, which are interpreted as follows:

– LAp1—perceived relevance of the item in the construction of a sustainability image for universities;
– LAp2—perceived relevance of the item in universities attractiveness;
– LAp3—perceived commitment to the item by the university investigated.

The level of agreement LAp1, LAp2 and LAp3 for each sustainability initiative, calculated with the data collected in this research, is further presented in Table 4; together with the prioritization criterium.

The prioritization criterium is based on identifying the items with greater contribution to the university's sustainability image and attractiveness—higher LAp1 and LAp2—and with lowest perceived commitment by UFF—lower LAp3. Those items would represent more room and opportunity for UFF to gain branding value and to build a sustainability reputation by engaging with these initiatives.

To calculate the prioritization criterium it is first necessary to unify LAp1 and LAp2 into the Sustainability Attractiveness indicator (SAt), whilst LAp3 is interpreted as the University Image indicator (UnI). Therefore, it is possible to calculate de divergency gap between both indicators, resulting in the factor of prioritization P. P is calculated for each item of the questionnaire by:

iv. $P = SAt - UnI$, where:

v. $SAt = \left(LA_{p1} + LA_{p2}\right) : 2$

vi. $UnI = LA_{p3}$

Value of P varies in an interval of $[-100; 100]$ and can be interpreted by Table 3, proposing a classification into levels of priority. Negative value of P is not divided in intervals, as negative P ($0 \geq P$) is not considered a priority.

The prioritization criterium calculation for the results of this study are presented in Table 4, where the sustainability initiatives are identified by their item numbers, sided by their category. There are also presented the calculated level of agreement to each stem statements (1), (2) and (3), and their consequential Sustainability Attractiveness indicator (SAt), University Image indicator (UnI), factor of prioritization P and level of priority.

Although no item was considered of strategic priority, out of the 23 university sustainability initiatives, eleven were considered of high priority and eleven were considered of moderate priority. In comparison, only one was categorized of low

Table 3 Level of priority by value of *P*

Value of *P*	Level of priority
$P > 80$	Strategic
$80 \geq P > 60$	High
$60 \geq P > 40$	Moderate
$40 \geq P > 20$	Low
$20 \geq P > 0$	Lowest
$0 \geq P$	Non-priority

Source Nicolino (2016), p. 92

Table 4 GAUSI prioritization criterium applied to the case study results

No.	Category	LAp1	LAp2	LAp3	SAt	UnI	*P*	Level of priority
13	COp	98.48	97.71	23.46	**98.10**	**23.46**	74.64	High
1	A&R	96.18	92.25	21.15	**94.22**	**21.15**	73.06	High
11	COp	96.95	96.56	24.81	**96.76**	**24.81**	71.95	High
14	COp	94.27	95.38	23.85	**94.83**	**23.85**	70.98	High
16	COp	98.47	98.09	27.91	**98.28**	**27.91**	70.38	High
2	A&R	87.31	87.50	17.31	**87.40**	**17.31**	70.10	High
15	COp	95.83	96.18	28.08	**96.01**	**28.08**	67.93	High
17	COp	91.92	92.69	25.78	**92.31**	**25.78**	66.53	High
22	COr	91.09	93.85	27.31	**92.47**	**27.31**	65.16	High
18	COp	96.15	96.15	31.40	**96.15**	**31.40**	64.76	High
3	A&R	90.77	91.86	31.30	**91.31**	**31.30**	60.02	High
4	A&R	83.08	86.05	25.38	**84.56**	**25.38**	59.18	Moderate
20	COr	93.89	96.18	36.82	**95.04**	**36.82**	58.22	Moderate
8	E&R	87.79	90.00	34.11	**88.89**	**34.11**	54.78	Moderate
21	COr	95.77	93.89	42.75	**94.83**	**42.75**	52.08	Moderate
23	COr	87.40	88.85	36.92	**88.13**	**36.92**	51.20	Moderate
9	E&R	98.85	97.33	46.90	**98.09**	**46.90**	51.19	Moderate
7	E&R	90.08	93.85	41.09	**91.96**	**41.09**	50.88	Moderate
12	COp	78.24	82.69	29.77	**80.47**	**29.77**	50.70	Moderate
6	E&R	73.46	81.15	29.07	**77.31**	**29.07**	48.24	Moderate
10	E&R	95.83	95.04	53.10	**95.44**	**53.10**	42.33	Moderate
19	COr	96.51	97.69	55.04	**97.10**	**55.04**	42.06	Moderate
5	E&R	95.42	96.54	64.89	**95.98**	**64.89**	31.09	Low

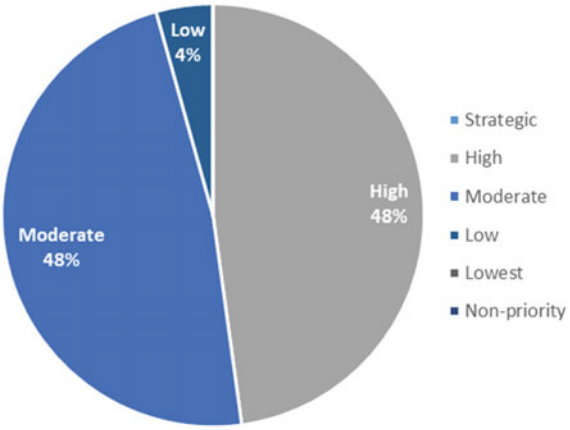

Fig. 3 Results distribution of level of priority

priority, whilst non was considered of lowest or of non-priority for UFF to engage with (Fig. 3).

This result displays a serious scenario for the university to be credited as a sustainable institution, with students considering that UFF is not significantly committed to any of the sustainability initiatives. On the other hand, it might also present some great opportunities for the university to start a new program for Campus Sustainability, as it can easily be observed that the 'Campus Operations' category stands out in the prioritization criterium, while the 'Education and Research' category is the best evaluated by students.

3.3 Graphical Representation Outcome

The proposed graphical representation for the GAUSI instrument is presented in Fig. 4, displaying the obtained results for this study. This representation facilitates the understanding of the prioritization criterium, with a visual illustration of the gap between the Sustainability Attractiveness indicator (SAt) and the University Image indicator (UnI) for each sustainability initiative. The items with a wider gap between SAt and UnI, have higher level of priority, meaning they are considered as of great potential to contribute to the sustainability image and attractiveness of UFF, but perceived with low engagement by the institution at this present moment. Therefore, these items with higher level of priority present opportunities for the university to efficiently build its sustainability image with its stakeholders.

From a marketing perspective, this gap between the Sustainability Attractiveness indicator (SAt) and the University Image indicator (UnI) can be interpreted as a Brand identity versus Brand image of UFF, respectively. Considering UFF is interested in positioning its brand as a sustainable university, differentiating itself from other institutions and creating a unique and meaningful brand value, SAt indi-

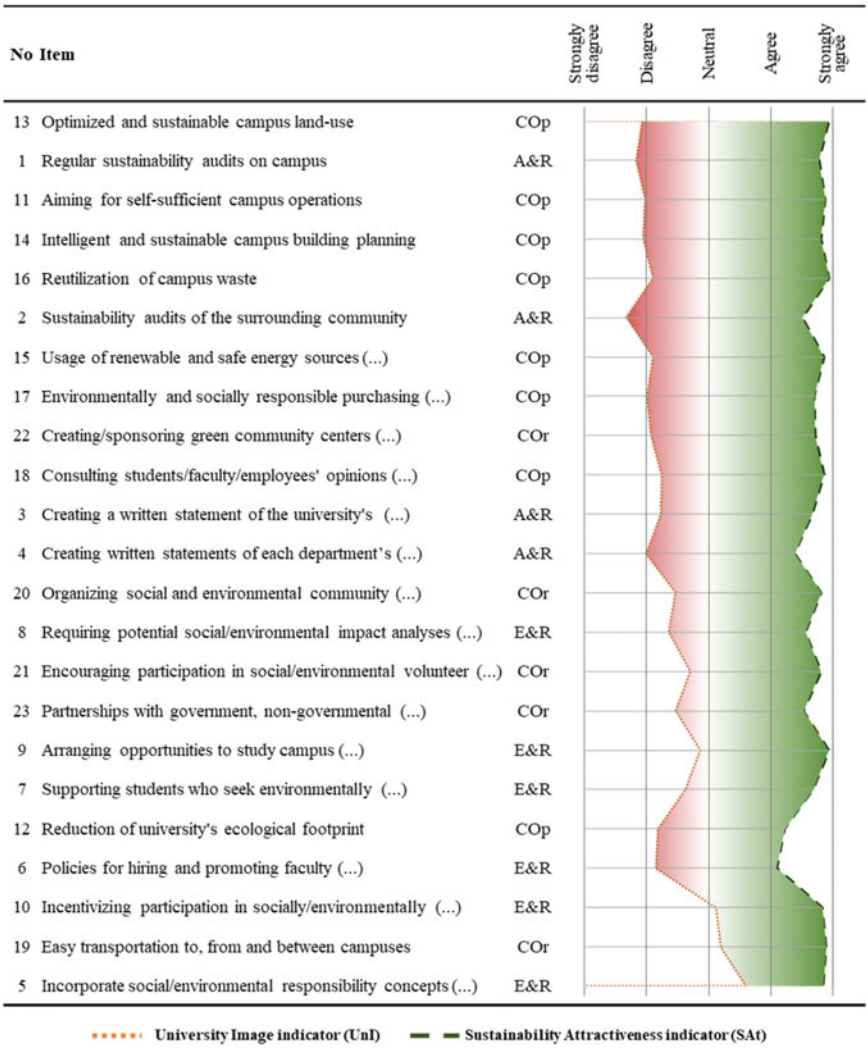

Fig. 4 Graphical representation of results with the GAUSI instrument

cator can be considered as how UFF aspires to be perceived, therefore, its Brand identity (Sääksjärvi and Samiee 2011). On the other hand, UnI indicator represents how stakeholders perceive the university concerning sustainability, which constructs UFF's Brand image (Keller 1993).

From the graphical representation of results in this case study (Fig. 4), it can be observed that only one item of the Campus Operations category is not on the top 10 priority sustainability initiatives to engage to. The initiatives in this category presented some of the highest SAt indicators, in agreement with the findings of

Wright and Wilton (2012), that identified a great influence of the environmental component in the concept of sustainability, especially regarding resource and waste management. Combined with the low UnI indicators for perceived engagement of UFF with these items, the Campus Operations category is strategic for UFF to start a sustainability marketing plan.

It is important to highlight that UFF's perceived low engagement to campus sustainability could be due to several reasons: for once, there could actually be an absence of sustainability initiatives to optimize and reduce the impact of campuses activities. It is also possible that students perceive any existing initiatives as ineffective. Another possibility is that the steps taken by the university in this direction are not being efficiently communicated to stakeholders, who are unaware of the sustainability efforts taken by UFF.

In any case, as the GAUSI instrument is a marketing tool, it aims improve the sustainability image of UFF, which composed by how stakeholders perceive that university's sustainability efforts. Therefore, the action plan designed by the institution to improve its Brand sustainability image should include furthering the existent sustainability initiatives, introducing new ones, but also developing a thorough communication plan to engage stakeholders in this sustainability project and make them aware of the initiatives on campus.

Education and Research was the best evaluated category concerning UFF's engagement to sustainability. This represents students are aware of UFF's ideological alignment to sustainability and aspiration to promote sustainable development; but they do not perceive this ideology incorporated in the institution's management or activities, as per the evaluation of the other categories.

3.4 Reliability

The Paraconsistent Annotated Logic with annotation of 2 values (PAL2v) is used in this research for data analyses and, consequently, it was also applied for data reliability calculation, as proposed by Sanches et al. (2011). The PAL2v system of logical signals offers an appropriate treatment to contradictory information, appropriate to identifying the presence of uncertainty in a database (Da Silva Filho 2011).

The PAL2v analysis is based on calculating a Certainty Degree (D_c) and Contradiction Degree (D_{ct}) for the obtained data. The Certainty and Contradiction Degrees form an ordained pair (D_c; D_{ct}) to be placed on the Cartesian plane. D_c and D_{ct} are calculated by the following mathematical sentences, which are thoroughly explained in Sanches et al. (2011) work about PAL2v:

i. $D_c = \mu_{1R} - \mu_{2R}$

ii. $D_{ct} = \mu_{1R} + \mu_{2R} - 1$

These sentences provide the ordained pair (D_c; D_{ct}) is positioned in a reticulate on the Cartesian plane which forms four extremity vertices, as represented in Fig. 5. For this analysis, the vertices' limits were defined by the control-value of |0, 5|. The vertices' areas attribute the following logical values to the analyzed data: True (t), False (f), Inconsistent ($\top$) or Indeterminate ($\bot$). Thus, the reliability of the data is given through the position of the ordained pair (D_c; D_{ct}) in the Cartesian plane.

The Certainty Degree D_c (horizontal axis) relates to the logical values of "truth" and "falseness", which reflects the level of agreement obtained in the Likert scale questionnaires. Whilst, the Contradiction Degree D_{ct} (vertical axis) assigns either "Inconsistency" or "Indetermination" to the data obtained by the questionnaire; Therefore, it is necessary that (D_c; D_{ct}) is not placed at the extreme states $\top$ and $\bot$ for the data to be considered reliable.

For the purpose of this research, the reliability was calculated separately to each questionnaire for stem statements (1), (2) e (3). Initially a degree of belief $\mu 1$ and disbelief $\mu 2$ was calculated for each questionnaire factor (categories A&R, E&R, COp and COr), with the Likert scale responses. The agreement and disagreement in responses are considered as favorable or unfavorable evidences (Sanches et al. 2011).

i. $\mu_1 = \text{Agreement (Ap)}/Total\ number\ of\ responses$

ii. $\mu_2 = \text{Disagreement (Dp)}/Total\ number\ of\ responses$

As $\mu 1$ e $\mu 2$ were defined for each factor/category data, it was then calculated a resultant $\mu 1$R e $\mu 2$R for the full questionnaire data, through a four-factor diagram of logical connectives for maximization OR and minimization AND (Fig. 6). Finally, $\mu 1$R e $\mu 2$R were used to achieve the Certainty Degree D_c and Contradiction Degree D_{ct} (Nicolino 2016), as referenced above.

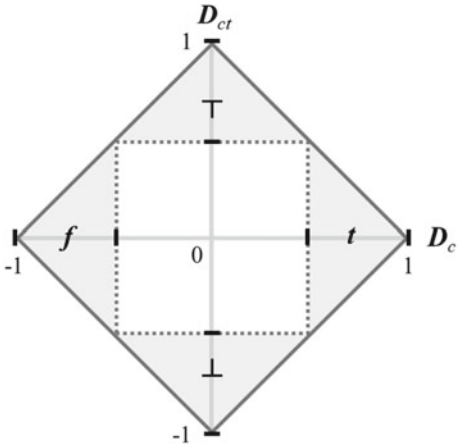

Fig. 5 Representation of PAL2v extreme logical states in the Cartesian plane. *Source* Nicolino (2016), p. 77. Adapted from Portuguese to English

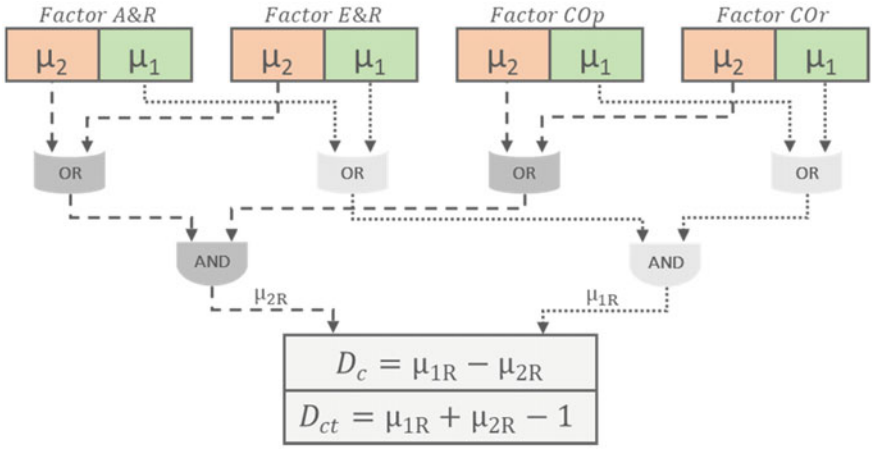

Fig. 6 Four-factor diagram of logical connectives OR and AND. *Source* Nicolino (2016), p. 80. Adapted from Portuguese to English

Table 5 presents D_c and D_{ct} obtained for the stem statements (1), (2) and (3) in this research, with the purpose of analyzing the reliability of the data through the PAL2v method. It is also exposed the calculated degree of belief $\mu 1$ and disbelief $\mu 2$ to each categories A&R, E&R, COp and Cor; and finally, the resultant $\mu 1$R e $\mu 2$R for each questionnaire, so D_c and D_{ct} could be obtained.

The final graphic results are presented in Fig. 7, showing the data for all the three questionnaires are reliable, and therefore were considered acceptable in this research. Ordained pairs (D_c; D_{ct}) for stem statements (1) and (2) are both located in the extreme state $\boldsymbol{f}$, with logical value of truth. This means these stem statements received a high level of agreement in the Likert scale questionnaire. Their (D_c; D_{ct}) are also positioned in the central area of the chart, away from extreme states $\top$ and $\bot$, representing reliable data.

Ordained pair (D_c; D_{ct}) for stem statement (3), evaluating UFF's perceived commitment to university sustainability, was not placed in one of the extremity vertices. The logical value accessed is of almost falseness, tending to inconsistency (Sanches et al. 2011), which reflects the students' light disagreement to the items in stem statement (3) questionnaire. However, the Ordained pair (D_c; D_{ct}) does not indicate relevant inconsistency or indetermination, therefore data for this questionnaire was also considered reliable and accepted in the research.

Table 5 Certainty degree D_c and contradiction degree D_{ct} calculated for data reliability

	(1)				(2)				(3)			
Factor	μ_2	μ_1	μ_{2R}	μ_{1R}	μ_2	μ_1	μ_{2R}	μ_{1R}	μ_2	μ_1	μ_{2R}	μ_{1R}
A&R	0.893	0.107	0.080	0.903	0.894	0.106	0.080	0.903	0.238	0.762	0.700	0.360
E&R	0.903	0.097			0.923	0.077			0.449	0.551		
COp	0.941	0.059	$\boldsymbol{D_c}$	$\boldsymbol{D_{ct}}$	0.941	0.059	$\boldsymbol{D_c}$	$\boldsymbol{D_{ct}}$	0.300	0.700	$\boldsymbol{D_c}$	$\boldsymbol{D_{ct}}$
COr	0.920	0.080	**0.823**	**−0.018**	0.920	0.080	**0.855**	**−0.009**	0.920	0.080	**−0.340**	**0.060**

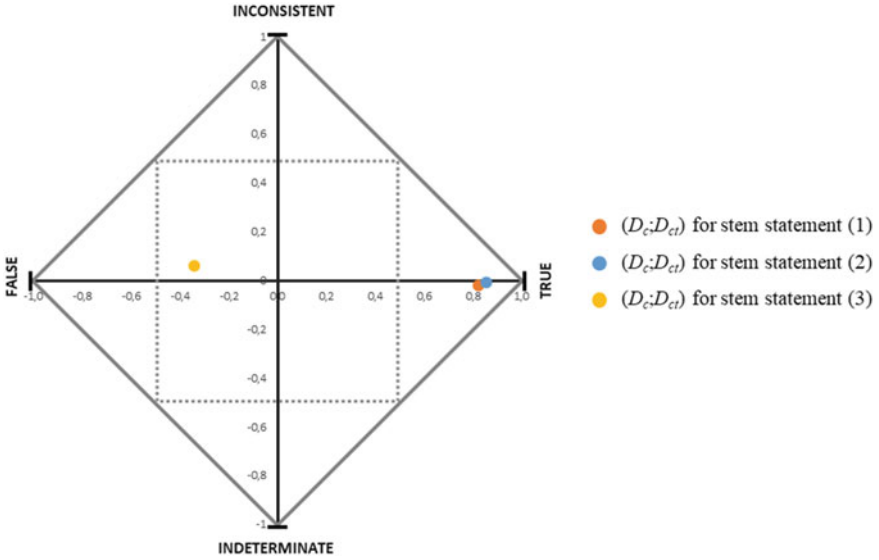

Fig. 7 Reliability analysis through PAL2v in the Cartesian plane

4 Conclusion: Sustainability as an Asset in Universities' Brand Image and Attractiveness

In pace with the growth in society's sustainability awareness, the results of this research present students are more conscious, critical and engaged with sustainable development. The GAUSI instrument faced students with all the aspects of university sustainability, to which all items were considered relevant and attractive in a higher education institution.

The overall level of agreement to the attractiveness of sustainable initiatives in a university to students was of 89% to Assessment and Reporting (A&R) category; 92% to Education and Research (E&R); 95% to Campus Operations (COp); and finally, 93% to the Community Outreach (COr) category. Figure 8 presents the level of agreement calculated for the stem statements (1), (2) and (3) out of the obtained results.

On the other hand, results also show it will require a significant effort by UFF to be perceived as a sustainable university, as its commitment to most sustainability initiatives was evaluated as neutral or negative. While Education and Research category stands out as better evaluated with 45% level of agreement, Assessment and Reporting only scored 24%; Campus Operations and Community Outreach categories respectively got 30 and 36% level of agreement.

These results are reflected in the prioritization outcome, that reveals 48% of the initiatives are of moderate priority, while another 48% are of high priority for the university to construct a sustainability institutional image. Although A&R category

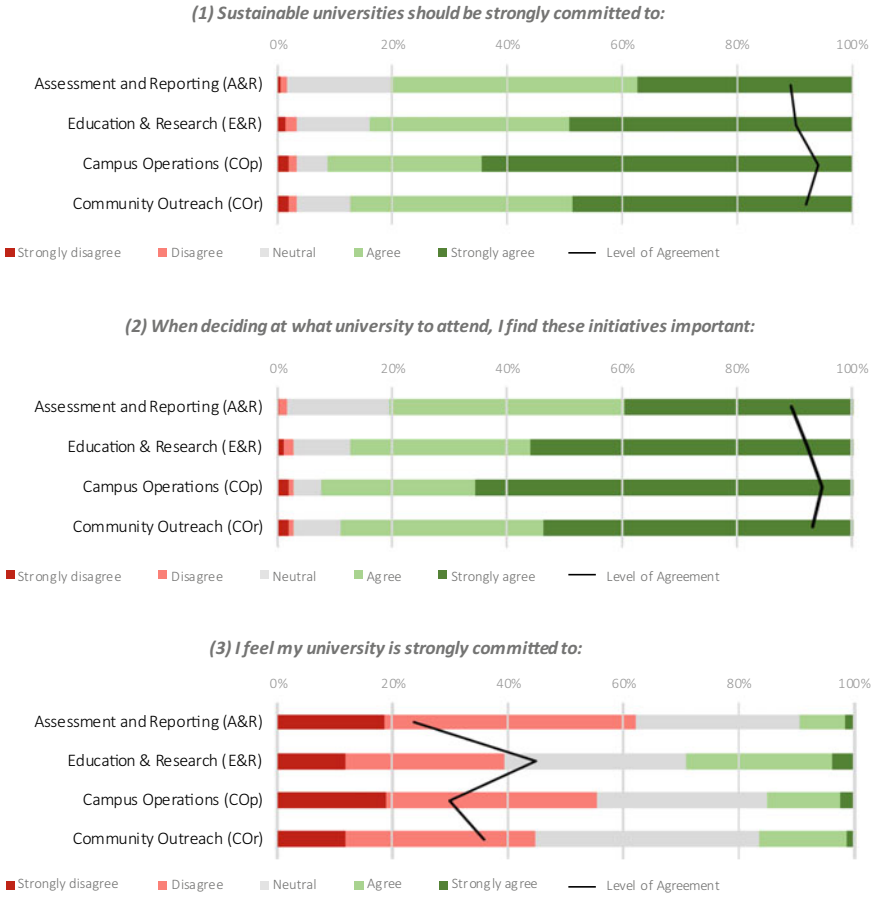

Fig. 8 Categories' level of agreement results for stem statements (1), (2) and (3)

received the worst evaluation by students, the prioritization criterium suggested the Campus Operations initiatives should be prioritized by UFF. By combining the results obtained to stem statements (1), (2) and (3), the prioritization criterium shows sustainability initiatives in this category should be the ones to better contribute to the brand image and attractiveness of UFF, as they present higher Sustainability Attractiveness (SAt) indicator and simultaneously lower University Image (UnI) indicator.

This enhanced data-analyses method for the GAUSI instrument provided a more accurate prioritization criterium for administrators to interpret which sustainability initiatives have greater impact in the sustainability image of the university. Results present a customized guide for the institution to initiate or further introduce sustainability into management and administration, efficiently building their sustainability image. The method incorporated the perspective of the university's stakeholders into management's decisions, engaging and valuing students' opinion. Hence, the

institution can maximize the awareness of sustainability initiatives implemented on campus.

For the purpose and viability of this research, a limited number of students were interviewed, according to internal policies of UFF. This number provides statistical consistency concerning the Environmental Science and Environmental Engineering departments. As most of the Campus bachelor's degrees incorporates sustainable development concepts in the curricula, it is believed that the sample group in this research provides an insight into students' perceptions of the university. For a more comprehensive analysis of UFF's institutional image, it would be interesting to complement this study by also investigating the perceptions of other stakeholder groups.

It is important to establish that as a marketing tool, the GAUSI instrument and analyses-method provided the prioritization criterium outcome in this research based on an item's impact into the university's institutional image and attractiveness. The results do not take into account the social and/or environmental impact, positive or negative, that each sustainability initiative would generate. Furthermore, the prioritization criterium outcome disregard the financial investment necessary to implement, advance or maintain each of the sustainability initiatives. It is then suggested that a complementary analysis is conducted verifying the economic viability of the items, compared to the available investment budget.

Finally, by showing universities the value of sustainability into improving their attractiveness, this research and proposed analyses-method intends to incentivize higher education institutions to embrace and engage with sustainability efforts, by teaching, experiencing and promoting sustainable development to students, staff, faculty members and their community.

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Comparative Analysis of Sustainable Practices/Innovations Between University of Pretoria, Gauteng and University of Venda, Limpopo

Emma Eudine Mukwevho and Mucha Togo

Abstract Universities have become crucial in dealing with environmental challenges facing the world. Their role is fundamental in addressing environmental issues firstly due to the impact that the institutions have on the environment and secondly due to their massive potential as custodians of education, research and community development. Their role in sustainable development has been reiterated through various global agendas with one of the latest being the Sustainable Development Goals (SDGs). The role of education is mentioned in several SDGs especially SDG 4. This study was undertaken to unpack and understand the contribution of universities to Sustainable Development based on two South African universities with different histories and socio-economic contexts. The research was undertaken at the University of Venda, a former black university situated in the poor Limpopo province of South Africa and at the University of Pretoria, a former white institution located in Pretoria, the country's administrative capital city in the Gauteng Province. The study focused on sustainable development initiatives employed in university operations, research and community engagement only. The scope of the research (especially time limitations) did not allow inclusion of initiatives in other university functions. Qualitative data collection methods were employed, such as interviews and site observations. Analysis of the data was basically through a comparative analysis of implemented initiatives based on quantity, stage of implementation, the focus and types of initiatives, and the scale of implementation. Critical realist structure/agency stratification of reality was employed as an analytic frame for further interpretation of the results to establish how these two strata influenced the sustainability initiatives at the two institutions. A number of practices were identified at each of the institutions. The practices however differed in terms of focus and the scale of implementation. The University of Pretoria has numerous partnerships in research which has led to fundamental developments in tackling environmental issues both in its context and other

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contexts. The University of Pretoria has also committed resources to making its operations more sustainable which can be seen in its water and energy management practices which are aimed at conservation. The University of Venda is restricted in its research outputs but has focused on addressing issues that affect its local community. Sustainable initiatives at The University of Venda are aimed more at resolving its lack of resources, developing ways to attain resources in a sustainable manner. The influence of structure was quite clear especially in terms of the scale of implementation and allocation of resources. The capacity of agents is then limited by what is possible or is given priority at the level of the structure.

Keywords Sustainability in higher education · Environmental management · Campus greening · Sustainability practices · Critical realism

1 Introduction

Addressing mounting environmental pressures rising from high population growth, economic activities and the associated increased rate of consumption has become an important agenda for the world. The environmental crisis is quiet extensive ranging from increasing pollution, loss of habitats, loss of biodiversity, diminishing resources and increased greenhouse gas emissions. There is an overriding view from scientists that in order to prevent further degradation, and to prevent further increases in emissions, organizations, industries and governments must adopt sustainable practices and commence mitigation actions (Stern 2006). In 2015, UN member states adopted agenda 2030 on sustainable development, which is an agenda for people planet and prosperity and is to be implemented by all countries and stakeholders in collaborative partnerships (Dhlamini 2017). The call was made for all activities within developments to be sustainable and this translated to universities as well as they have significant environmental impacts associated with their activities and complex operations.

Sustainability in higher education is not a new concept. Since 1990, 300 university signed the Talloires Declaration (UNESCO 1990a, b). The Swansea Declaration was developed in 1993 (UNESCO 1993) and in Rio de Janeiro in 2012, education for sustainable development was placed on the global agenda by the United Nations (UN). The Kyoto protocol also challenged higher education to integrate sustainability into student education and within community outreach and was adopted by 90 universities around the world (Anderberg et al. 2009). The Global Action Plan on Education for Sustainable Development (ESD) is a follow-up programme aimed at strengthening education and learning in all agendas, programmes and activities that promote sustainable development, ultimately contributing substantially to the 2030 agenda (UNESCO 2019).

Under the mounting pressure, Universities have become more inclined to adopt environmentally sustainable practices into their activities and environments. A sustainable university is defined by Velazquez et al. (2006, p. 812) as “A higher edu-

cational institution, as a whole or as a part, that addresses, involves and promotes, on a regional or a global level, the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources in order to fulfill its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyles". Many more authors dissected what a sustainable university is and explained its role in sustainable development (Alshuwaikhat and Abubakar 2008) and (Ryan et al. 2010).

A great number of universities that committed to sustainability have focused more on environmental management; more specifically making the campus greener. The greening of the campus can be tracked back to North America where Higher Education has made great advances in implementing sustainability within university sites through management and administration (Wright and Elliot 2011). Canadian universities have played a role in propelling efforts across the world; and this can be attributed to the 2008 Higher Education Sustainability Act (HESA) which promulgated the university sustainability grant program (Wright and Elliot 2011). In 2010, $50 million was budgeted to support the implementation of major campus sustainability initiatives.

The United States of America (USA) has also been at the forefront of sustainability in higher education and there are many examples of good practices. The University of Michigan restrained pollution since 1998 within its campus. The university joined the Green Lights Program initiatives to promote more effective use of energy (Callewaert and Marans 2017). Students get to go on summer practices in agriculture and ecosystems development and lectures about sustainable development organized by Appalachian State University. The University of Buffalo is another example from the USA where 15 policies focused on efficient use of energy and consumption are being implemented. New York University is saving US$9 million annually due to effective management of energy.

There has also been a number of initiatives in the Asian countries, for instance in China. China's Agenda 21 plan of 1994 authorized the higher education system, under the guidance of the Ministry of Education, to promote sustainable development (Niu et al. 2010). Since 1997, more than 300 universities have established courses on sustainable development as they strive to incorporate sustainability into their curricula (Niu et al. 2010). In 2011, Tongji University, Zhejiang University, and eight other universities set up and co-hosted the China Green University Network (CGUN) in Shanghai which had the purpose of providing a platform for universities to communicate and develop the green campus concept. Since then 18 universities have become members of CGUN (2014).

Africa has also been paying attention to the need for sustainability and, in addition to Agenda 2030 that was adopted by member states of the UN, the African Union introduced Agenda 2063 which has several aspirations for socio-economic transformation and pays attention to the need for sustainable development (African Union 2015). Sustainability is not a new focus in Africa and more stakeholders are taking initiative. In South Africa, the Sustainable Development Goals (SDGs) align with the National Development Plan (NDP), which has objectives that relate to people, prosperity, planet, peace and partnership (Dhlamini 2017). These sustainable frameworks

have prompted institutions, government and the private sector to promote sustainable development in all activities. Many institutions have also started implementing sustainability initiatives though the initiatives and scale of implementation differ with countries and mostly with institutions. A study by Nyerere et al. (2013) looked at African universities and their efforts to be sustainable. The study reported on how the University of Zambia has shown commitment to sustainable development through teaching approaches and its relationship with government, industry and communities thus facilitating the building of a sustainable society. This trend was also observed at the University of Development Studies in Ghana and the University of Nairobi in Kenya. However, the University of Zambia has fallen behind with regards to research and technology advancement due to lack of funding for research (Nyerere et al. 2013).

Issues pertaining to lack of resources in Africa have restricted sustainability practices in some institutions to curriculum and teaching, and sometimes community outreach, leaving gaps in term of innovative practices in the continent. This can be confirmed from a review of initiatives undertaken as part of the Mainstreaming Environment and Sustainability in African Universities (MESA) Partnership. The MESA Universities Partnership was initiated by the United Nations Environment Programme to advance the implementation of sustainability in African Universities. The Association of African Universities (AAU) and the United Nations Education, Scientific, Cultural Organisation (UNESCO) were collaborating with UNEP in the project. The initiative resulted in many universities actively engaging with environment and sustainability related social practices in universities (Lotz-Sisitka 2012). About 41 New programmes and courses were developed in institutions across Africa (e.g. Botswana, Egypt, Ethiopia, Kenya, Nigeria, Tanzania, Seychelles and South Africa to mention a few) (Lotz-Sisitka et al. 2015). Other initiatives included development of new policies and strategies, development of new management practices, development of sustainability tools and methods and new structures and networks. In terms of new management practices, only five initiatives were recorded from the participating institutions—confirming the tendency in Africa to target initiatives that do not require huge financial investments.

The realization of sustainable development in African Universities can also be seen through research and new knowledge generation. In this sphere, there appears to be more regional/sub regional and international partnership initiatives influencing sustainable development research than locally constituted directions, which can be attributed to the lack of funding for research in Africa (Lotz-Sisitka 2012). The survey by GUNi/IAU/AAU conducted in 2011 showed that universities themselves were investing in sustainable development research, not only from developing partnerships, but also internally from national governments (Lotz-Sisitka 2012). An example is the Southern African Development Community (SADC) ESD Research Network that supported small-scale studies through seed funding valued at $500 per local project (SADC REEP 2011). Adams et al. (2010) relates research output to GDP where he found that the countries with a higher GDP in Africa had universities with leading research outputs. Four of the six countries identified to have high research outputs, namely South Africa, Egypt, Nigeria, Tunisia, Algeria and Kenya; are also leading in terms of GDP.

Various factors influence the progress of sustainability practices in universities. In a study of Australian and English universities, Ralph and Stubbs (2014) found that universities are finding it easier to green the operational areas of their campuses, rather than taking transformational changes across all universities activities. Another aspect identified by Ralph and Stubbs (2014) was that financial motivations drive the focus in operational areas. Wright and Elliot (2011) support the observation by Ralph and Stubbs and highlighted how implementation of sustainability initiatives at universities can be limited due to financial constraints because of rivaling priorities for limited resources and because the long term savings of these projects are not accounted for. Ferrer-Balas et al. (2008) indicated that there is some correlation between developing incentives and a better organizational framework for sustainable development; they also noted that the predominant trend is lack of incentive structures to promote changes at the local level.

Faculties and students play important roles in generating awareness about sustainability issues and influencing decisions made by management as seen through student initiatives, which, sometimes, are consequently adopted by the entire university. The existence of coordinatiing bodies and projects and the creation of centers or other structures that act as an interface to external actors may be important internally and can be converging drivers (Ferrer-Balas et al. 2008). Brinkhurst et al. (2011) highlight the importance of faculty and staff in areas ranging from facilities design and maintenance, in the design of programs and curricula, procurement and administrative policies, student engagement and encouragement, fundraising, and networking campus groups with other sustainability action organisations.

The important role of students and staff is supported by Ralph and Stubbs (2014) who reported how 'people' were a key success factor identified in the study of Australian and English Universities; committed individuals in operations and teaching areas gave dedicated resources and quality work above what was required from their functional role to promote the objectives of environmental sustainability. Abubakar et al. (2016) found in their study that 65% of students expressed a great deal of concern about environmental sustainability. In addition, 26.3% indicated a great deal of willingness to participate in planning sustainability and implementing sustainability initiatives. These figures highlight the human resource capital that universities have with regards to implementation of initiatives; it is only a matter of creating opportunities. Ferrer-Balas et al. (2008) found that an indirect driver for more sustainable focus on research and curriculum was a growing demand for environmental managers from the corporate sector.

2 Research Sites

The focus of this research is the University of Pretoria and the University of Venda. The two institutions are situated in different contexts, with the University of Pretoria located in Pretoria urban area, which is also the administrative capital of South Africa while the University of Venda is located in a rural area. Development in the country

is not even and the roots for such diversity can be linked to the history of segregation, which resulted in the creation of reserves for black people (Allan 2005). This also permeated education and black only institutions were developed. The University of Venda was one such institution (Kros 2010) and it ended up being located in the outskirts, deprived of resources and financial support. The University of Pretoria was a white only institution for Afrikaans speaking people (Kros 2010) which had access to resources, infrastructure and financial support. The University of Venda is located in a rural setting in the Limpopo Province, which is also one of the poor provinces in the country. The Limpopo province has low unreliable rainfall and is seriously affected by droughts (Maponya and Mpandeli 2016) while the Gauteng Province in which the University of Pretoria is located has a good climate with adequate rains in most years. South Africa is a water stressed country, is generally experiencing changes in climate and there are predictions for water shortages (DEA 2011). Some of these impacts are already being experienced with the worst affected city of recent being Cape Town. Water use restrictions have also been introduced on and off in Johannesburg and Pretoria.

This research was aimed at determining the progress made with respect to implementation of sustainable development at the University of Pretoria and University of Venda. No such research was carried out at the two institutions before. Institutions from two different contexts were chosen to establish whether there are any differences in the initiatives they are implementing, in terms of both the focus and the scale of implementation. The idea was to do a comparative analysis of the initiatives based on the same parameters and to establish the role or influence of structure versus that of agents (structure agency stratification of reality) in actualisation of sustainability initiatives at the two institutions.

3 Research Design and Methods

The research was designed as a qualitative study which took both the form of descriptive research and explanatory research. Descriptive research involves identifying the characteristics of an observed phenomenon (Leedy and Ormrod 2015); it thus describes what is happening, providing details about the phenomena as it is. This informed establishing the nature of initiatives at the two institutions and the focus and scale of implementation. The explanatory research sought to establish the role of structure and agency in making the initiatives a reality. The research is also a comparative case study of two cases (universities) in different settings and with different histories.

Basic critical realism was employed as a theoretical framework (Archer 2003; Bhaskar 1978). The foundation of critical realism lies in its basic principle which states that there is a reality which exists beyond what we know and experience and that reality is stratified in ordered levels where:

- the observed events occupy the empirical level of events which is our experiences.

- the actual level of events which take place independent of our experiences
- the real level of tendencies and mechanisms which have not been exercised and are therefore beyond our knowledge (Sayer 2000; Benton and Craib 2001).

Of interest to this paper is morphogenesis theory (Archer 1995, 2003); which is an analytical theory which draws from critical realism philosophy. Critical realism regards society as consisting of two theoretically distinct elements of structure and agency, that is, social institutions and the creative individual (agent) (Archer 2003). Social structures are the rules and resources which are both the medium and the outcome of social action (duality) while agency is the capability of doing things (Giddens cited in Weik 2006). Archer (1995) argues that reality is stratified into levels which cannot be reduced to one another. Structure and agency can be analytically distinguished as separate strata of reality, as the bearers of quite different properties and powers (Archer 2003). This makes it necessary to study social strata separately so as to be able to examine how the properties and powers that people possess causally interlink with those of parts (Archer 1995). Explanation must attend to both structure and agency as any explanation that excludes one of these may be inadequate (Archer et al. 1999). Based on the structure and agency theory, the influence of structure versus that of agency in implementation of sustainability initiatives was established.

Interviews were used to generate qualitative the data. Gillham (2000) outlined how interviews are one of the qualitative data collection methods that are primarily employed in case studies. They are also an appropriate technique which aligns well with critical realist research. The interviewees (and respondents) were personnel from the Facilities Management Department at the respective universities who were purposively selected based on the offices they occupy as managers in the department. They were deemed knowledgeable of the kind of information the research was seeking.

The staff interviewed at the University of Pretoria were from various departments and faculties. Staff interviewed were from the Facilities Management Department which includes an Environmental and Waste Manager, Landscape and Water Manager, and the Energy Manager as they are well versed with the different sustainability practices being implemented in their areas. Faculty members, research students in the Faculty of Natural and Agricultural Sciences and the Faculty of Engineering were also interviewed to provide insight on research based initiatives at the University of Pretoria.

At the University of Venda, staff members interviewed include members of the Infrastructure Monitoring Unit, the Electrical Engineer and Waste Manager. An outside contractor was also interviewed with respect to the University of Venda as outside firms conducted feasibility studies for some initiatives such as green building design and grey water reclamation. The interviews also extended to management in the university in order to properly understand their influence on sustainability within the universities.

Table 1 shows the list of people interviewed at the two Universities.

Data was also collected through review of environmental management documents including reports and plans from each of the two universities. The purpose was to

Table 1 Interviewees

University of Pretoria	University of Venda
Environmental and waste manager	Infrastructure monitoring unit manager
Landscape and water manager	Waste manager
Energy manager	Electrical manager
Research coordinator, institutional research on energy	Research coordinator
2 Research students	External contractor
UP projects coordinator	1 Research student

provide more insight into initiatives being implemented and provide details on the initiatives/practices. These documents included:

- a water management plan (Ueckermann 2016) from the University of Pretoria,
- a proposal for greywater reclaim and recycling, sustainable (Green) design for new and existing buildings and rainwater harvesting reports were reviewed at the University of Venda.

The documents helped address the how and why questions as well as providing enough information for a comparative analysis. Some observations specifically targeted at green buildings, LED lighting, waste management and water management practices at both universities were carried out in order to authenticate the information outlined in the provided documentation.

Collected data from each institution was collated into a narrative. Content analysis was then employed to each of the narratives. It emerged that the identified practices could be sub-divided into three categories which align with functional units of universities, that is: research, community engagement and operations. Data from each university was organized according to these functions. Identified initiatives were then presented based on these categories. A comparative analysis was performed followed by a recontextualisation of the data within the structure and agency strata to establish their role in the identified initiatives.

4 Research Results and Discussion

4.1 Sustainability Initiatives at the University of Pretoria and the University of Venda

Implemented initiatives at the University of Pretoria are presented in Table 2. They range from research on energy and capital cities, to various community engagement projects and operational practices like green building design, water conservation and recycling.

Table 2 Implemented sustainability initiatives at the University of Pretoria

Research initiatives	Community engagement	Operations
Institutional research • Energy • Capital cities Centre of environmental studies Biodiversity conservation Climate change observations	Sci-ENZA Science Centre • Camera Obscura • TuksChess • Scientific instruments and puzzles The community-based project Module (JCP) Community engagement activities • Clinical engagement • Pretoria zoo Partnerships with orphanages and other NGOs	Design of buildings • Low-flow water systems in buildings Water wise gardening • Water to the root-zone Reclaimed water • Grey water usage Storage of borehole water • Storage tanks and reservoirs Automated lighting systems • Sensory systems Automated cooling systems Solar energy Recycling Compost and mulch manufacturing

The listed projects are not exhaustive of all the projects the institution is involved in—particularly where research and community engagement are concerned. For those two areas, these are the initiatives interviewed individuals are involved in. It is only in the operations division where the managers who could give more comprehensive information about the initiatives were interviewed.

Table 3 shows the initiatives that are currently being implemented at the University of Venda. The initiatives were also categorised into research, community engagement and operations.

Similar to the case of the University of Pretoria, this was not a holistic study and hence for research and community engagement, the listed initiatives are what the interviewees are involved in. Interviews in the operations division were done at management level.

Beside implemented initiatives, interviews also sought to establish future planned sustainability initiatives. Table 4 captures the initiatives that the two universities want to implement in future. The initiatives below have certain aspects that have already been implemented.

Table 3 Implemented initiatives at the University of Venda

Research and curriculum	Community engagement	Operations
Institute of rural development Centre of excellence in animal assisted reproduction	Vuwani science Resource centre Centre of excellence in animal assisted reproduction community project	Rainwater harvesting • Storage tanks Solar energy Low energy lighting systems

Table 4 Planned initiatives at the universities

University of Pretoria	University of Venda
Leakage detection and repairs Water efficient irrigation systems • Soil moisture sensors • Rainfall shutoff devices • Micro-irrigation Rainwater harvesting	Grey water reclaim (surface runoff)

4.2 Comparative Analysis of Sustainability Initiatives at the Two Universities

The discussion below entails a comparative analysis of initiatives at the University Pretoria and the University of Venda. The comparative analysis is based on focus and the scale of implementation and is mostly based on initiatives by the operations division since it is the only division in which responsible managers were interviewed. In the other areas (community engagement and research), chances are that more initiatives are taking place which have not been revealed by this research as only a few individuals were interviewed compared to the operations divisions where responsible managers were the respondents.

When analysing the sustainability initiatives in operations at the two respective universities, the University of Pretoria has more diverse initiatives than the University of Venda. There is a difference in the key foci of the universities. The University of Pretoria has initiatives which cover water management, waste management, green building design and energy use. The University of Venda projects mainly focus on water and energy. While willingness to do more was mentioned at the University of Venda, the major challenge identified was lack of resources.

The University of Pretoria has various water collection/source systems such as municipal, borehole and reclaimed water and thus has a constant flow/access to water. The University of Pretoria, in addition, installed various systems to restrict water flow from taps. The University of Venda, due to its location, however faces the challenge of not having enough water. The University falls victim to the surrounding water issues that happen periodically in Thohoyandou and thus has had restricted access to water and is heavily reliant on its borehole systems. There have been reported instances of resident students being without water during periods of water shortages (low rainfall periods). The focus at the University of Pretoria is saving water through low flow taps, shut off devices, targeted irrigation and restricting use. At the University of Venda, priority is on collection of water through its rainwater harvesting initiative. The same focus areas apply where planned initiatives are concerned with the University of Pretoria mostly targeting reducing water wastage and the University of Venda wanting to extend its water sources by actively looking into having a form of grey water reclamation system implemented. The University of Pretoria is also extending its focus beyond water saving as it is now planning to start practicing rainwater harvesting.

The University of Venda is a rural university located in an area with undeveloped infrastructure and extreme weather conditions and today the university finds itself struggling to construct infrastructure for running its operations and activities. The university struggles with access to water which is a persistent problem during periods of high temperatures and droughts (Maponya and Mpandeli 2016) and the lack of dams and reservoirs to provide water to the campus population.

The University of Pretoria was established in an urban area which is much more developed and is ahead in terms of technological advances. This makes it easier for the institution to access resources. It has also helped the university to easily access and be at the forefront of relevant technology. The university has an advanced solar system, one of the best in the country. Location in a city with a concentration of research institutions has also given the university an advantage in terms of exchange of information and research collaborations.

Both Universities have outfitted their buildings with LED lights, which is the starting point for energy savings in most institutions. Both universities implemented solar systems for their residences but their capacity differs substantially. The University of Venda has solar systems designed to add 6 °C to the hot water system whereas the University of Pretoria has systems installed which raise the hot water temperature from 20 to 60 °C. From this comparison, it can be seen that the capacity of the systems installed at the University of Pretoria is greater than that installed at the University of Venda. A member of the infrastructure monitoring unit at the University of Venda relayed that the University of Venda could have a system with greater capacity however it is an issue of lack of funding and lack of partnerships that has restricted the implementation of this system.

4.3 The Influence of Structure and Agency

An important aspect that came up during this research at the two universities was the human resource that each university has. It is expected that a bigger university will have a bigger compliment (this is enabled at the level of the structure) of staff members but when looking at staff focused on sustainability initiatives, specifically the facilities department, the importance of this difference is clear. The University of Pretoria has an Environmental and Waste Manager (with own support team), Water and Landscape Manager (with own support team), an entire division focused on energy eanagement and more staff members focused on specific projects like rainwater harvesting and grey water reclaimation. The number of staff within specific focus areas translates to the amount of attention that the area receives and increased innovation potential where sustainability initiatives are concerned—provided they have capacity and willingness to make the necessary contributions (agency).

The University of Venda has a Waste Manager and Project Manager in the facilities department. The Project Manager oversees energy management projects, water management projects and projects related to university infrastructure. The manager has a team that handles different aspects of the projects like an Electrical Engineer

who handles energy related aspects. There is a shortage of staff and opportunities for human capacity development in terms of skills and innovation, which influence agency. Brinkhurst et al. (2011) noted the importance of faculty and staff in facilities design and maintenance as this area impacts on university operations. Consequently, if a university does not have adequate human capacity in this area, implementing sustainability initiatives will be difficult.

An important driver which enables the success of projects is finance (at the level of the structure). Ralph and Stubbs (2014) highlighted how financial constraints limit the implementation of initiatives. Shortage of financial resources affects all aspects of the university including staff procurement and skills development (hence agency). This affects faculties as well as support departments resulting in fewer initiatives. This was identified from interviews as well during which lack of resources were mentioned to be a restriction in terms of what the university can do.

The University of Pretoria historically received more resources (structure). This gave the university access to funds for various researches, partnerships in research and also made acquisition of advanced technologies used in sustainable practices much easier. An example is the advanced solar system mentioned before, which is a testament of access to financial resources. A better financial position also puts the university in a better position where staff acquisition and skills development it concerned (agency).

Both structure and agency have played a role in influencing initiatives at the two institutions. Within the context of the University of Pretoria, initiatives seem to have been influenced by allowances made at the level of structure, which has then enabled the university to employ more staff members hence structure enabled agency. At the University of Venda, the opposite is true. Shortage of financial resources at institutional level (structure) resulted in low investment in sustainability initiatives as well as investment in human resources (restrictions on agency). The result is fewer initiatives which are also taking place at a lower scale when compared to University of Pretoria initiatives. Agency (willingness was expressed) is clearly being restricted by structure.

5 Conclusion

The purpose of this study was to determine the sustainable development initiatives that are being implemented at two Universities and to do a comparative analysis of these initiatives. Results show that the University of Pretoria is involved in more sustainability initiatives in its operations; which include installation of LED lightning, solar heating systems, water efficient irrigation and grey water reclamation. This is opposed to the University of Venda which has fewer initiatives which do not use technologies as advanced as the University of Pretoria. University of Venda is situated in a less developed context and has fewer resources in comparison, hence it has to optimize resources use.

From probing issues of structure and agency, it would appear as if, in both contexts; availability of resources— financial resources and human resources—are the main factors influencing what a university can do. The University of Pretoria is in a better position financially and was able to implement more initiatives than the University of Venda which is poorly resourced. Having agency may not be enough if the structure is not providing enabling conditions.

This research managed to show differences that exist in terms of sustainability initiatives between two universities located in two different geographical areas. The influence of structure was also discussed. The research did not do a causal analysis to establish mechanisms influencing the realities of the two institutions. Such an analysis might help unearth the root causes of such disparities as well as influential absences (critical realism theory of absence). Further research can focus on causality and establishing absences which have to be 'absented' to influence positive outcomes in cases where sustainability implementation is low.

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Universities, Sustainability and Businesses: A Common Agenda for 2030

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Abstract Science and Technology are the most important frontier between Universities and Businesses (U&B). The interaction between U&B has always paved the way innovations came to life for the well-being of our communities and the world. The purpose of this work is to analyze the bridges that were, and are, being built to connect both perspectives of human progress and to evaluate options for renewed cooperative actions. The idea is to support the creation of modern tools for Research and Development, under the framework of the United Nations Agenda 2030 and its 17 Sustainable Development Goals (SDGs). (United Nations *TRANSFORMING OUR WORLD*.) This initiative suggests focusing Sustainability on the Development of Capacities in companies and academia in Brazil, starting in Sao Paulo, a State that is already implementing many projects generated under the umbrella of the Goals, with the typical characteristics of their developing reality. The SDGs provide innumerous lessons for all, and it is important to evaluate their implementation processes in order to help define joint priorities for other Universities and Businesses. The specific objective of this paper is to support the strengthening of the efforts made at the University of São Paulo, Brazil (USP) to enhance its quest for economic, social and environmental sustainability. The focus is to discuss how U&B could transit common paths looking to the current and future challenges. The intention is to make an initial approach to the practices of U&B for a Sustainable Agenda in order to propose some joint actions, examining USP initiatives and their partners as an emblematic Case Study.

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1 Introduction

Science and Technologies are now being created, adapted, and transformed under different structures of the traditional institutional division but, in many cases, the innovation rhythms and processes have become differentiated and frequently distant from each other. Nevertheless, evidences also show that more and more renewed efforts are being made, looking for common endeavors in order to build win-win partnerships that benefit the special capacities being developed both in campuses as in marketplaces.

There is a consensus that both Universities and Businesses were originally created for the benefit of their surrounding communities. Companies normally started looking for the most pressing needs of their nearby customers. That was also the main objective of colleges and schools that flourished around the world destined to serve the present and future requirements of their surrounding youth and their families. An important issue nowadays is that the "nearby" communities of users and students are located as far as the milliseconds of a digital message. Traditional companies used to study their economic environment, but now, they are looking at the trends from all around Earth.

Universities always had and have a long term purpose. Currently, they are impacted by the worldwide perspective of their quantitative and qualitative inputs and outputs. Before, universities were mainly providers of knowledge. Now, they are both providers and consumers. Before, businesses were not clearly associated with societal progress. Now, they cannot live without it. Before, the language of College Boards, and the reports from the strategizing CEOs meetings were rather different. Currently, the same issues are discussed, eventually with different names, but with more and more similar visions. The public-private borders are becoming more and more blurred. Both U&B have become global and long-term oriented, and society is demanding clear solutions from both sides.

The Sustainable Development Goals (SDGs), as adopted by all the countries of the world under the umbrella of the United Nations, are the most common guide allowing organizations to share a vision and concrete long-term objectives for both Academia and Companies, in conjunction with other official and non-governmental organizations.

To start, we have verified that it is possible to widen, sustain, and strengthen this bridge between U&B. The question is more "HOW to do it?" and there are many possibilities and examples of potential alternatives for collaborative efforts in this direction. A common ground is being built and signs are being sent from U to B, and vice versa. Both sides are looking for emblematic solutions that would fit their own specific future agenda. In other terms: "How are systemic bridges between U&B being built and how can they be sustained and strengthened towards the future?"

2 The Sustainable Development Goals

Brazil has been a crucial protagonist of the Sustainable Development creation and evolution. In Rio de Janeiro (1992) AGENDA 21[1] was considered the consensus of humankind's quest for a Sustainable Planet. It paved the way for diplomacy since then, and this consensus guided science and policy decisions for the 21st Century. Ten years later, in Johannesburg (Rio+10), the balancing of the implementation of Agenda 21 demonstrated progress and failures. The world was still struggling with the weight of inequalities and violence in the aftermath of September 11 in New York. Nevertheless, it was the year that Businesses irrupted in the theater of major global decisions. They brought pragmatism, resources and, knowledge to the table. New partnerships were launched, and performance issues were brought into the debate.

So, the methodology of establishing concrete and feasible TARGETS was incorporated in the global consensus. This new methodology used a typical approach used by Businesses, and adopted indicators to measure progress, quantify results, and evaluate efficiency; it enabled conditions for a global and collective management system. In that moment, Agenda 21 landed in the arena of the MILLENNIUM DEVELOPMENT GOALS (MDGs),[2] that was the first consensual step adopted by humanity in the aurora of the III Millennium.

Ten years later, in the Rio+20 Summit held, again, in Rio de Janeiro, the conclusion was that most of the MDGs really influenced great progress along the way towards Sustainable Development. Extreme poverty decreased well beyond targets, child mortality rates were down, less hunger existed, more people were able to read, more initiatives for Nature conservation appeared, criteria for human activities on land and sea improved, important economic growth occurred in many regions, etc. The balance also showed, of course, that there was still much to do ahead, in the same and in new fronts. But the most important achievement of this process was that the Planet learned how to build and implement important technological and social tools to widen a constructive collective path. In this context, three years after Rio+20, the unanimity of 193 countries adopted Agenda 2030, which includes 17 Sustainable Development Goals (SDGs).

At that point, more and more Academia became an essential partner required to improve and sustain the efforts behind the SDGs. Government, Civil Society, and Business couldn't sustain the process by themselves; the efforts for the development of capacities required a long-term endeavor. Science and Technology were more needed to ensure the achievement of the Goals and to implement most of the international agreements. Knowledge sharing and creation became a must, and Research was highlighted as crucial for innovation and development. So, this evolution gave birth to a renewed working table sustained by four pillars: Government, Civil Society, Business, and Universities. The last of the 17 SDGs, the Partnership Goal,[3] is the one supporting the other 16 for their implementation in practice. So, building

[1] Agenda 21—Earth Summit—Rio de Janeiro 1992.

[2] United Nations, The MDGs Report 2015.

[3] United Nations, *TRANSFORMING OUR WORLD*.

bridges between those protagonists became the most important Goal of the Agenda 2030 (SDG 17).

3 The Digital Era

The current historic time has been called the DIGITAL ERA. Some consider that the most valuable resource of today's world is no longer oil or gold, but data, most of it generated, transmitted, and stored in digital format. Others emphasize the world-wide changes in the means of production, calling it the period of the 4th Industrial Revolution. Other groups consider that the most crucial characteristic of our times is the speed of changes, highlighting that the only constant of our times is precisely change, and not a linear change but an exponential one. People are also calling the current period the Age of Accelerations, given the impact of three simultaneous gigantic accelerations of current life: information, globalization, and the use of natural resources.

The most mentioned example of exponential change on Digital information is the case of the "Moore's Law," in which its creator, Gordon Moore,[4] predicted in 1965 that the number of transistors in a dense integrated circuit would double in about every two years. That's highly exponential, as many other examples of highly accelerated change. Similarly, the flows of information and knowledge connecting the world of economic transactions and exchanges also brought accelerated transformations in culture and habits. Currently, there are no doubts that the planet is more and more inter-connected and inter-dependent.

It is also clear now that solutions researched need to be treated under that global, accelerated and systemic approach, a concept that the Sustainable Development paradigm inherited from the Systems Theory, including the idea of measurement, parameters, and quantitative method of targets and goals around human beings and Life in general. Looking at Earth as a System, or as a System of Systems, implies a multi-dimensional approach, and that has impacted geology, mechanics, robotics, and even the mutual influence between engineering and human or socially complex systems. In other words, the Digital Age and the Sustainability Science are converging.

4 The Exponential Organizations

Two rivers converge bringing waters of change at the current crossroads of the new Millennium. They bring the Scientific wisdom of the Sustainability Paradigm and the Technological tools of the Digital Era. Both are the most creative flows bring-

[4]Moore's Law—Wikipedia.

ing solutions and opportunities for the challenges ahead of us, as individuals, as organizations, or as local or international citizens.

History has shown so many times that civilizations evolve and transform themselves, always seeking new bridges that connect them with a new promised land. Nowadays, there is no desert to cross: the vehicles are here, more and more available for all of us. The problem is the other way around: the transportation is so rapid that many people are being left behind because their social or professional organizations have not developed accordingly to the accelerating speed of the potential being placed at their disposal.

Thomas L. Friedman,[5] the prestigious New York Times journalist, wrote: "There is a mismatch between the change in the pace of change and our ability to develop the learning systems, training systems, management systems, social safety nets, and government regulations that would enable citizens to get the most out of these accelerations and cushion their worst impacts." Friedman emphasized that a mismatch "is at the center of much of the turmoil roiling politics and society in both developed and developing countries today. It now constitutes probably the most important governance challenge across the globe."

Regarding this issue, Friedman interviewed Eric "Astro" Teller, the CEO of Google's X research and development lab, which produced Google's self-driving car, among other innovations. Astro said to Friedman: "Another big challenge is *the way we educate our population*. We go to school for twelve or more years during our childhoods and early adulthoods, and then we're done. But when the pace of change gets this fast, the only way to retain a lifelong working capacity is to engage in lifelong learning." Yes, LIFELONG LEARNING! There is no other way. Again, the question is HOW. How do we transition from an Analog World to a Digital one? How do we adapt to the accelerating transitions that are happening around us?

Experiences about co-operating instruments have shown that there are new kind of systems that are not only surfing the new realities, but, in many cases, are the leaders of the adaptation and transformation on their internal and external environment. They are being called "EXPONENTIAL ORGANIZATIONS" (ExO), precisely because they are molded to adapt, follow, and eventually contribute to the accelerating speed of changes. First of all, ExOs believe that most of the solutions for modern problems will come from Scientific Progress. Second, they believe in adaptability, and they create and apply technological innovation to their old structures. Third, they are built to create and grow capacities for them and their surroundings; they include in their mission the task of learning faster and continuously.

Salim Ismail[6] defines Exponential Organizations as those "whose impact (or output) is disproportionally large compared to its peers because of the use of new organizational techniques that leverage accelerating technologies." Ismail also says that "the driver fueling this phenomenon is information." Once any domain, discipline, technology, or industry becomes information-enabled and powered by information flows, "its price/performance begins doubling approximately annually."

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[5]Friedman, Thomas—*THANK YOU FOR BEING LATE*.

[6]Ismael, Salim—*EXPONENTIAL ORGANIZATIONS*.

Most Universities and Businesses are still evolving to innovate changes at the accelerating pace of the current technological changes. But there are new ways to create bridges between them, based on the mutual necessity of serving society at the modern digital era speed. Both U&B have a common mission, stated mainly on the SDGs. Both U&B want faster learning and adaptability. Experience has shown the necessity of launching a proposal for a mutual learning mechanism, a bridge for a Continuous Education project structured as an Exponential Organization. We could name it as an "Exponential Bridge," with its 17 lanes being the SDGs.

5 The Academic Perspective

The SDG's framework provides many benefitting opportunities for Academia. The main basic grounds of involvement are: Learning and Teaching; Research and Innovation. The effective involvement with 17 SDGs, and their respective 169 indicators, in order to achieve a significant degree of accomplishment, requires acceleration in the engagement of undergraduates, graduates, junior and senior professionals, universities' management, and support staff.

6 The Case of the University of São Paulo (USP)

6.1 Learning and Teaching

An important holistic step given by the University of São Paulo (USP) was the inauguration of the five-year Complexity Engineering[7] course by the Polytechnic School (Poli), that deployed at its coastal campus of the city of Santos their Thematic Modules. They cover Services, Cities, Energy, and Sea, selected for requiring paradigms of complexity in problem solving and the development of innovation. The Cities module, for example, would cover topics such as Smart Cities, Basic sanitation, and Urban Mobility, among others. In Services, there are disciplines such as Decision Support Tools, Work and Work Psychodynamics, and Education, Health, Public Security Services. In Energy and Sea, there are disciplines such as Data Sciences Applied to Maritime Exploration and Energy Production, Biological and Mineral Resources of the Sea, and Maritime Operations—Port Infrastructure and Logistics. Its major virtue is the interlinkage of the SDGs in the context of one another, and not separately or sequentially. This approach is a paradigm for the early understanding by the students of the comprehensive SDGs framework.

[7]Jornal da USP April, 12 2018—https://jornal.usp.br/universidade/poli-apresenta-proposta-de-curso-de-engenharia-da-complexidade-na-usp/.

At post-graduated level, USP has been extremely successful in the implementation of the so-called Extension Courses (USP Extension Courses).[8] Since 1976, about 40 years prior to the SDGs establishment, the interaction among several sectors of society and USP has led to the formation of hundreds of extension courses. These, albeit conceived in a "business as usual" basis, have shown to be, and currently are, perfectly aligned with SDGs due to close interaction with Industry, Construction, Agriculture, Financial Management, Health, among other sectors. USP Extension Program allows for the involvement of recognized worldwide specialists while preserving a minimum of fifty percent participation of its professors. Full scholarships are distributed at a typical ten percent audience in all extension courses, for those students at poverty level, thereby contributing also to SDG1 (Poverty).

Special requests from society, not covered by the regular extension program, are attended by USP own staff complemented by local or foreign specialists, if required. Although strategic courses like Labor Safety, Occupational Health, and Environmental Management are offered in online versions, the majority of courses are still on site mode only.

The growth and diversification of online courses is one of the short-term goals of the program. With this in mind, an online course was introduced to familiarize teachers with online teaching resources, as well as to perfect and modernize teaching techniques.[9]

6.2 Research

The Pro-Rectorate for Research (PRP) is a central body of the University of São Paulo that aims to foster interdisciplinary research and manage programs and policies related to research at the University. Currently, USP accounts for 22% of all scientific production in Brazil,[10] with 1,632 research groups certified by the National Council for Research (CNPq), in perfect alignment with all 17 SDGs. Its structure comprises:

– The Centers for Research, Innovation, and Dissemination (CEPIDs),[11] which are responsible for developing fundamental or applied research focused on specific themes, contribute to innovation through technology transfer, and offer outreach activities for primary and secondary education for the general public. The research themes of the Centers include: food and nutrition, glass and ceramics, functional materials, neuroscience and neuro-technology, inflammatory diseases, biodiversity and discovery of new drugs, toxins, immune response and cell signaling, neuro-mathematics, mathematical sciences applied to industry, obesity and associated diseases, cell therapy, metropolitan studies, human genome and stem cells,

[8] USP—*EXTENSION COURSES* https://cursosextensao.usp.br/.

[9] See https://pecepoli.com.br/PT/EOP/.

[10] https://prp.usp.br/wp-content/uploads/guia-usp-online.pdf.

[11] CEPIDs—https://prp.usp.br/cepids/.

computational engineering, oxidant and antioxidant processes in biomedicine, violence, optics, bio-photonics and atomic and molecular physics, researches on carbon capture and storage, gas fuel technologies, energy and economy policies, and studies on happiness and well-being.

- The Research Support Centers (NAPs)[12] promote greater communication and integration between the USP Units and several areas of knowledge, reinforcing joint research, both interdisciplinary and transdisciplinary. Currently, a total of 143 NAPs bring together specialists from one or more units and agencies around research programs of an interdisciplinary nature and/or instrumental support to research.
- The National Institutes of Science and Technology Program (INCTs)[13] aim to articulate and aggregate, at the national level, the best research groups in frontier areas of science and strategic fields for the sustainable development of the country. The centers also aim to boost internationally competitive scientific research, as well as stimulate the development of advanced scientific and technological research associated with applications, promoting innovation, and entrepreneurship, in articulation with innovative companies in the areas of the Brazilian System of Technology (Sibratec).

6.3 Innovation

USP's technological innovation policy is managed by AUSPIN, the USP Innovation Agency. AUSPIN is the nucleus of Technological Innovation, responsible for managing the innovation policy to promote the use of scientific, technological, and cultural knowledge produced at the University. AUSPIN sites are located in São Paulo, Bauru, Lorena, Piracicaba, Pirassununga, Ribeirão Preto, and São Carlos.[14] The Agency acts in the protection of industrial and intellectual heritage generated at the University, performing all necessary procedures for the registration of patents, trademarks, copyrights of books, software, and music, among other creations.

AUSPIN provides support to faculty, students, and staff in the design of projects in partnership for better management of relations with the business sectors, as well as to disseminate the impact and benefits of innovations developed by USP researchers. Through business incubators, technology parks, and specific training, it promotes entrepreneurship, offering technical support, management, and complementary training to the entrepreneur. It also works on the transfer of technologies in order to make them available to society.

RCGI,[15] the Research Center for Gas Innovation, located in Poli/USP, is also a clear example of joint U&B and governmental initiative for the crucial Oil and Gas

[12] NAPs—https://prp.usp.br/naps/.

[13] INCTs—https://prp.usp.br/incits/.

[14] AUSPIN—http://www.inovacao.usp.br/.

[15] RCGI—https://www.rcgi.poli.usp.br/pt-br/.

sector. It is funded by FAPESP, the research Foundation of the State of São Paulo, and SHELL, together with the University of São Paulo. Most of the RCGI projects are related with key technologies for Brazil and the world energy issues. RCGI and its partners are unifying visions and actions toward a low carbon Planet.

7 The Business Perspective

One of the most influential business organization (BSDC) says: "Taking the UN's new Global Goals for Sustainable Development as the basis for our action plan, we lay out how pursuing these goals in partnership with government and civil society will lead to greater, more widely shared prosperity for all by 2030."[16]

The 2030 Agenda for Sustainable Development Article 67 acknowledged that: "Private business activity, investment and innovation are major drivers of productivity, inclusive economic growth and job creation."

The World Business Council[17] (WBCSD) believes that, "by developing and delivering solutions for the achievement of the SDGs, companies will discover new growth opportunities and lower their risk profiles. Companies can use the SDGs as an overarching framework to shape, steer, communicate and report their strategies, goals and activities, allowing them to capitalize on a range of benefits."[18]

The BSDC also highlight the risks of not joining this trend: "Big business and major financial institutions are increasingly perceived as detached and rootles… So, at the core of our argument is also the need for business to **regain the license to operate**."[19] Yes, regain the LICENSE TO OPERATE! That has increasingly become the cornerstone for Business engagement.

On making the case for the Business shift towards the SDGs, the BSDC also looks at the digital changes impacting the world: "Technology has the potential to drive a better, more sustainable economy, but only if there is a continuous dialogue between the innovators and society. Business is a bridge for that conversation. It can apply the capital and skills needed to scale new ideas, taking them from the garage or lab to where they have local and global impact." So, the renewed Business perspective has a clear purpose in mind, which is "building a powerful movement for a new kind of business."[20]

The systemic view of the renewed businesses considers as strategic the issues of jobs and wages, the impact of automation, the questions about globalization, and the unpredictability being created with the Environment. Alternatively, Business is proposing "setting business strategy and transforming markets in line with the

[16]From *Better Business, Better World*, a report by the Business and Sustainable Development Commission—BSDC.

[17]World Business Council for Sustainable Development—*CEO GUIDE FOR THE SDGs*.

[18]WBCSD.

[19]BCSD.

[20]BCSD.

SDGs." The new companies believe they should contribute to the building of a renewed "economy of abundance." and have clearly expressed that "Business need the SDGs, as the SDGs need Business."[21]

Companies will always be looking for renewed opportunities, but now they are aware they need to pursue social and environmental sustainability as well, and "as avidly as their market share and shareholder values." The BSDC research shows that achieving the SDGs in only 4 economic systems could open "60 market hotspots worth an estimated US$12 trillion by 2030 in business savings and revenue." Particularly, BSDC estimates that "achieving the single Goal of gender equality could contribute up to US$28 trillion to global GDP by 2025."

8 The Markets of the Future[22]

This path towards 2030 shows a promising way for jobs and markets. As mentioned above, the BSDC estimate of $12 trillion a year in business value includes only figures for four of the most promising economic systems: Food and Agriculture (US$2.3 trillion), Cities and Urban Mobility (US$3.7 trillion), Energy and Materials (US$4.3 trillion), Health and Well Being (US$1.8 trillion). That means creating more than 380 million jobs in areas where they are also socially and environmentally crucial.

At this stage, it can be said that sustainability is not another burden; to the contrary, it is a renewed path towards prosperity. The issue then becomes how to prepare and sustain old and younger generations for this new kind of exponential economy?

Two questions remain on the Business approach to the SDGs:

1. How are Companies organizing themselves to tackle this challenge?
2. How much progress has been achieved so far?

Concerning the first question, a recommendation from the GRI (Global Reporting Initiative, a Business Organization supporting companies on the tools, processes, and outcomes of their internal and external reports), has prepared a "Guide for business action on the SDGs." The guide is called the SDG COMPASS.[23]

The Compass suggests that Companies should follow 5 steps on their Action Plans:

1. Understanding the SDGs;
2. Defining Priorities;
3. Setting Goals;
4. Integrating;
5. Reporting and Communicating.

[21] BCSD.

[22] BCSD.

[23] GRI—A Business Compass.

Another kind of Business engagement is the case of the "GOALKEEPERS,"[24] an initiative of the Bill and Melinda Gates Foundation that articulates "leaders who take a stand on the issues they care about and innovate in their communities to achieve the Global Goals." This Foundation focus on poverty and deal with education, family planning, HIV, and agriculture, particularly in Africa. "GOALKEEPERS" priority is the Human Capital, considered as important as the Physical Capital.

As seen, there is a large common frontier between Universities and Businesses in the practical arena of innovation. The remaining question is about how much progress has been achieved by companies in this new world of Sustainability.

In the course of the third year since SDGs were launched in September 2015, a qualitative and quantitative study by KPMG[25] (2018), based on world's top 250 companies by revenue across 15 industry sectors, revealed that 40% of those companies already reference the SDGs in their Corporate Reports. The study proposed quality criteria grouped in 3 themes: Understanding, Prioritization, and Measurement.

8.1 Understanding

This is a key area for improvement, since only 6% of companies satisfied all criteria for understanding SDGs. Two thirds (68%) scored low scores. Major deficiencies are absence of business cases, lack of SDGs discussions in leadership messages, and unbalanced assessments of SDGs impacts, focusing on the positive but not the negative impacts. It was noted that the absence of the SDGs could lead to missing opportunities on the very large potential market of over US$12 Trillion for SDG-related products and services.

8.2 Prioritization

Although 84% of companies identified the most relevant SDGs to their business, only 54% have disclosed the process used to prioritize them. With respect to the 169 targets set by United Nations in relation to the 17 SDGs, a few 20% have reported on any of them.

Prioritization, however, scored higher than the other two areas, indicating that it is maturing at a faster pace. Identifying specific SDGs targets relevant to the business constitutes the most urgent area for improvement for 80% of the companies studied.

[24] Bill and Melinda Gates Foundation.

[25] KPMG—*HOW TO REPORT ON THE SDGs*.

8.3 Measurement

Only 35% of companies reported performance goals related to SDGs, and only 25% reported indicators to measure performance on the SDGs. Another very relevant finding is that only 10% of companies have set time bound goals for their SDG-related activity, despite the fact that targets set by United Nations are time-bounded.

The companies' progress has also been evaluated by Price Waterhouse,[26] whose figures show that there is a 92% awareness of the SDGs among the business communities against only 33% of the citizens'. Their statistics show that 71% of the companies have already started to take action. They are optimistic that by 2020, 22% of the business responders that reported doing nothing in their sample will decrease to only 4% for those who are thinking in the usual strategic period of 5 years. This confirms that companies are moving and setting out commitments to specific, actionable, and measurable business goals.

9 An Emblematic Solution: Continuous Education

It has been noted that the SDGs may pave the bridge between Academia and Business. In the case of USP, its exhaustive repertory of extension courses for continuous education[27] forms a formidable repository, built over decades to reflect the demands of society, as a whole, for professional updating and improvement. With the advent of the 2030 Goals, the contents of each course have to be continuously molded to address the three fundamental pillars required for the timely achievement of goals, namely, the understanding the relevance of the SDGs for each sector of business, the prioritization of goals, and the design of performance targets and measurement systems, including their communication to stakeholders.

USP's approach to combine its expertise with local and foreign experts could be the formula to minimize the time to attend such challenging demands. Particular emphasis has to be given for geographic coverage by expanding the availability of online courses. USP's flexible norms of short, medium, and long term extended education courses allows for certified courses from 8, 30, 180, 360 or more hours, providing several ways to fulfill specific needs of education and training at convenient hours of the day.

The intense activity of extension courses, which have certified hundreds of thousands specialists since 1976, has proved to be the most effective way to bridge Academia and Business companies. The 2017 opening of the first UN Regional Office of the Cities Program at the USP campus has widened the bridge between private sector and Academia, creating cooperation in a neutral scientific environment, thereby creating further relevant opportunities for joint programs orchestrated with the 2030 Agenda.

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[26] Price Waterhouse.

[27] USP—*EXTENSION COURSES* https://cursosextensao.usp.br/.

10 Closing Remarks

The gap between Academia and Business has always existed. But in this exponentially changing era, despite examples with growing distances between them mainly in developing countries, the technological changes are quickly modifying the landscape, and institutions are trying to catch-up with the accelerations.

In order to face these challenges of the future, it is not possible to act in isolation. This is the time for connectivity. This is the time for partnerships. The first thing that innovators always do is to find a partner for any initiative, for their project, or for building and sustaining their businesses. Together with the Government and the Civil Society Organizations, Academia is and will continue to be the first source of Knowledge and Research. Similarly, Academia is also nurtured by Business, and normally there are more common than differentiated objectives.

Currently, there are no more "local" Universities or "local" Companies. Borderless communities are now empowering themselves and deciding to give or not to give their "Social License to Operate" to public or private initiatives. In some cases, even technology is seen as "threatening" the status quo, but everybody also knows that Science has always solved most of the pressing problems of humankind. Many examples show the intense acceleration of technological changes, and how slowly relatively, human institutions are adapting to it. Technology is going to continue to evolve rapidly: the challenge is to accelerate the changes in the organizations that are supposed to manage the Human and the Physical Capital required by the common good.

For the above mentioned specific cases, and many others, this journey towards a widening digital future could be accelerated by better connecting their main protagonists: Universities and Businesses. Science certainly will continue to be the light ahead of all for all innovating processes, at least for many generations ahead. Of course, for this processes to succeed, it will be necessary to generate a common purpose and a common language.

As an example, the planet was wise enough to practically close the gap in the Ozone Layer by adapting its technologies to a well-recognized risk. It was done in parallel to the implementation of the Millennium Development Goals. The MDGs helped to channel reductions in extreme poverty, child mortality rates, and gender equality, among others. The Sustainable Development Goals (SDGs) improved them, creating 169 indicators, and progress is already visible in just a couple of years since their launch. The legitimacy jointly built by 193 countries gave the world a common purpose and concrete directions. Then, it is possible to expect that the 17 SDGs could be the lanes of the bridge connecting U&B, together with many other initiatives promoting partnerships.

In regards to the "common language" issue, it has never been so simple to communicate with each other due to the instruments provided by the modern Information and Communication Technologies (ICT). Their wide availability allows us to affirm that the Digital language already is and will increasingly be the way to reshaping trust and paving the way to better connect with ourselves, with our environment, and

with our neighbors across the street, at the extreme of our nations, or at the other side of the Planet.

These processes need to be made transparent, visible to public awareness and engagement. This can be achieved by using the best ICT technologies, with their inherent Systems approach, and their flexibility for permanent and accelerating changes. They are an essential part of the solutions. SDGs and ICT are certainly the main tools for the proposed EXPONENTIAL BRIDGE between U&B.

But if HUMAN CAPITAL is at the center of our concerns, the present and the near future will require, as mentioned before, "education for life" or "lifelong learning," to be able to form the leaders required for this transformation.

Our analysis of the case of the University of Sao Paulo has shown that it is possible, in many areas, to move ahead of the curve of change. Our conclusion is that this trend needs to be supported and enhanced through the channels of the Exponential Bridge. As an Emblematic Solution, Continuous Education should increase its scope, having the SDGs in mind and increasingly using the Digital Tools at their disposal. Continuous Education and Knowledge Sharing could become an Emblematic Solution for providing a Lifelong Learning experience to form the Human Capital: the renewed men and women that will be the pillars that sustain the world.

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Teacher's Approach on Climate Change Education a Case Study

Vanessa Tibola da Rocha, Luciana Londero Brandli, Janaina Mazutti, Leila Dal Moro, Liane Dalla Gasperina and Rosa Maria Locatelli Kalil

Abstract Climate change education—CCE—is a new proposal for training, teaching and learning focused on sustainable development. CCE needs scientific support for its insertion in the world context of schools, universities and other institutions. Teachers are the key to the development and insertion of this theme in society. According to 2030 Agenda, CCE contributes directly under two SDG's: 4 (quality education) and 13 (action against climate change). The aim of this paper is to describe the relationship between sustainability and education, with a focus on climate change education. To achieve this goal, the work was divided in three stages. The first one is the theoretical analysis of the relationship between environmental education—EE, education for sustainable development—ESD and education on climate change. The second stage identifies the panorama of climate change education through bibliometric analysis. And finally, the third step describes the insertion of the CCE theme for sustainable development in a public school in the south of Brazil. The results of the study reinforce the importance of the theme, which has a direct impact on two SDGs (4 and 13), since the teachers reported difficulties of inserting discussions and approaches related to climate change education in the school context. In addition, the work serves as an experience for future proposals with a focus on CCE.

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1 Introduction

Climate change is real and is occurring at this moment, in different territories and levels of intensity (Giddens 2009; McNeal et al. 2014; IPCC 2014). Understanding the context of Climate Change Education (CCE) requires an earlier understanding of approaches such as: Education for Sustainable Development (ESD) and Environmental Education (EE).

According to Gough (2006), strategies for teaching, research and extension, focusing on sustainability have generally been recorded since the 1960s. However, approaches specifically addressed to ESD, EE and CCE are resentful and in many territories are undergoing by "difficult processes" of insertion in the curricula at all levels of education (Gough 2006; Læssøe et al. 2009; UNESCO 2009; Dima and Meghisan-Toma 2018).

Overall, the three education classifications (ESD, EE and CCE) present "simple" ideas, which can contribute to global sustainability. However, the insertion of these strategies implies in "complex actions" for many societies, since it involves: behavior change, sense of belonging, social equality, environmental responsibility, conscious consumption and other necessary answers for the environmental and social sustainability (UNESCO 2005; Jacobi 2005; Læssøe et al. 2009; UNESCO 2009; Bortolon and Mendes 2014).

1.1 The Environmental Education—EE

According to Gadotti (2008), it would be appropriate to approach and include in the learning curricula, environmental themes that are part of daily life, emphasizing their continuity with the dissemination and engagement of society.

With the intention of overcoming the environmental crisis, scientific and specialized knowledge is necessary, including professional qualification and teaching action (Guimarães and Inforsato 2012).

Environmental education assists in the capacity for global learning from the environmental point of view. Including a series of pedagogical and cultural practices and policies in both public and private power, associations and civil society (Carvalho 2001). When the subject is environmental education, the population also needs to assume the central role of the process, participating in the environmental problems and in the search for solutions, so over time the citizen becomes a transforming agent, leading to behavioral changes in society (Gadotti 2008).

In the context of environmental education, there are two challenges to recognition: the challenge of human nature and its limits and the challenge of pedagogy (Tozzoni-Reis 2001).

The challenge happens when the population needs to preserve the environment. Society encourages community participation to promote environmental practices, making environmental education actions dynamic as a knowledge tool. In addition, environmental education should be systematically placed, in all levels of education, guaranteeing the environmental dimensions in the curricula of different school disciplines (Alcântara et al. 2012).

There is a challenge in attracting students' interest in "sustainable development". Still, it is difficult to carry out actions without impacting the environment. In this way, it is necessary to seek individual and collective consciousness, and work sustainability as public policy. Including education for sustainability in basic education curricula and expanding to other levels of education needs financial support and theoretical/practical commitment to the theme (Jacobi et al. 2011).

In order to implement the provisions of the National Environmental Policy created in 1981, the Brazilian government prepared the first version of the ProNEA (National Environmental Education Program) in 1999, presenting pedagogical alternatives and educational actions that contribute to the consolidation of sustainable societies (ProNEA 2005). This policy has not yet been implemented, even after nineteen years, and is under Public Consultation. This factor underscores the inefficiency of the system that deals with environmental education in the country.

Currently, in Brazil the EE is ensured by the National Curricular Parameters (PNC) and needs to be worked on all levels of lifelong learning (elementary, middle, undergraduate and postgraduate) in a transversal way, making the contents involving EE addressed by all disciplines (Brazil 1997).

1.2 Education for Sustainable Development—ESD

The practice of ESD generates a great opportunity for the appropriation and increase of the curricula of the education's formal models (Godotti 2008). Thus, the attributions of Universities, Teaching Institutions and Schools in addition to transmitting knowledge, is to train people with principles and values, giving opportunities to society's change. For Cardozo and Martins (2016), working with ESD is to make life habits go beyond school.

Including a series of practices, pedagogical and cultural policies, ESD assists global learning in the environmental field (Carvalho 2001). And despite its uncertainty, ESD is a positive outlook for the future (Godotti 2008).

Nonetheless, there is a standoff, in which refers to the initiatives that are focused on modifying individual attitudes, values and lifestyles, without considering social policy (Huckle and Wals 2015). This, needs to integrate fundamentals in all aspects in education and teaching.

According to Hesselink (2000), ESD represents an education strategy that has its strands of EE's sectioned studies. Thus, ESD can be considered as a fragment of studies involving EE.

ESD aims to stimulate and develop in people (children, adolescents, adults and/or the elderly) perceptions and capacities directed at human sensitization on the importance of natural resources, fair economies and social integration, respecting the environment, the economy and the society. Sustainable development is still a field to be explored, a topic that is branched and deserves attention in all its aspects—environmental, economic and social.

1.3 Climate Change Education—CCE

According to Leal Filho et al. (2018), research is fundamental in all dimensions when it comes to climate change. And, the authors emphasize that transdisciplinarity becomes crucial to address this issue. In addition, the use of funding for innovation research leads to effective education.

The nature of climate change education is complex and teachers are forced to simplify it. According to Oversby (2015), methodologies are necessary to ensure that information remains clear to students, thus creating new charges for teachers.

CCE should receive more attention and bring more sensitivity to society and educational institutions, since every day environmental problems are gaining strength. There is some concern on teachers' behalf to incorporate lessons that integrate personal and social connections to introduce practical actions, in which individuals can have a positive impact on their communities (Drewes et al. 2018).

The CCE is interdisciplinary, which requires negotiation among teachers based on discipline, schedule, and curricular commitments, limiting some teaching opportunities (Oversby 2015). The author affirms that there is a certain difficulty on the part of teachers who are unprepared for the integration, action and knowledge of content on CCE. For some students, the science of this subject is seen as controversial and makes it very different from other areas of science.

2 Education as a Way to Sustainability

Since 1972, during the Conference on the Human Environment in Stockholm, the UN underlined the importance of developing a more sustainable culture. Five years later, in 1977, during the Tbilisi Intergovernmental Conference in Georgia, global discussions focused on the theme of Environmental Education. And only after 15 years, in 1992 in Rio de Janeiro, the International Conference on Environment and Development, emphasized in its Chap. 36 (of Agenda 21), that EE should highlights sustainable development (Ramos 2001; UNESCO 1997; Rio+20 1992; Agenda 21 2004).

Thirteen years after the first global initiative to discuss EE in 2005, UNESCO declared the Decade of Education for Sustainable Development. In this historical context of theoretical approaches directed to the terms "education" and "sustainability", Education in Climate Change emerges in 2009 (Læssøe et al. 2009).

Recently, in 2015, the UN launched the 17 Sustainable Development Goals (SDG). The agreement between the member countries involves a series of actions aiming a better world by 2030. More precisely, the fourth SDG deals with Quality Education, with the overall goal of ensuring inclusive and equitable quality education, promoting long learning opportunities (UN 2015). In addition, the goal 4.7 aims to ensure that all students gain skills and knowledge in order to promote sustainable development and lifestyle. Thus, instigating many educational centers to work and create projects in favor of society and environment, contributing to sustainable development.

The thirteenth SDG, in general, addresses actions against global climate change. The goal 13.3 makes it explicit: "to improve education, increase human and institutional awareness and capacity on global climate mitigation, adaptation, reduction of impact, and early warning of climate change" (UN 2015). There is a need to integrate SDG 4 in the success of learning related to climate change—SDG 13. According to Freire (2001), "if education alone does not transform society, society will change without it."

The aim of this work is to describe the relationship between sustainability and education, with focus on climate change education.

3 Metodology

Figure 1 illustrates the methodological structure of the article, which is divided in three stages.

3.1 Step 1: Education and Sustainability

UNESCO—Educational, Scientific and Cultural Organization is a specialized agency of the UN system and carries out several important actions in the world for the sake of sustainability. Yet many of UNESCO's annual publications are distributed at no cost to global communities. Among many UNESCO's study themes, it is necessary to emphasize education. Since UNESCO is the reference and the source (in this area of study) more secure, developed with different collaborative views (Blanchfield and Browne 2013).

In this sense, step 1 identified UNESCO publications focusing on: Environmental Education, Education for Sustainable Development and Education in Climate Change (UNESCO 1997, 2005, 2014).

The content analysis of the selected materials identified the following descriptions for each publication: interrelationships between EE, ESD and CCE; objectives

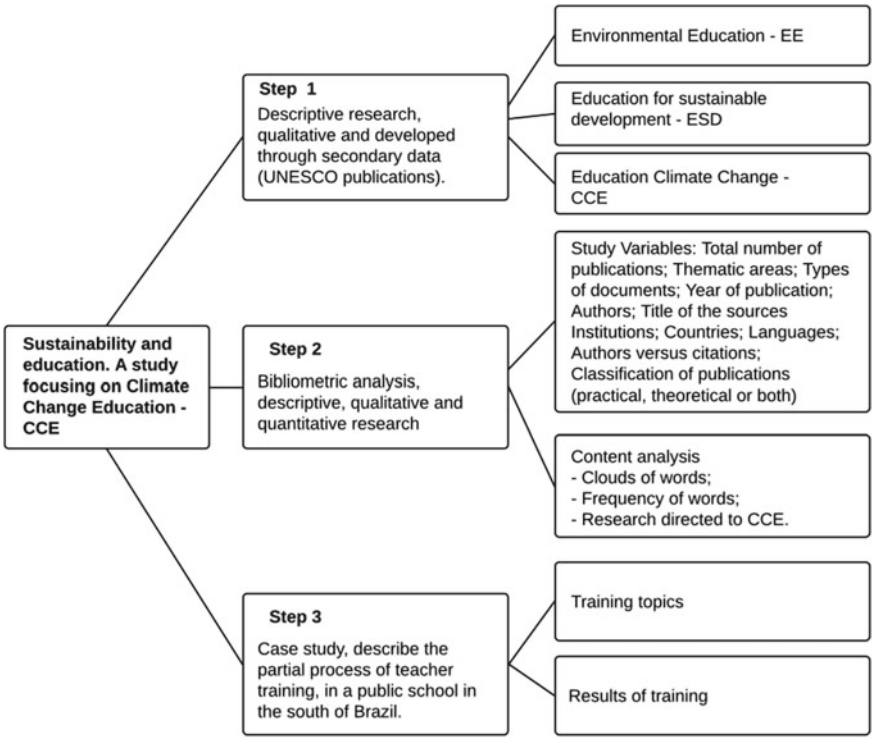

Fig. 1 Metodological stages

of each direction of education; approaches and impacts; authors (references); and, finally, year of publication.

The information served as theoretical support for understanding the issues that integrate education and sustainability. Becoming possible to direct the discussions through the following contexts: macro, intermediate and micro. The last one is directed related to the article's focus, Education in Climate Change.

3.2 Step 2: Bibliometric Analysis on Education in Climate Change

Step two identified the state of the art of scientific publications on the subject of Climate Change Education—EMC. This was done in the Web of Science (WOS) database of the Institute for Scientific Information (ISI), in order to raise the global panorama of the publications on the subject.

Thus, through Web of Science (WOS) search engines, using the keywords "climate change education", delimiting the search for the period from 1945 to October

21, 2018, identified a total of 111 publications. It is observed that there are few publications with international scientific recognition on the subject (CCE), considering the time of analysis of the publications—73 years (beginning of the searches in the base period—1945—suggested by Web of Science).

The search variables on the theme, climate change education, were: (a) Total publications; (b) Contemplated thematic areas; (c) Type of document; (d) Year of publications; (e) Authors; (f) Source of publication; (g) Institution of origin; (h) Country of origin; (i) The language in which it was written; (j) Number of citations; and (k) Classification of the study (practical, theoretical or both).

Based on the publications identified in the WOS, content analysis was developed according to the language of the interpretation of the meaning of words (Silva and Fossá 2017). Thus, the results produced are: cloud of words and frequencies of terms.

3.3 Step 3: Education in Climate Change: A Case Study in Southern Brazil

The third step describes a case study carried out at the Cardeal Arcoverde Institute, in the city of Passo Fundo, in southern Brazil. Passo Fundo, according to data from IBGE (2018), has more than two hundred thousand inhabitants; a schooling rate of 97.3% (among people aged 6–14 years); about 1,853 teachers (considering middle and high school) and 103 schools, also considering both primary and secondary education.

The school is part of the public network of the state of Rio Grande do Sul (Fig. 2) and was founded in 1957. It serves approximately 980 students and has a total of 75 teachers and staff. According to the School Rules (2016), the philosophy is to ensure: "a democratic and humanistic education, starting from the reality where it is inserted, in a pedagogical proposal that favors the construction of meaningful learning, so that the student acquires critical and participatory spirit, making a conscious citizen capable of interacting and intervening in society and the world of work".

Table 1 describes training themes, held on July 5, 2018, and the characteristics of the group of teachers who participated in the research.

The teachers participating in the research were identified by the administrative management of the school and released from their teaching activities during the training process. Thus, the direction of the school understood the importance of the research for the development of sustainability in the educational environment.

Fig. 2 Location of study area

Table 1 Case study overview

Training description	Teacher's description
Title: Learning about climate change for sustainable development Subjects studied – What is CCE—concept – Global warming × climate change – Difference between climate and weather – Climate change and ecosystems	Total teachers: 4 Disciplines: Physical Education; History and Geography; Arts; Mathematics and Physics Personal data – Profession – Discipline(s) teach – Gender – Year of birth – Educational level – Religion

4 Results and Discussions

The results of this research emphasize the importance of studies towards sustainability and education. According to UNESCO (1996), education is capable of developing a society for peace, freedom and social justice.

4.1 Education and Sustainability Describing Their Connections and Commitments

Education has the main objective of transforming different realities positively (UNESCO 1996). However, Lobino (2007) in his studies emphasizes that knowledge about issues involving the environment is necessary. However, it is also necessary to develop actions and practices in favor of it.

In this sense, practices are concrete examples of the transformation and contribution of each person to a better future. And, every type of education (environmental, sustainable development or climate change) aims to stimulate behavior change in order to increase the quality of life of people on the planet.

Environmental education is a broad field and contributes to education for sustainable development, adding towards education on climate change. Thus, EE is wide; ESD is intermediary and CCE is focused on a specific theme—climate change—that interferes with different contexts (human, economic, environmental, social). Figure 3 illustrates the interrelationships between Environmental Education; Education for Sustainable Development and Education Climate Change.

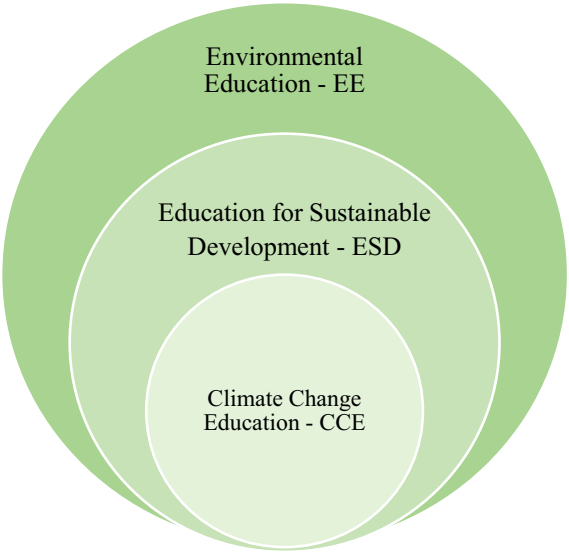

Fig. 3 Correlations between education and sustainability. *Source* Prepared by the authors based on Hesselink (2000), UNESCO (1997, 2005, 2014)

Table 2 describes a chronological analysis of the occurrence of EE; ESD and CCE. In addition, it presents the objectives and approaches of each of the education focuses.

There are many publications describing and addressing EE, ESD and CCE issues (Sartori et al. 2014). However, the officially published, elaborated and open-access documents developed by UNESCO on the above-mentioned themes present recent dates compared to the context and the relationship between man and planet earth.

In 1997 UNESCO, in Georgia, emphasized that education needed to be directed towards environmental issues, and education should bring man and nature closer together in a more harmonious way.

In 2005, UNESCO was tasked with producing the document known as: "The decade of education for sustainable development". The report presents important contributions, emphasizing the importance of living sustainably, and that ESD value the care and respect of people with the place.

Table 2 Case study overview

Topics	Goal	Approaches/impacts	Authors	Year
Environmental education	It is linked to the understanding of three fundamental concepts: acquisition of new knowledge and values, new patterns of conduct and interdependence. It should also be emphasized that the EE must result from a dimension of educational content and practice, oriented towards the preservation and resolution of concrete problems of the environment, through an interdisciplinary approach; to take the understanding of the environment in its totality and interdependence using the systemic approach to the global issues that surround the environment	– Acquisition of new knowledge and values – New standards of conduct – Interdependence EE should emphasize sustainable development, thus adding a new concept to the many others introduced earlier Environmental education appears as an essential element to solve this impasse. It must be able to transform man's relations with the environment, between the individual and nature	UNESCO	1997

(continued)

Table 2 (continued)

Topics	Goal	Approaches/impacts	Authors	Year
Education for sustainable development	1. To enhance the role of education and learning in the common pursuit of sustainable development 2. Facilitate contacts, networking, exchange and interaction between the parties involved in the ESD program 3. Provide the space and opportunities to improve and promote the concept of sustainable development and its transition 4. To promote the improvement of the quality of education and learning in education for sustainable development 5. Develop strategies at all levels to strengthen capacity for ESD	– Living in a sustainable way – Promote values, attitudes and capacities to face the challenges of this century – Leaving a more sustainable legacy for other people (behavior change) – Be interdisciplinary and holistic – Aim at the acquisition of securities – Develop critical thinking and the ability to find solutions – Use of multiplicity of methods – Stimulate the participatory decision-making process – Be applicable – Be closely related to local life	UNESCO	2005
Climate change Education	The CCE needs to achieve themes such as: sustainable development; the future of communities; adaptation and mitigation; the local focus; the global focus and the empowerment of those involved in the process	– Understanding of climate change and alertness – Adapting to change climatic – CCE needs to achieve themes such as: sustainable development; the future of communities; adaptation and mitigation; the local focus; the global focus and the empowerment of those involved in the process	UNESCO	2014

Source Prepared by the authors according to UNESCO (1997, 2005, 2014)

Recently, in 2014, UNESCO published a handbook describing education on climate change. According to Læssøe et al. (2009), this education has its first theoretical approaches published in 2009, in the cross-national report from the International Alliance of Leading Education Institutes. However, only in 2014, UNESCO presented its findings on the subject (CCE), worldwide, in the form of a document structured as a "course"—preparatory material for teachers to work with the themes in the classroom.

CCE addresses more "complex" issues that go beyond behavior change. This is because this education (CCE) discusses important concepts such as: understanding the differences between climate and time; adaptation and mitigation; resilience and vulnerability, among other important issues that are analyzed in local, regional, national and global contexts.

Thus, EE comes first, then ESD and more recently CCE, all education focuses primarily on contributing to sustainability. One education contributes to another, representing that there are always positive impacts from the moment a person changes his/her behavior in favor of issues involving the preservation of natural resources and well-being of others.

4.2 Bibliometric Analysis on Climate Change Education

In total, 111 papers were found resulting from the search for the terms "Climate change education". According to the variables described in the methodology, the following are the results of the bibliometric analysis on the EMC theme.

4.2.1 Areas

In the large area designated as "Climate Change Education" it was identified 21 thematic areas, highlighted in green, in Fig. 4. Of these areas, it was possible to highlight the four largest contributors.

The main contributions came from "Education & Educational Research" with 41% of the publications, representing 46 papers. This area was deployed in two subareas: "Environmental Sciences & Ecology" and "Social Sciences—Other Topics" highlighted in blue in Fig. 4.

Secondly, with 27% of the total, or 30 jobs, is "Environmental Sciences & Ecology". This area was developed in five subareas: "Meteorology & Atmospheric Sciences", "Science & Technology—Other Topics", "Biodiversity & Conservation", "Physical Geography" and "Education & Educational Research". Two of these subareas have also been deployed in others, "Science & Technology—Other Topics" has added works from the subarea "Engineering" and "Physical Geography" has added works from "Meteorology & Atmospheric Sciences".

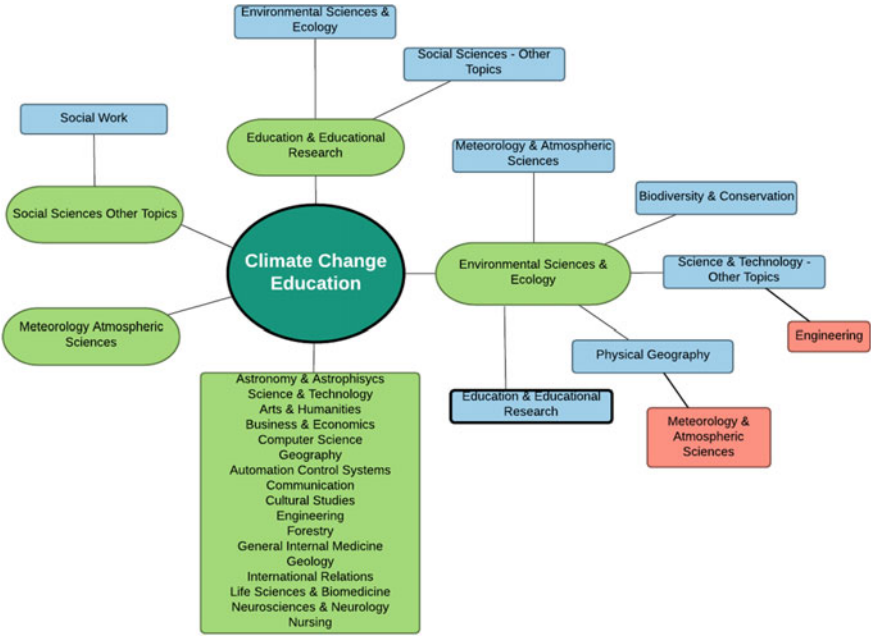

Fig. 4 Relationship between the main study areas

The third thematic area highlighted was "Social Sciences Other Topics", with 5.4% of the total publications, representing 6 works. This area gave rise to the subarea "Social Work".

In addition, it was possible to highlight a fourth thematic area, "Meteorology Atmospheric Sciences" with 4.5% of all publications, or 5 works. This area has not been deployed in subareas.

Finally, the other thematic areas in which the papers were classified, representing 17 fields, are listed below as "Climate Change Education".

4.2.2 Sources of Publication

Among 70 sources identified, the majority (79% or 54 sources) were periodicals while a small part represented events (10% or 7 sources) and a smaller part (4% or 3 sources), bulletins. In Table 3, the main sources of publications and their respective numbers are listed.

Table 3 Main sources of publication

Source	Nº of publications
Environmental Education Research	9
International Research in Geographical and Environmental Education	7
International Journal of Science Education	6

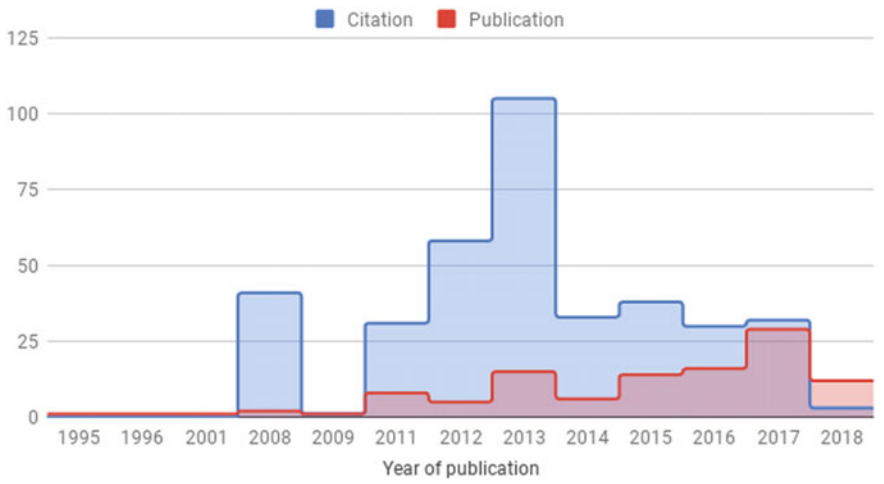

Fig. 5 Publications and citations

4.2.3 Year of Publication x Citation

The year with the highest number of publications was 2017, recording 29 papers. And, in 2013 the greatest number of citations was registered, with 105 citations (Fig. 5).

4.2.4 Country

The country where the largest number of publications was generated is the United States, with 46% of the total or 51 papers. The next is Canada with 7% of the total, or 8 works and third, Germany and England are tied with 5% of the total, or 6 works.

The overview of the countries that produced the most work related to the theme is presented in Fig. 6.

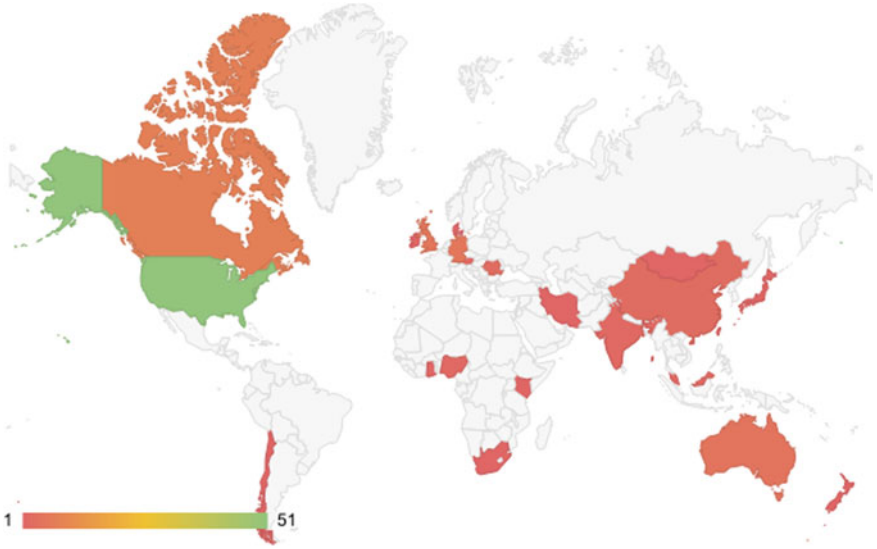

Fig. 6 Country of publication

Table 4 Paper's caracterization

Description	Number	Percentage (%)
Practical study[a]	53	50
Theoretical study[b]	34	32
Theoretical-practical study[c]	18	17

[a]Practical study: the classification of publications identified as practices followed the concept of Yin (2015), the author classifies with: linear, interactive and action research—case study
[b]Theoretical study: in this case the contribution of the researchers reaches the conceptual field, being only descriptive research (FONSECA 2002)
[c]Theoretical-practical study: involves both processes described above

4.2.5 Characterization of Publications

Regarding the nature of the studies, half of the studies were practical and 32% were theoretical studies. Still, it was possible to classify 17% of the works as theoretical-practical, according to Table 4.

4.2.6 Clouds of Words and Frequencies on the Has CCE

Figure 7 illustrates the main words described in the 111 articles found and directed to the CCE theme. Still, it is emphasized that, the bigger the size of the words,

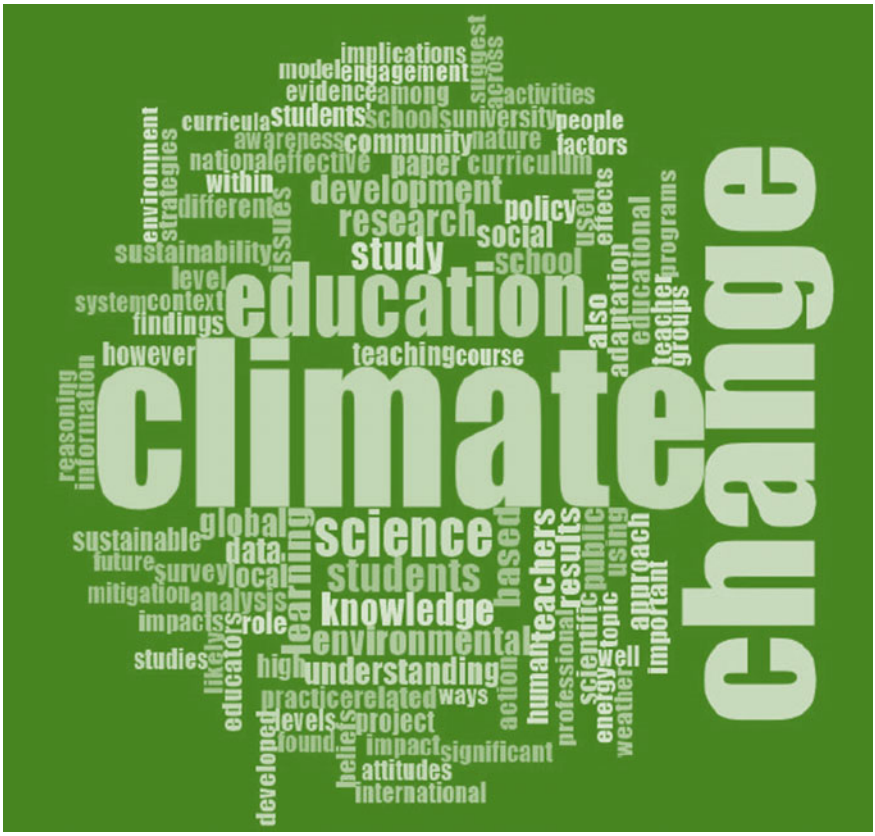

Fig. 7 Frequent words on studies

the greater is the frequency that it appears in the texts. Thus, as expected, the most repeated themes are: climate; change; education; study and science.

4.3 Education in Climate Change: A Case Study in Passo Fundo, Southern Brazil

The training of the teachers, participants of this research, has a schedule with a total of seven meetings. Beginning on July 5, 2018 and ending on December 6, 2018. Following the material prepared by UNESCO (2014), each meeting addressed a specific issue related to CCE. According to the main goal of this article, in which describes the findings of the first meeting that focused on the theme: "Learning about climate change for sustainable development".

Table 5 Characterization of the group of teachers who are part of the research

Teacher	Subject(s)	Gender	Age	Education level	Religion
A	History and Geography	Female	38	Postgraduate	Catholic
B	Physics Education	Female	43	Postgraduate	Catholic
C	Arts	Female	51	Graduate	Catholic
D	Mathematics and Physics	Female	26	Postgraduate	Spiritist

4.3.1 Characteristics of the Research Group

Table 5 describes the characteristics of the teachers who are part of the research.

The teachers who were part of the research were indicated by the school board, taking into account three factors: (a) teaching for elementary school; (b) different areas of knowledge; and (c) different age groups.

It was observed that, 75% participants of the research presented some type of complete graduate. Considering the type of religion, the majority of participants (75%) are Catholic and 25% (a person) is spiritualist.

4.3.2 Meeting Purpose and Topics Covered

The meeting was held on the school premises in the afternoon shift (3:45–5:35) on July 5, 2018. Important topics such as 2030 Agenda and the 17 Sustainable Development Goals (SDG) were part of the training. Then, the concept of education on climate change was presented to the group, who said, 100% of the answers, that had never heard of it.

Discussions about the differences between climate and time have been clarified; understandings about atmospheric components have been illustrated; other issues addressed were: the greenhouse effect, greenhouse gas emissions and the implications of climate change on ecosystems; human systems; urban systems; economic systems and social systems were presented.

The teachers reported that their specific knowledge about climate change was superficial and that they saw many limitations/difficulties of inserting the theme in the context of the classroom. However, at the end of the encounter this perception was altered.

Table 6 describes the first activity performed by the group of teachers, in the training. The objective of this activity was to construct some concepts that involve climate change (the teachers could complete the columns of Table 6 according to their acquired knowledge, through lived experiences or information seen in some medium of communication, besides being able to interview other people and to make such inquiries), in total the table presents twenty-one sentences that involve learning about the CCE.

The questions in Table 6 can be grouped into four main themes within the main discussions presented in the questions: (a) engagement: issues 1; 8; 10 and 18—

Table 6 Framing and understanding of climate change concepts

	Find/Rimind someone who…	Source	Notes on the discussion
1	Had engaged in some community action related to climate change?	Report of one interviewee, not identified and described by teacher D	– "*Yes. Personally I haven't been engaged, but I watched on TV a news article about retirees making PET bottle brooms*" (Teacher description D) Note: the other teachers (A, B and C) did not respond to this line
2	Are worried about what the future might bring?	Report of one interviewee, not identified and described by teacher D	– "*Yes. At a dinner with my family we discussed the importance of bees. Currently, we don't notice their presence as if they had disappeared. Our concern is with the future of ecosystems*" (Teacher description D)
		Report of teachers A and B	– "*Yes. If the population doesn't realize, the future of the planet could be devastating*" Note: teacher C did not respond to this line
3	Ever heard that warmer weather will bring new diseases?	Report of teachers A and B	– "*Yes*" In this item teachers A and B emphasize that, they believe that with the warmer climate, besides new diseases, the intensity of these will be greater Note: teachers C and D did not respond to this line
4	Not sure about the difference between climate and weather?	Report of teachers A and B	"*We're safe. Weather is the time right now (one day) and the climate is formed over a long period of time (on average of 30 years)*" Note: teachers C and D did not respond to this line
5	Feels that the normal pace of the seasons is changing?	Report of teachers A and B	"*Yes, it's changing and there are no more four seasons with well-defined characteristics*"

(continued)

Table 6 (continued)

	Find/Rimind someone who…	Source	Notes on the discussion
		Report of one interviewee, not identified and described by teacher D	"*Yes, and this change has resulted in illness*" Note: teachers C did not respond to this line
6	Knew people who had to move because of the effects of climate change?	Report of teachers A and B	– "*No*" Note: teachers C and D did not respond
7	Can think in adjustments being made to stem the increase in climate change?	None of the teachers (A, B, C and D) answered this question	–
8	Blame the rich nations for climate change?	Report of teachers A and B	– "*A kind of*". *Because they are the ones who has most goods* Note: teachers C and D did not respond
9	Can share a recent history about climate change?	None of the teachers (A, B, C and D) answered this question	–
10	Are trying to be "green" by reducing energy use?	None of the teachers (A, B, C and D) answered this question	–
11	Believes that climate change is not so serious?	Report of teachers A and B	– "*We consider it serious. For the short term climate change will bring serious challenges to the world population*" Note: teachers C and D did not respond
12	Know some farmer who is concerned about climate change?	Report of teachers A and B	"*We don't know any, unfortunately*" Note: teachers C and D did not respond
13	Feels that his lifestyle and culture is under threat by climate change?	Report of teachers A and B	– "*Yes*" Note: teachers C and D did not respond
14	Believes that girls and women will suffer more from climate warming?	None of the teachers (A, B, C and D) answered this question	–
15	Can feel the effects of climate change where lives?	Report of teachers A and B	– "*Yes. Especially in agriculture*"

(continued)

Table 6 (continued)

	Find/Rimind someone who…	Source	Notes on the discussion
		Report of one interviewee, not identified and described by teacher D	– "*Yes. Recently, there was a storm in Passo Fundo, with high rainfall and consequently, flood*" Note: teacher C did not respond to this line
16	Can think about adaptations being made to adapt to climate change?	Report of one interviewee, not identified and described by teacher D	– "*Yes. Specially related to waste recycling*" Note: teachers A, B and C did not answer this question
17	Feels very emotional about climate change?	None of the teachers (A, B, C and D) answered this question	–
18	Heard or read terrible predictions about climate change?	Report of teachers A and B	– "*Yes*" Note: teachers C and D did not respond
19	Learn about species extinction because of climate change?	Report of teachers A and B	– "*Yes. The polar bear is an example*" Note: teachers C and D did not respond
20	Believes that your children will not be able to live as he lives?	Report of teachers A and B	– "*Yes*" Note: teachers C and D did not respond
21	Believe that your students will be able to respond positively to climate change?	Report of teachers A and B	– "*Yes*, if they are well trained in the importance of the subject" Note: teachers C and D did not respond

represent 19% of the questions asked; (b) future: issues 2; 3; 5; 13; 2 and 21—represent 29% of the questions asked; (c) theoretical knowledge: 4; 7; 11; 14; 17; 18 and 19—represent 33% of the questions asked; and, (d) practical knowledge: 6; 9; 12; 15—represent, also according to the future, 19% of the questions asked.

When analyzing the answers, it is noted that 77% of the questions were completed by teachers while only 23% (five questions) were left unanswered by the participants. This shows that the participants have a good knowledge on the topics addressed by Education Climate Change.

The questions that were not answered by the participants (6, 9, 10, 14 and 17) emphasize that they do not belong to territories that experiences intense climate change. In addition, there are questions pertaining to the key themes that integrate the theoretical knowledge to the scientific one. These results reinforce the importance of this research.

Table 7 Climate change: experiences, causes, hopes and effects

Experiences with climate change	**Causes of climate change**
– Hail, on a large scale – Winds – Very intense floods in the city of Getúlio Vargas when I was teaching there – Storm and windstorm that resulted in the sanding of most of the houses in my neighborhood – Tornado that caused the hurl of two trucks in Rio Grande do Sul – Landslide – Floods in Paraná (São José dos Pinhais)	– Deforestation – Changes in rainfall and air masses – Disrespect for urban water resources, which in most cases have their paths altered and/or channeled through lack of planning – The human beings – Lack of education "It wasn't me" who threw the trash on the floor – Lack of adequate waste separation
Hopes and expectations	**Effects of climate change**
– Sustainability – Don't change the paths of the rivers – Use more efficient infrastructures – Don't experience lack of water – Change in the consciousness of people and also change their habits – More respect and environmental education – Consciousness of people in changing their behavior – Lack of water	– Financial losses – Damage to the environment – Loss of materials (in case of flood), many people lost their homes and other goods – Sudden temperature change over the same day – Mass movements – Defrosting of the polar caps – Storm – Tornadoes – Tsunamis

After the activity in Table 6 was carried out, the teachers described their experiences, thoughts of cause, hope and effects of climate change—as Table 7 shows.

According to Table 7, all teachers reported having some bad experience with climate change; they point out in the discussions that only the change of behavior could revise the forecasts of catastrophic weather and land warnings.

Finally, in pairs, teachers read real stories about the impact of climate change (UNESCO 2014) and then produced collages on the subjects studied. During the discussion of one of the texts, the teacher "A" emphasized that:

> Indeed, according to theoretical evidence, women are among the group of people most vulnerable to climate change.

Then the other participants agreed. In the end, the teachers committed to continue participating in the research and to transmit the knowledge acquired in the context of their classroom, at home and in the community.

4.3.3 Contributions and Limitations of Work

This article contributes to the science that studies climate change education as well as to educators in the area. Its methodology follows the principles structured by UNESCO (2014), considering and adapting the local needs of the area of study.

Thus, this case study can be used as a methodological parameter for other research in this line, in which researchers need to evaluate their territorial scenarios and study interest groups.

Also, as mentioned previously, due to the aim of this article, it describes only one of the seven meetings held in this training of teachers for education on climate change.

5 Conclusions

Education contributes directly to sustainability. This is because it stimulates in people the sense of commitment to themselves, to the other and to the whole planet. In chronological terms, EE is the first "category" of education, inserted in the global discussions in 1997. Later, in 2005, the importance of ESD is emphasized—as an integral part of the larger approach that is EE. In 2013, CCE is inserted in the global context, through a UNESCO publication—"Climate change in the classroom: UNESCO course for secondary teachers on climate change education for sustainable development". The CCE is a specific part of the studies involving ESD. In this way, both integrate and complement each other. The highest goal of education (EE, ESD and CCE) is to emphasize the role of everyone in the present, for a better and more sustainable life in the future.

Bibliometric research emphasizes the need for further research on CCE as there are only 111 published papers on this subject that can be characterized as "new", considering that the first publication occurred in the year 1995. It is known that climate change affects all territories and, according to the results of this research, there are currently few countries that are making efforts to understand CCE. In the last six years, the publications directed to the subject CCE have increased. This is a complex subject; ample efforts are necessary so that the CCE can be inserted in the school contexts of the global territories.

Before the beginning of the activities, the teachers reinforced a superficial knowledge about the subject—CCE and how difficult it is to deal with this subject in the context of the classroom, since the current impacts of climate change in Passo Fundo's region are not intense. However, they have demonstrated a good prior knowledge of the issues surrounding climate change education, as 77% of the questions were answered. And, they emphasize the importance of the theme being worked in the classroom. In addition, all teachers reported some bad experience related to climate change.

In addition, the CCE study has a positive impact on two SDGs, 4 (quality education) and 13 (combating climate change). In this sense, addressing this issue (CCE) contributes to 2030 Agenda.

This article expands the theoretical and practical approaches in the field of science that studies climate change education and serves as a basis for future studies with the same focus of interest. However, it should be emphasized that the new case studies should consider their local study areas.

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The Use of Mobile Devices in Environmental Education

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Abstract Digital media plays an essential role in the area of Environmental Education. This study intends to propose an activity involving media in environmental education. The participants came from a Technical Teacher Training school in the municipality of *Cabo Frio*, Rio de Janeiro, Brazil. This city has been suffering with environmental damages and precariousness in the supply of water and sewage treatment, in addition to the excessive amount of solid waste thrown on the beaches in the high season. Among these, coconut waste. Faced with this situation, a thematic proposal was developed with the students, comprising an interactive lecture about different ways of reusing solid coconut waste and about the harmful implications when it is released to the environment. In order to accompany learning, a playful activity was performed using the mobile device feature in the *Kahoot!* application. Students were then asked to answer a questionnaire in an interactive and collaborative way. It is therefore possible to understand the success of this kind of playful activities and its possibilities, associated to games using mobile devices, in the context of the teaching-learning process. It can be concluded that the media-education through mobile devices improves cognitive development, autonomy, creativity and enables an eminent awareness about social-environmental problems.

Keywords Environmental education · Mobile devices · Coconut waste

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1 Introduction

Cabo Frio is one of the seven municipalities of the *Lagos* Region, located in the state of *Rio de Janeiro*, Brazil. Data from the Municipality of *Cabo Frio* (PMCBF 2014) indicate that during periods of high season, there is a considerable increase in tourism. This contributes to additional generation of municipal solid waste (MSW), which can be found in large quantities, mainly in the sands of the beaches of this region. Pereira et al. (2018) reports that the green coconut shells, resulting from the commercialization on the beaches of *Cabo Frio*, are MSW of great importance, due to its weight and volume, causing serious environmental consequences for the city. Data from the Environmental Impact Report (RIMA 2015) relating the expansion of the sanitary landfill, located in the municipality of *São Pedro da Aldeia*, Brazil, show that the *Dois Arcos* landfill currently receives an average amount of 600 tons of waste per day. As a consequence, it is necessary to implement Environmental Education actions, aimed to promote the learning process and awareness about local environmental damages. Law 9.795/99 (Brasil 1999), which establishes the National Environmental Education Policy (PNEA) determines, in article 2, environmental education as a component of national education and to be articulated at all levels of the educational process.

Authors as Kalogiannakis and Papadakis (2017) emphasize that working with environmental education gives students the necessary skills, attitudes and values to ensure sustainable progress to the local and global human dimension. Thus, it can be stated that the pedagogical practice added to the use of mobile devices may become significant allies in the development of learning, since they belong to the daily life of children, youth and adults and contribute to a consolidated and significant knowledge, to those involved in the learning process. The insertion of digital technologies potentiates new ways of looking at the world, new interactions with the environment and better predisposes the citizen to preserve it. Therefore, teaching that only uses traditional methodologies becomes unattractive (Fardo 2013). According to the United Nations Educational, Scientific and Cultural Organization (UNESCO 2013), formal education has long been restricted to the universe of the classroom. However, digital technologies, such as mobile devices, have expanded new spaces for the teaching-learning process and, thus, the student has access to information, strengthening the construction of thought and globalized relationships beyond the school walls.

This work intends to propose an activity in environmental education associated with media-education. To achieve this, mobile devices are used through the *Kahoot!* (2018) application, in order to connect environmental education and the reuse of solid coconut waste, linked to the context of the student's reality, empowering future professionals to apply pedagogical practices to the students of Elementary School.

2 Materials and Methods

The scenario of this research is a Technical Teacher Training school, located in the centre of the City of *Cabo Frio*, *Rio de Janeiro*, Brazil. The target audience for this project are graduates of the 3rd grade, with an age group between 17 and 18 years old. It is worth mentioning that this research is qualitative, with an exploratory nature. de Souza Minayo (2011) states that qualitative research is concerned with the universe of meanings, with a level of reality that cannot be quantified.

The research was developed in four stages, distributed as follows: accomplishment of an interactive lecture; elaboration and creation of the *Kahoot!* game, composed of ten questions on the interactive speech; application of the game to the students, in the attempt to assess the learning process and analysis of the results.

Step 1: Lecture on reuse of solid coconut waste

A 50-min lecture was given on the theme: "The different forms of reuse of solid coconut waste" where the environmental impacts of improper waste disposal in the city of *Cabo Frio* were outlined. At this stage of the work, the participants were able to get to know and discuss the differences between solid waste and scrap, the estimated time to decompose waste in nature, health impacts when waste is improperly released into the environment and, above all, forms of reuse.

According to the curricular guidelines of the *Cabo Frio* Municipal Department of Education (SEME 2012), it is necessary to present Environmental Education within a systemic, critical, multidisciplinary, interdisciplinary and transdisciplinary dimension, in a continuous and permanent manner in all areas of knowledge, building dynamic interactions between environment, culture and society.

Step 2: Elaboration and creation of the *Kahoot!* game

The *Kahoot!* game comprised ten questions related to the content taught in the lecture, on reuse of solid coconut waste. In fact, Vasconcellos (2000) states that learning does not start from the void, but rather must be related to a given context. To create the game, it is necessary to have a *Kahoot!* account (https://Kahoot.com/) and to login with the access password. In the initial screen, the button "CREATE" must be pressed. In the "Create a new *Kahoot!*" screen, there are 4 options: 1. Quiz; 2. Discussion; 3. Jumble; 4. Survey. In this work, the "Quiz" option was used (Fig. 1).

Step 3: Running the *Kahoot!* game

In order to play the game using the mobile devices via browser, internet access is needed, to access the electronic address (https://Kahoot.com). The PIN provided by the teacher must be entered. Each student enters his/her name or surname in the devices. The questions that were previously created by the teacher are presented. Answers are given on the mobile device screen—selecting the option (geometric figure or colour) corresponding to the correct answer: triangle (red), rectangle (blue), circle (orange), square (green). In the following screens, new questions will arise, as shown in Fig. 2.

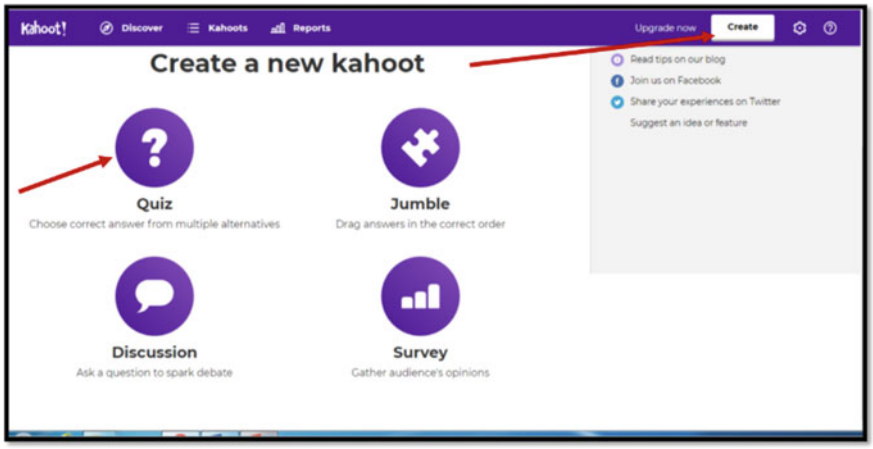
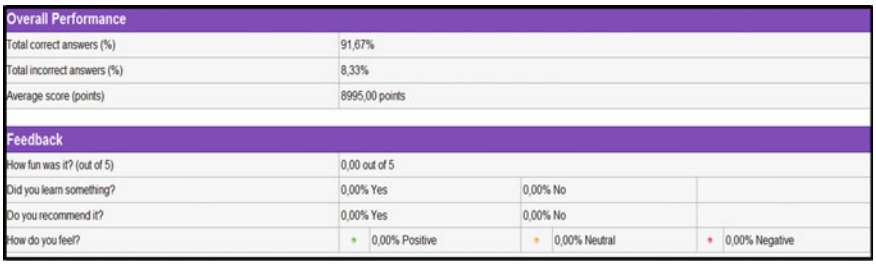


Fig. 1 *Kahoot!* game creation home screen

Fig. 2 Screen with presentation of each *Kahoot!* game question

Step 4: Analysis of Game Results

Figure 3 indicates the overall performance of the students who participated in the activity. In the general evaluation of the results, it was observed that 91.67% of the questions were answered correctly and 8.33% were incorrect. The overall score achieved in the game was 8995.00.

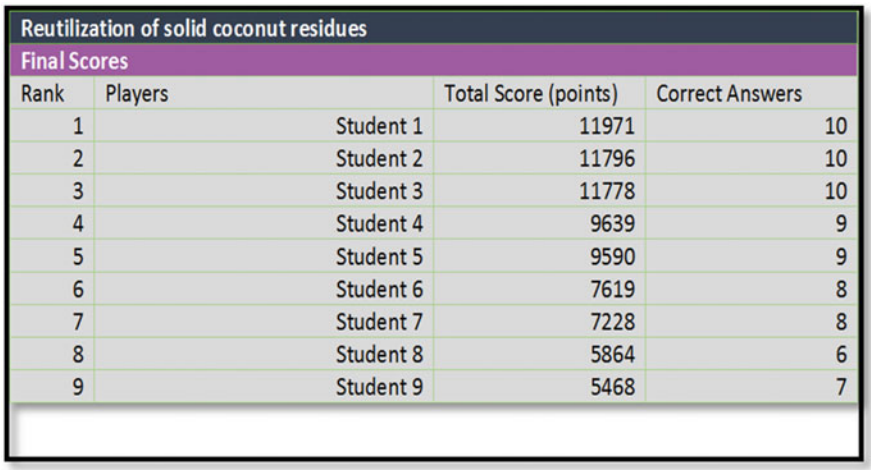


Overall Performance			
Total correct answers (%)	91,67%		
Total incorrect answers (%)	8,33%		
Average score (points)	8995,00 points		
Feedback			
How fun was it? (out of 5)	0,00 out of 5		
Did you learn something?	0,00% Yes	0,00% No	
Do you recommend it?	0,00% Yes	0,00% No	
How do you feel?	0,00% Positive	0,00% Neutral	0,00% Negative

Fig. 3 Screen showing students' overall performance

3 Results

The objective of this study was to propose an activity in environmental education associated to media education. This was accomplished through the application of the *Kahoot!* game structured in 10 questions, based on the lecture on "Reutilization of solid coconut wastes", which were applied to a class of 9 students of the 3rd year of a Technical Teacher Training school. The questions were designed in order that those involved could choose and select from four possible answers, where only one was considered correct. Students were instructed on how to access the *Kahoot!* platform with their mobile devices in order to play. Throughout the execution of the game, students kept the focus, concentration and enthusiasm to answer the questions. In fact, and as stated by Luis et al. (2016), the games used in classroom practice enable interaction among students, stimulating the quest to overcome difficulties through the activity of the game. Figure 4 indicates the final scores of the students, participating in the activity.



Reutilization of solid coconut residues			
Final Scores			
Rank	Players	Total Score (points)	Correct Answers
1	Student 1	11971	10
2	Student 2	11796	10
3	Student 3	11778	10
4	Student 4	9639	9
5	Student 5	9590	9
6	Student 6	7619	8
7	Student 7	7228	8
8	Student 8	5864	6
9	Student 9	5468	7

Fig. 4 Screen showing students' final scores

Regarding the performance of the nine players, three managed to answer all the questions in the estimated time of 20 s, established in the initial construction of the game. Two participants answered nine questions. Two others answered eight questions. Only one participant answered 6 questions. Based on the participants' performance, the teacher has an overview of each student and proceeds to review if necessary. In this way, the teacher is able to organize a didactic planning, articulated to the reality of the students, as pointed out by Vasconcellos (2000).

4 Conclusions

In general terms, this study outlines the need to develop Environmental Education projects involving media and education. In addition, it emphasises the challenging issues in the environmental context of the tourist town of *Cabo Frio*, Rio de Janeiro, Brazil, highlighting the significant increase of coconut waste on the beaches of the region, due to the increase in the flow of tourists, mainly in the high season.

It was clear that the students were enthusiastic about the activities proposed, essentially in the stage where mobile devices are used. Some students have even proposed using the application to explore other themes relating the city's environmental problems. In addition, since the target audience of this study is linked to the Technical Teacher Training school, it becomes relevant for the student to absorb the different possibilities of using games in an organized, didactic and pleasant way, in order to adapt the pedagogical activity with their future students.

It can be concluded that the media-education association through mobile devices improves cognitive development, autonomy, creativity and enables awareness about social and environmental issues, also allowing the use of learning games in the classroom context. The importance of associating the media with education is emphasized, since it arouses students' interest and motivation for the themes under study.

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The Role of Institutions in Promoting Resilience in the Development of Sustainable Food Systems: The Farmer's Perspective in the Northeast of Brazil

Monica Dantas

Abstract In the Brazilian context, agriculture presents itself in opposing directions: agribusiness and family farming. Through time, agribusiness has developed an extensive apparatus of institutions and policies to ensure its success. Family farming, on the other hand, has had considerably less support. However, in the last decade, reports attesting the importance of family farming, especially regarding food security and the promotion of sustainable agriculture—has put them in the spotlight. This study investigates family farming in the state of Rio Grande do Norte-RN, focusing on a cooperative named Rede Xique-xique and the Cooperative Central da Agricultura Familiar e Economia Solidaria (CECAFES). The guiding question for this research is: How vulnerable is family farming, and the Social and Solidarity Economy (SSE) to the recent dismembering of institutional structures of support in Brazil? The method used elements of participatory action research, the case study collected data from 30 semi-structured interviews conducted from May to August of 2017 in the state of RN, Brazil. The participants are family farmers and people directly engaged with solidarity economy. Also included is an interdisciplinary literature review concerning sociology of food, environment subjects and community development topics. The MAXQDA software was used for processing the unstructured data to support coding, analyses and the displaying of results. The regional focus of this study is the Northeast of Brazil a region that endures severe water shortages, rural exodus, the lowest income in the country, and a lack of infrastructure and public policies to support better living conditions. The results of the study bring a unique perspective from family farmers in RN about the role of institutions, especially governmental ones, and the effects of the recent institutional dismantling caused by the change in government in Brazil. The study also appoints ways the farmers foster resilience in times of crises.

Keywords Family farming · Solidarity economy · Institutions · Sustainable development

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1 Introduction

The industrial agriculture and factory-based food manufacturing have, in the last few decades, transformed people's relationship with their food systems, largely replacing family farming, home food preparation, food waste and eating habits from domestic and community-based heterogenic systems with a global industry of commodities. Local farming produce is now part of an alternative niche, cooking and sharing a meal with family and friends is reserved for holidays and special occasions. For everyday life, the food industry offers low-cost, standardized foodstuff, ready to eat in attractive plastic single-packages, designed to be microwaved and easily eaten on a desk, conveniently fitting our modern daily life. However, the effects of adopting an industrial approach to the production and distribution of food are devastating, and the real cost regarding socio-ecological and human health are mostly concealed from the public, while governments and institutions are doing little to protect both the people and the environment. If our governments' understanding of agriculture is that it is a business, then its outcome is no longer food; they are commodities, and as such, the policies and laws governing it emphasize increasing profits above all else. Governmental and non-governmental institutions play essential roles in shaping the food systems. The control of what and how we eat can be eroded or promoted by institutions. Nestle (2013), states the food industry invests an enormous amount of money in lobbying, and publicizing research results when it is favourable to the industry, while undermining results that criticize their products. In his book *Folks, This Ain't Normal*, Joel Salatin (2011) criticizes how the American government, much like the rest of the world, regulates the food market staging, ensuring the public health while also preventing healthy eating by making it more difficult for small farmers to have direct access to local consumers.

This paper will focus on the role of institutions in small-scale farming and the development of Social and Solidarity Economy (SSE) as marketing and distribution systems in the in the state of RN, Northeast of Brazil. It includes an interdisciplinary review on the role of institutions and how they shape social interactions, introduces the industrial food system, and explores some of its adverse economic and environmental effects, highlighting their relevance against the United Nations Sustainable Development goals SDGs. The literature reviewed peasants' social movements, and also includes a brief description of the supporting institutional structure created in the Brazilian context to support family farming and SSE in the past decade.

For the methodological approach, the research is a case study that uses elements of the participative action research (PAR) process, such as mapping and collective reflection. The data comes from participatory observation, social media, online news communication, and interviews carried out with family farmers, SSE producers and other stakeholders, between July and September of 2017 at the Brazilian Northeast state of Rio Grande do Norte (RN). In a first contact to map general conditions, actors and contributors were approached at the CECAFES, which is the largest and only market exclusively focused on family farming and solidarity economy, located in the capital of RN. After the mapping phase, the researcher visited working groups

and local and periodic markets, conducting interviews with farmers and other stakeholders from the Rede Xique-xique and CECAFES, bank agents, community developers and academics. Coding and analysis made with the support of software called MAXQDA were used for the processing of unstructured data. The study investigated the perspective of small-scale farmers and artisans, as well as the role of institutions involved. It also analyzed the vulnerability of family farming in that region, due to the recent dismembering of institutional structures of support that occurred in Brazil as the result of the change in government direction.

The results offer the unique perspective of the actors, involved in family agriculture and solidarity economy in the state of RN, concerning the effects of the late change in government within the scope of this research project. The research showed that reducing the institutional support for family farmers can have devastating consequences to the working and living conditions of farmers. It also exemplified the resilience within community organization and networks.

2 Alternative Food Systems

Family farming has had considerably less political and economic support than agribusiness. However, in the last decade, reports attesting the importance of family farming, especially regarding food security and the promotion of sustainable agriculture, has put the sector in the spotlight. The Brazilian Special Secretariat of Family Agriculture (SEAF) states the relevance of family farming goes beyond that of income generation; the very relationship with the land is different from that of agribusiness landowners where they may not even be farmers at all, while in small rural municipalities, family farmers' land means home, heritage and culture. In the case of Brazil, family farming has great socio-economic importance, supplying the domestic market and controlling the inflation of staple foods consumed by Brazilians. Therefore, family farming is fundamental for food security. The 2006 Census of Agriculture (2009) found most of Brazil's farmers are family farmers. 84.4% of all Brazilian agricultural establishments belong to small or medium family groups out of approximately 4.4 million establishments, with half of them in the Northeast Region (Census 2009).

Social and solidarity Economy is an excellent ally for family farmers, and it means more than a way to sell their products: It is a fair-trade opportunity, capable of transforming the quality of life of those involved. SSE is an international movement that respects social and environmental issues, and also encourages responsible production and ethical consumption. The term SSE has been present in the academic and political sphere for some time now. The definitions of its principles are somewhat similar around the world, with some limitations in ranges of its coverage. The first World Social Forum in 2001 marked the rise of the solidarity economy topic as a study subject, and as an emergent movement, it was organized to oppose the World Economic Forum dedicated to representing the most significant capital industries, such as banks and multi-nationals. In 2003, the Brazilian Secretariat of Solidarity

Economy within the Ministry of Labor was created. In its first mandate, the Secretariat was to map solidarity economy and its impact in Brazil (Lechat 2009). The role of the social economy is to offer "alternative economic strategies to reduce poverty and unemployment, and to implement new civil-society-based economic revitalization strategies" (Mendell 2009, p. 178). For Gaiger (2004), one of the main objectives of the solidarity economy is to provide a new practice of workforce, breaking with the degrading working conditions and reconciling the worker with the process and fruits of their labour in order to overcome the disposable and alienating character of the productive activity. Mendell (2009) states that there are three supporting pillars of the social economy, which are the social enterprises themselves, an enabling policy environment, and leadership. The role of government is to create institutions to provide the enabling conditions for social economy to thrive, such as: capacity building, political spaces for discussion and representation, and research and networking. A definition adopted by the Chantier de l'économie sociale states that, "As a whole, the social economy refers to the set of activities and organizations stemming from collective entrepreneurship" (Mendell 2009, p. 186). Though there are common characteristics to it, the limits, boundaries and definitions for SSE sometimes overlap, as different manifestation of it are observed all over the world.

Today, SSE is commonly found within the third sector, in the informal economy and cooperative models. What is known as the Social and Solidarity Economy (SSE) seems to be a natural manifestation of society or community organizations to collectively produce and distribute goods and services according to their own needs and aspirations. In the case presented in Mendell's work, the government support enabled the beginning of a movement, while lack of support represented difficulties, which demonstrates the vital importance of the relationship between the government and the well-being of the social economy. When government support was withdrawn in Quebec, a space for political negotiation was already established. In the recent case of Brazil, not only have funds been cut, but the very space for political representation is being dismantled. Mendell and Neamtan state the social economy assimilates individuals into the labour force, asserting that SSE "play an active role in ensuring that marginalized groups have access to jobs and certain services" (Mendell and Neamtan 2010, p. 15). In the same work, the authors suggest the social economy takes on similar roles elsewhere in the world. Mendell and Neamtan appointed various institutions as part of an extensive network of backing for SSE supported by Quebec, such as the *Chantier de l'économie sociale.*

The SSE has presented itself in a variety of arrangements throughout time, including in existing non-monetary exchanges groups or alternative local currencies. In Brazil, the SSE is and has long been deeply embedded in regions and microregions. An interviewed community developer stated that, "Outside the capital cities, in the interior rural communities of Brazil, communities are naturally organized in solidarity" (Dantas and Silva 2018, p. 5). This is due the historic situation of exclusion of small farmers, thus making solidarity essential.

In the Brazilian context, there are two frequently opposing directions: agribusiness and family farming. Although agriculture has been in the heart of the socioeconomic fabric, the role of institutions in the development of the food systems was

all but neglected by economists and academics until recently, especially the portion that comprises the role of institutions representing small-scale agriculture. The rise in economic growth, powered by the shift in the ways and amounts of consumption that started in the 1960s, marked the begging of a continuous race for producing and consuming more while disregarding real needs and environmental limits. Adjusting to this systemic design, the institutions were restructured to support the development and shaping decisions to trigger economic growth. Institutions partake in great roles in our societies, representing "the humanly devised constraints that structure political, economic and social interaction" (North 1991, p. 97). They are the formalized measuring organism of society that promotes partial standardization of groups of people that are too large to know each other. Institutions may be governmental, private, religious or otherwise, and "with the standard constraints of economics, they define the choice set and therefore determine transaction and production costs of economic activity" (North 1991, p. 97).

Among the leading institutions involved in agriculture are banks, as credit can be used to expand influence and institutionalize economic directions. In the position of creditor, banks commonly act in the political and economic fields at the international sphere, conveying models of development to be followed by regions or entire countries. Governmental institutions also play a significant role in agriculture. For instance, the Brazilian Ministry of Agriculture, Fishery and Supply (MAPA) formulates and implements policies for the development of agribusiness in Brazil, and is one of the oldest and most powerful institutions in the country. Institutions geared towards the promotion of knowledge play a similarly vital role in the sector. The Brazilian Agricultural Research Corporation (Embrapa) provides technological support nationally, and the National Supply Company (Conab) focuses on distribution and food security. Both Embrapa and Conab are public companies that operate under the coordination of the MAPA (MAPA: Institutional, n.d). The interests of the agribusiness sector coincide with international trade interests, and thus it is easy to deduct agribusinesses have been provided with plenty of institutional representation and support.

Trends created by large institutions are dominant but can and do change, especially when challenged by other institutions or community mobilization. In the 1980s, Brazil, under military regime, suffered from drastic state downsizing imposed by the International Monetary Fund. Thus, "as political parties and their domesticated organizations became increasingly irrelevant for rural peoples, a new generation of peasant organizations came to the fore" (Martinez-Torres and Rosset 2010, p. 152), referring to la Via Campesina. Brazilian social movements actively participated in the forging of international institutions such as the Coordinadora Latinoamericana de Organizaciones del Campo CLOC, and La Via Campesina, a broad coalition of farmer's organizations from Europe, Latin America, Asia, North America and Africa. Another vital institution in the Brazil agricultural scenario is the Landless Workers Movement (MST), one of the most significant movements of its kind in the world, organized in 24 states in the five regions of Brazil. In all, there are about 350,000 families who have acquired land through the struggle and organization of rural workers. After settling, most families remain organized in the MST since the

conquest of the land is only the first step towards the realization of agrarian reform. An example of how mobilization has contributed to the creation of an institution is the events that resulted in the creation of the Ministry of the Agricultural Development (MDA). On April 17th of 1996, nineteen MST members were killed by the military police while they were doing a blockade protest for agrarian reform in the state of Para, North of Brazil. This massacre, known worldwide, became the International Day of Peasants' Struggle. According to MST history archives, the mobilizations and worldwide repercussions of this event pressured the Federal administration to create the MDA (MST: History journal n.d). The MDA was an essential and long-anticipated achievement to represent the other spectrum of agriculture in Brazil, as the MAPA has clear objectives towards industrial and large-scale agriculture. The MDA was the institution to serve as an umbrella for agrarian reform, sustainable development, family farming, and Social and Solidarity Economy interests. With a separate budget administrated independently from the MAPA, Brazil saw significant development of the family farm and solidarity economy institutional support from 2003 until 2015. However, when Brazil experienced a major political and economic crisis, following the impeachment of the President Dilma Rousseff, under pressure to stop the crises, the MDA was eliminated at the beginning of President Michel Temer term as part of administrative reform to cut public spending. For a large portion of the population, it seemed acceptable to cut funds supporting family farmers.

Communication and education also play an important role in shaping popular belief systems which translate into popular support or demand for change. For instance, in Brazil there is a widely accepted belief that government support for family farming is social assistance, while the support for agribusiness is an economic investment, disregarding the fact that it is family farming that produces most of the food people eat. Thus, concerning the systemic design behind our global food system, a significant institutional change is needed, especially regarding how lobbying and the control of the public image of certain institutions by the elite influences policy making to reflect private interest.

The election of Jair Bolsonaro for the Brazilian presidency in October, 2018 forecasted additional support for agribusiness and more disregard for environmental issues. An interview for the Agência Brasil on November, 2018, demonstrates his support for agribusiness, following the French president's G20 declaration of concern on taking on an ecological transition at home only to sign trade agreements with countries that do not commit to ecological transitions, trade between Mercosur and the European Union was suspended. In response, President-elect Bolsonaro stated, "He does not intend to take on any environmental commitments that impact Brazilian agribusiness," citing protection of national interests as his reasoning [my translation] (Agencia Brazil 2018).

The United Nation's (UN) Food and Agriculture Organization (FAO) is the largest institution to promote food access in the world. Their goal is "to achieve food security for all and make sure that people have regular access to enough high-quality food to lead active, healthy lives" (FAO, About us). FAO framework, research and reports helped identify issues and possibilities around the world, stressing the enormous potential of family farmers in preserving natural resources and eradicating hunger.

"They not only produce about 80% of the world's food, but also serve as custodians of about 70–80% of farmland" (FAO 2014). In 2015, the UN announced the Sustainable Development Goals (SDGs), which is the result of a global partnership for world transformation towards peace and prosperity (UN General Assembly 2015). The global food system is a paramount challenge if we are to achieve the SDGs. About 75% "of the extreme poor lives in rural areas, with most dependent on agriculture for their livelihoods and food security" (FAO 2015). Within the industrial food system lies the biggest culprits against sustainable development.

3 Case Study

As previously discussed, institutions are socio-economic constraints able to determine the way exchanges, transactions and production of economic activities function. They have a fundamental role in enabling systemic changes; it is also clear there is opposing institutional rhetoric regarding the scope of food systems. This case study looked at the role of institutions from the perspective of family farmers in the RN state in the Northeast of Brazil, demonstrating their needs, expectations, experiences and exchanges with institutions at play. Most participants in the study were family farmers; a few interviews were conducted with bank representatives, community developing agents and academics. The institutions represented were involved in the projects CECAFES and Rede Xique-Xique, which are the focus of this case study.

The concept of a network is similar to that of an institution, as it also embodies a set of rules for political, economic and social interactions. However, networks involve more personal interactions and trust, and are conducted by a thinner, non-institutionalized balance of power. North (1991) describes it as organizations where the positions are constantly vulnerable and are usually not taken for granted, and everyone needs to be continuously involved in securing their position, where they must prove their good intentions. The network type of organizations is common in community development projects as well as in the Social and Solidarity Economy. For this study, cooperatives, associations and informal collective organizations are also considered networks.

The Xique-Xique Network is a solidarity economy cooperative from the semi-arid region of Northeast Brazil in the state of RN. The Xique-Xique Network started as a network in 1999, with a group of women from the MST settlement called Mulungunzinho in Mossoro, RN. Once they acquired land through the MST mobilization and federal government agrarian reform program, they realized their struggles did not end there, and their chances of flourishing individually were slim. the given lots were located in a somewhat isolated area, far from urban centers. They began as many solidarity initiatives do, brainstorming ideas on how to generate income through collective production in order to overcome hardship. Agriculture was already part of their daily lives and traditions. Thus, they decided to form a network to market their organic produce surplus. According to the association online portal, the network today has urban and rural workers from settlements across the RN state, organized

in more than 50 production groups and articulated in 19 municipal periodic-markets and one permanent market location (Org. Portal: Rede Xiquexique).

The CECAFES in the state capital is a space for direct marketing of farmers' produce, and is the result of ten years of social demands and mobilization. CECAFES was built in 2007 but only came into operation as of March, 2017. Currently, it offers a modern commercial space with 40 small booths for family farming units and 27 store booths for legal organizations, that is, cooperatives and associations of local farmers and artisans. The participants interviewed for this case-study were 19 individual farmers and artisans participating in the CECAFES market, and six farmers who are members of the Xique-Xique Network. The other participating actors involved with the projects are three community economic development agents, two academics and two economist bank representatives.

In one question the farmers were asked if they had the support of any institutions for their projects or farming activities, and to share their experience and nature of the involvement with the institutions. The actors' representants of supporting institutions were asked to share their experience with farmers and cooperatives, and the nature and experience of their involvement with the two projects the Xique-Xique Network and CECAFES. The second question concerned the identification of expectations from institutions. That is, what is expected and from whom. The participants were asked if the recent change in governments has affected their projects, and if yes, how?

4 Results

4.1 Institutions and Networks Actively Supporting Farmers and Artisans

As for the roles of institutions actively supporting farmers and artisans, by type the most relevant, equally mentioned institutions are governmental and local networks, followed by banks and funding agencies, then NGOs (Fig. 1).

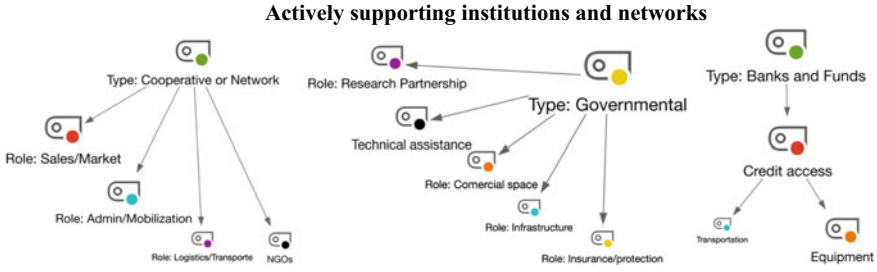

Fig. 1 Hierarchical code model created with the use of software MAXQDA

Participating in network organizations such as formal and informal cooperative groups was cited as a fundamental requirement, especially in difficult times. The main difficulties for the farmers in the individual family booth at CECAFES involves transportation and logistics, especially in off-season periods when the amount of surplus is too small to arrange transportation. For many, the CECAFES market is the only place to sell their produce. The logistic problems usually come in the peak of fruit harvest. One farmer has a cashew tree plantation—in Brazil, cashew fruit can be consumed fresh, used to make juice or alcohol, and the cashew nut can be roasted and processed. However, since the farmer does not have the means or access to a facility to process the juice or the cashew nut, she harvests only the amount she can sell fresh at the market and lets the majority fall and rot. All farmers interviewed from the Xique-Xique Network are from the semi-arid area of the RN state, and stated that being part of the Network kept them in the farming industry, as opposed to getting a side job or abandoning farming altogether. For most of them, it would be impossible to sell their surplus directly to the consumer because of transportation costs. Also, off-season amounts of surplus are not viable to sell individually. Participation on the cooperative also gave them access to micro industrialization, as some members produce frozen fruit pulp. The administration of the Xique-Xique Network participates in public biddings to provide products to public bodies in order to expand sales.

The governmental institutions' involvement varies significantly. Some farmers are beneficiaries of programs such as the provision of public-school lunches, which gives farmers direct market access by catering for public schools. While many of the programs were positive, the continuity of their support seemed uncertain because of the recent federal cuts to the program.

In general, participation in public contract biddings is not significant and was observed only within the collectively organized farmers; the individual farmers usually do not qualify to participate in public bids. The collectively organized farmers demonstrated interest to increase participation in public bids and cited as impediments, over bureaucratic process, lobbying and lack of cash flow which, if increased, could enable them to still function while waiting for commonly delayed government payments.

The most significant observed support received from institutions is technical assistance. The central institution currently offering courses and assistance to promote development is the SEBRAE, an institution credited for implementing water treatment workshops at the farms. The periodic markets managed by municipalities provide a local opportunity for commercialization. One farmer used access to facilitated credit to buy a car to transport his produce. Many farmers declared they have unsuccessfully sought institutional support, especially for credit access and other government program participation. This is especially true for the respondents that are not organized collectively. After the loss of support from federal institutions focused directly on family agriculture, one partnership that still flourished in the past year is one with public universities and colleges, a partnership perceived as extremely important for the time.

From the perspective of funding agents and community developers on the experience and involvement with the projects, it is apparent the governmental involvement

leaves a lot to be desired. One funding agent interviewed oversees project implementations in the region. He was involved with the CECAFES cooperative since it began being built in 2007, though it was only inaugurated in March 2017. He explained that in the initial draft for the project, the proposal was for the bulk investment in equipment and building to come from the MDA. The state government was to directly fund expenses for water, electricity, telephone and security. Starting with 100% of these expenses, each year it would transfer 20% of the expenses back to the coop, that is, in five years, the government would be completely absent. However, in most of the ten years of construction, a concretization of these terms did not occur. According to the bank representative, recently there was a renegotiation between the state government and the cooperative. "The government is to finance only those costs for one year, which has not yet happened. With all the political, debt and legal issues, the government failed to transfer this promised resource, that is, so far the [RN state] Government has not paid a dime" (my translation) (Anonymous. 2017. Interview by author). The CECAFES was funded mainly by the now extinct MDA. The cooperative administration declared that after ten years of waiting, they decided to enter with the final finishing costs to be able to get the fire department's approval and open for business.

4.2 The Expected Role of Institutions and Networks

The second question asked in the case study was about the identification of expectations from institutions. For the networks, the farmers expect further development in the roles of logistics capabilities of their networks, such as better access and more sharing opportunities, to social knowledge, especially in the area of developing micro-industrialization and food processing, and also increasing transport capabilities to expand and reach surrounding regional markets. The farmers acknowledged the importance of the network organizations but also recognized its limitations and challenges. For the individual farmers, many would like to see a change in the bureaucracy and difficulties in organizing and legally starting a cooperative (Fig. 2).

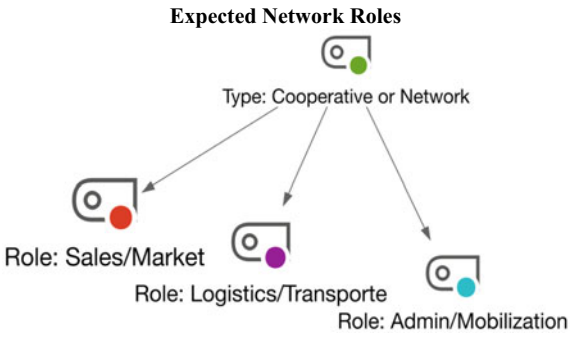

Fig. 2 Hierarchical code model created with the use of software MAXQDA

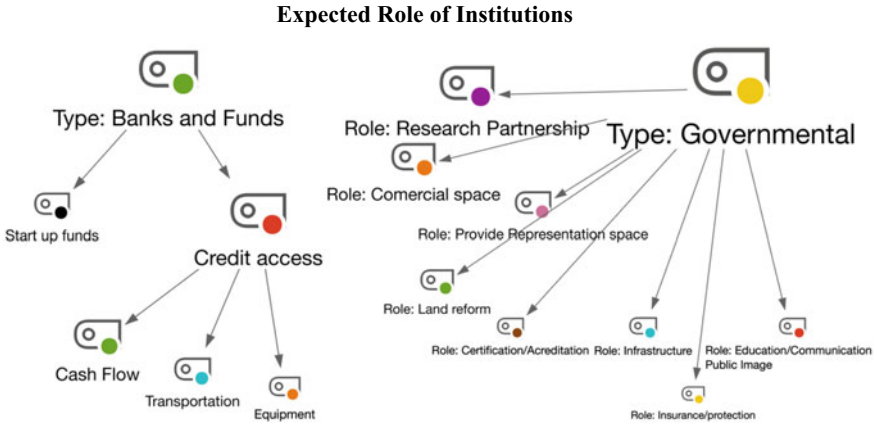

Fig. 3 Hierarchical code model created with the use of software MAXQDA

For community developers, the role of institutions is to create spaces for representation and implementation for continuous development. "We had the MDA that was a space, a type of guarantee in terms of resources, channels of dialogue with the government and through it achieve effective public policies, …it was limited, but we were there building it up" (my translation) (Anonymous. 2017. Interview by author).

Public universities and colleges participants have high expectations for the role they might hold in the partnership opportunity. Not only in respect to internships and research, but also to consider family farmers as a direct food supplier. In the case of the Xique-Xique Network, they have had an administrative assistant intern position filled by the local federal college students, and reported that having tech-savvy young people around has helped them implement the use of logistics and management software. That meant having their production, sales and finances better documented, affording them better odds while competing for markets. However, they also criticized the way knowledge is produced *with* the farmers, but not necessarily *for* the farmers. In their onion research, methodologies and knowledge dissemination in academia is frequently inaccessible or of difficult applicability.

Some NGOs, such as the AACC, was said to have significantly contributed to the development of the Xique-Xique Network in past years with technical and mobilization support. However, the NGO was mostly funded by federal programs linked to the MDA, and has now been defunded and is no longer able to continue with the project (Fig. 3).

4.3 Government Ideology and Vulnerability

The National Confederation of Agricultural Workers (CONTAG), the largest federation of agricultural workers' labour unions in Brazil, issued an open letter of dissatisfaction with the government's cutbacks towards the solidary economy and

family farming, after the announcement of the 2018 national budget. Below is a translation of a portion of the letter highlighting cuts made by the administration, published in September 2017.

> …The Food Acquisition Program (PAA) of the Ministry of Social and Agrarian Development (MDSA) will be virtually extinct. In 2017 it had a budget of R$318 million, and for 2018 R$750 thousand, that is, a cut of 99.8%. The PAA at Sead will suffer a reduction of approximately 70% compared to 2017. …For the Food and Nutrition Security policy, whose main suppliers are family farmers, the cut reaches 84.42%. The Special Secretariat for Family Agriculture and Agrarian Development (Sead) will have its overall budget reduced from R$1.03 billion this year to R$790 million in 2018. …The agrarian policy will be abandoned. The resources for obtaining land for agrarian reform will be reduced dramatically from R$257 million to R$34.2 million. The organization of the land structure from R$108 million in 2017 to R$8.1 million in 2018. …In this sense, the Expanded Deliberative Council of CONTAG reinforced the need to carry out an agenda of struggles and decided to hold the NATIONAL MOBILIZATION WEEK from October 16 to 20, 2017, with the UNIFIED DAY OF FIGHT being held on October 18, 2017, all over the country. (CONTAG, 2017)

When asked about the recent change in governments, the participants interviewed had distinct narratives. Referring to the extinction of the MDA and the changes to the Solidarity Economy Secretariat, one of the funding agents stated that:

> …the question of extinction of acronyms does not always determine the extinction of functions. In fact, that was not it. What happened was just a cleaning of the public machine that had been swollen, …but the functions and assignments, they remained. …They continue with INCRA, CONAB and PAA. Only instead of running in three buildings, it's running on one, but public policies continue even with a unified budget. At least this is my perception [my translation] (Anonymous. 2017. Interview by author).

When reminded that the programs mentioned had suffered severe cutbacks, the funding agent stated that even with the federal cutbacks there was still funding available for the family farmers, due to agreements between the local government and the World Bank and other funding institutions. He cited that the RN state Government has recently made an accord with the World Bank, and is heavily investing in family agriculture, He stated there is a pilot project of approximately R$3 million for the recovery or fruit pulp and cashew processing, and another R$12 million for the development of dairy micro-industries, with a focus on the purchase of equipment, infrastructure, and infrastructure assembly.

> All the projects I have been following in the last ten years, gender diversity is required. There are projects aimed at young audiences. Others make demands on a percentage of women. …As for the question of need and size, also, all investment is only completed after diagnosis in the community itself. There will be a team of technicians, agronomists, economists to talk to them to identify the area of need, how much of production is in the community to determine the size and type of the industry [my translation] (Anonymous. 2017. Interview by author).

From farmers and community developers, the primary reaction to the change of government direction was fear and uncertainty. They stated the cutbacks have already affected them, however with the lack of communication with the government, they are not sure how severe the situation will be in the future, provoking even more

widespread fear. According to one of the farmers, the CONAB has worked to grant the minimum price sale for agribusiness for a long time, but not for family farming produce. Through the articulation of the MDA, the CONAB started, in the past decade, to include the family farmers with the PAA, thus, when the middleman offered a price lower than the market value, they would not sell it because they had another option. "Now the Temer administration has defunded CONAB, not a little, it was to kill it, and we will go back to have no other option" [my translation] (Anonymous. 2017. Interview by author). Another farmer stated that, "Temer [administration] destroyed in one year 20 years of rights we built with struggles and blood" (my translation) (Anonymous. 2017. Interview by author). Concerning the role of banks and funding agencies, it seems the option is that it is a top-bottom approach that for some does not necessarily attend to their needs. One of the farmer's explanation was that, "They usually want us to buy things we do not need or want, then some people buy into the idea, and all they acquire is dept." [my translation] (Anonymous. 2017. Interview by author). In a top-down approach it is difficult for the needs to coincide, but there are cases where it does. One of the communities used the facilitated line of credit to buy three vehicles. "They do not have credit for all our deficiencies, …but you can buy a car to distribute the production, and you have three years of grace, that was very relevant, it changed life a little." [my translation] (Anonymous. 2017. Interview by author). On the other hand, the most commonly observed opinion was more in line with this farmer, who shared their experience with a recent project implementation from the RN state Government.

> First, they come here and spend way too long and too much money running diagnostics workshops. I must have participated in at least ten of them, but every time we tell them what we need they say, oh but this is outside the World Bank scope. …To the point that we just ask, what is in the scope? Then they say it is participative! We already had a facility and equipment. We need money for buying supplies and inventory, we need cash flow to improve operations. Oh, that the World Bank cannot finance, then don't tell me its participative, …to say that the needs were determined by the community, please, these projects, especially those from Sudene and the World Bank already comes in a ready package. (Anonymous. 2017. Interview by author).

Regarding the withdrawal of institutional support and the direction of the recent government, the negative outcomes are observed by all participants, including the bank representatives. One economist was emphatic, stating that when institutional policies of acquisition of production of family agriculture by the state, Municipal, and Federal Government are present, "we observe an improvement of life there in the base, in the field, where the farmer is living with his family. When the machine cuts that down, we notice a significant drop in the quality of life of the countryman" [my translation] (Anonymous. 2017. Interview by author).

5 Conclusion

This study demonstrates that institutions have an overwhelming importance not only in the development of family farming, SSE and the promotion of sustainable agriculture, but is paramount to the wellbeing and health of peasants. It also shows that Network organizations promote resilience if compared to individual family farming units, especially in times of crises when under increased pressure, and time constrains diminish farmers' ability to participate in administrative, logistical and political roles. It also highlights the incredible institutional power the industrial food systems holds over most federal governments and institutions that shapes public opinion and industrial trends on food, including regarding health and economic importance.

The SDGs goals of ending poverty and hunger; promoting health and wellbeing; providing decent work for all; sustainable use of oceans; sustainable management of water; reducing inequality; and protect, restore and promote sustainable use of terrestrial ecosystems that are heavily dependent on our ability to change our food systems. The 16th and 17th goals discuss the enabling framework to implement the changes. Goal 16 asserts the need for "effective, accountable and inclusive institutions at all levels to promote just, peaceful and inclusive societies," highlighting the importance of a healthy agricultural system. The goal 17 is on partnership, and it urges "all development actors to engage and share knowledge and resources" for the implementation of SDGs (FAO 2015). However, even though the need to change the industrial approach of the global food system has become harder and harder to deny, recent political events have shown that the institutional structure is continuing to support economic growth over peoples' and the planet's well-being. In Brazil, there was a brief development of a national institutional structure towards the support of family agriculture and economic solidarity in the last decade. It was an incomplete construction, slow and truncated, but it seemed for a moment to be stable. After the change in government in 2015, a lot of this structure was dismantled in a little over a year. North (1995), talks about the change in institutional structure by the incorporation of challenging institutions until its substitution. However, while the alternative structure was slowly being established, there was no dismantling of support institutions for agribusiness. In fact, they have strengthened, and agribusiness has experienced tremendous growth in the same period.

Determining what the importance of institutional spaces for the SSE and family farmers is is complex and multifaceted. The institutional influence in the sector can be observed long before the choices of what is going to be produced and how are made, and goes beyond the sales or food distribution as the outcomes of institutional involvement can affect the well-being of the people involved. Although there are many important features observed in the scope of this case-study, a few roles stood out.

First, is the role network, usually in the form of cooperatives. Due to the continuous pressure for increasing production and sales while decreasing prices, and in some cases the added struggles to access minimal living conditions, cooperatives have alienated many farmers from essential functions, such as administrative tasks

and political participation that, in turn, increases vulnerability. There was a visible difference in working and living conditions between farmers and artisans organized in cooperatives, associations or even informal networks compared to those working in individual family units. The main benefits of being part of a network were sharing administrative and logistic costs, primarily related to transportation and having a community as a backup. Thus, farming network organizations promote resilience.

Partnerships between farmers and education institutions showed a promising role in helping to develop local, sustainable food systems. Education institutions of different levels are present in most municipalities, and they could mutually benefit from internships, research partnership to develop small-scale farming technologies and direct transactions of an agroecological food supply.

As for the role of the government, offering technical assistance was appointed as one of the most critical roles. Another policy considered fundamental to the well-being of farmers was the acquisition of production of family agriculture by the State, such as the PAA executed by Conab. A bank agent interviewed in this study credited this program with keeping farmers and their family out of risk of hunger, and providing them access to health.

Mendell (2009) described the beginning of the development of an enabling structure for the Quebec social economy to develop with the initiative of a 'proactive' government in 1996, inviting the community to participate in the Summit on the Economic and Social Future of Quebec, drawing civil society to form task forces to attend their own demands with the support of the state. Subsequently, the author mentions the limits imposed by a new government in 2003. The future of family farming in Brazil is being threatened, and with the election of Bolsonaro for the presidency of Brazil, it might take some time for it to recover. However, the SSE and family farming is older than agribusiness and the mainstream's economy, and it has changed with it, in moments advancing, in others declining as it responds to socioeconomic and political stimulus. The vulnerability of the sector to the recent dismembering of institutional structures is high, but so is the resilience of organized people.

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Benchmarks Analysis of the Higher Education Institutions Participants of the GreenMetric World University Ranking

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Abstract The approach of the first concept of sustainable development released in the Brundtland report (The Brundtland report: "Our Common Future". Oxford University Press, New York, 1987), has led to a global diffusion of important discussions concerning the environment until the present. Posteriorly, the significance of Higher Education Institutions (HEIs) to reach sustainability was noticed due to their role as educators and research potential. Numerous conferences, focusing on sustainability in HEIs took place in the post-Brundtland era, strengthening the need for joint work between society, governance and HEIs to achieve sustainability worldwide. However, the various possibilities of sustainable development actions presented in charters and declarations for sustainability in HEIs, since the 1980s have made their implementation a complex task. The UI GreenMetric World University Ranking (WUR) is one of the most recent evaluation tools of sustainability in HEIs, but with significant participation of private and public HEIs. Designed to engage HEIs from developed and developing countries, the tool encourages the continued pursuit of sustainable practices, healthy competition among HEIs, and even fosters financial investments from third parties. In this sense, therefore, the present work aimed to identify and compare the benchmarks of four-best ranked HEIs and of four Brazilian HEIs participants of the WUR. Through the benchmarking methodology, and with the support of the selected HEIs sustainable reports, divergences, and similarities were identified about

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the focus and importance given to the implementation of sustainable development initiatives of the HEIs. Also, the main strategies and practices adopted for these HEIs to be considered sustainable by the WUR were discussed through their benchmarks. In general, the four-best ranked HEIs direct their efforts towards structural changes, capital investment, actions with a long-term return, investments in alternative technologies, and students' continuous and direct participation. On the other side, the four Brazilian HEIs have their central actions being implemented in infrastructural maintenance, exchange for more efficient equipment, campaigns of environmental awareness through email and social media, and other efforts with the short-term return. Based on the benchmarks analyses result, a final table was created with the related benchmarks of the selected HEIs, aimed to be used as a guide/first path, so that other HEIs can integrate sustainability in their organizations and strategies.

Keywords Education · Higher education institution · Sustainable development · World ranking

1 Introduction: HEIs' First Steps Towards Sustainable Development Practices

Since the 1970s, issues that led to environmental degradation, climate change and the exacerbating use of natural resources emerged due to several factors, including intense industrialization and population growth. For this reason, scientists, and decision-makers have started meetings, congresses and other events to discuss the importance of environmental preservation, as well as ways to raise public awareness on a global scale. Hence, da Veiga (2013) emphasizes that from that moment on, any process necessary to make the world follow the path of sustainability could only be achieved through multiple global actions, even though these actions were still in their initial stages.

The Brundtland report entitled Our Common Future (1987), stands out for addressing, for the first time with worldwide repercussion, the concept of sustainable development. The report exposes the urgency of broad actions that interconnect companies, governors, education institutions and citizens working as one to achieve sustainability for both society and environment. Encouraged by the post-Brundtland moment, sustainability discussions also drew the attention of HEIs representatives, triggering the creation of charters and declarations signed as a form of commitment towards sustainability. Is this way, the Talloires Conference, held in France (1990), addressed for the first time specifically, the role and interests of HEIs in the promotion of sustainability (ULSF 1990).

Numerous charters, declarations, and reports on sustainable development initiatives were launched after the Talloires Conference. These documents highlight relevant topics such as the importance of HEIs to educate; to be the model on transformations for sustainability; to generate research on the subject, and to create a sustainable culture and establish partnerships with public and private agencies.

Given the above facts, and as exposed by Fernández-Sánchez et al. (2014), there is a consensus in the literature regarding the crucial role of HEIs in the global efforts to reach sustainability (see: Calder and Clugston 2003; Cortese 2003; Corcoran and Wals 2004; Lukman and Glavič 2007; Mochizuki and Fadeeva 2008; UNESCO 2009; Disterheft et al. 2013; Thomashow 2014; Filho et al. 2015).

de Oliveira et al. (2016) emphasize that in order to be sustainable, it is necessary that HEIs go beyond their pre-molded teaching methods viewed as traditional. Also, as highlighted by da Veiga (2013), the move towards sustainability cannot occur from the coexistence of new environmental initiatives and the permanence of old economic development actions. Thus, it is fundamental that HEIs also practice what they teach, rather than being institutions that propagate knowledge only (de Oliveira et al. 2016).

Another critical factor that has been globally debated is the concept of Sustainability in Higher Education Institution, since it may vary according to the reality of each country, or even the focus followed within the Institution's organizational structures. Due to the multiple aspects that guide this theme, according to Tilbury (2011), the term sustainability should not be seen as a strategic plan with a single, inflexibly demarcated goal to be achieved. Otherwise, it needs to be understood as a list of tasks to be fulfilled in the same way that needs to be questioned, as they vary according to environmental influences and time (Tilbury 2011). In that way, for an HEI to be sustainable, it needs to transform itself, so that it breaks with old paradigms that preach the unidisciplinary and the vertical organization of its activities and processes. Therefore, all stakeholders involved must be considered: professors, community, research centers, academics, officials, investors, as well as local and regional administrators (van Weenen 2000; Tilbury 2011; Quist and Tukker 2013; Fernández-Sánchez et al. 2014, 2015).

The UI GreenMetric World University Ranking (WUR) is an initiative of international significance that promotes and directs HEIs to integrate sustainable development actions in its operational and organizational sectors. Through its six questionnaire indicators, HEIs from all localities can be more active in planning and implementing sustainable strategies, as well as being able to gain international visibility (Universitas Indonesia 2016). Nonetheless, despite the positive aspects and active participation of HEIs from all over the world, only a few Brazilian HEIs have been participating in the WUR since its first ranking was shared (2010), and those who are participants have so far been below average in the overall ranking. Several factors may justify the low-ranking results of Brazilian HEIs, while some international HEIs remained at the top of it over the years. Therefore, believing that greater involvement of HEIs from all over the world in the WUR can have a positive impact on the sustainable approach and generate the creation of secure networking, this research seeks to understand which benchmarks guide the strategies and actions adopted by four best-ranked HEIs in comparison with four-Brazilian HEIs both participating in the WUR.

2 Sustainable Development—Concepts and Global Discussions

The term sustainability can be absorbed by different ideologies and policies or economic and ecological biases in different ways (O'Connor 1994). Therefore, there is difficulty for researchers, in trying to determine how sustainable development should be defined to suit a wide variety of discourses.

It is necessary to present previous discussions that led to the emergence of the term "sustainable development" known worldwide as well as other definitions that appeared after the Brundtland report. In 1972, the book *The Limits to Growth* of the Club of Rome promoted discussions about the possible limits to the continued progress of society. Its central argument was based on the premise that the increase of technological and social development could not continue since humanity would be doomed to collapse if urgent actions to reduce or stabilize the so far exponential growth of society were not taken (Meadows et al. 1972)

Mankind at the Turning Point (1974), also from the Club of Rome, stated that social, industrial, and economic developments should be replaced by non-growth or by a stagnant world economy. However, after the conclusions of "zero development" by the Club of Rome, another hypothesis arose among researchers, where it was emphasized a new belief of what could be done, rather than what should not be done (Mesarović and Pestel 1974). This shift in thinking was fostered through two main reports that culminated in the intensification of sustainable development debates (Mitcham 1995).

The first report, the *World Conservation Strategy* (1980), defined Development as "the modification of the biosphere and the application of human, financial, living and non-living resources to satisfy human needs and improve the quality of human life" (IUNC 1980, p. 18). Thus, it is understood that the materialization of the "limits to growth" was based on the inclusion of strategies for the conservation of biotic and abiotic resources, and in the definition of limits for continuous development. The second report, *Our Common Future* (or the Brundtland report), which has achieved significant prominence in the global scenario by correlating issues of environmental protection with economic growth and global development, presented its concept of sustainable development. The report defines sustainable development as the process that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987, p. 16). Hence, for Mitcham (1995), Our Common Future reinforces the need for dialogue changes, which were previously bounded to limits, and that now need to be bounded to sustainability. Therefore, from the definition of the Brundtland report, another option has emerged, different from the collapse or leveling of development, as pointed out in *The Limits to Growth* (1972). The third possibility was a moderate development, that is, the sustainable development, which would meet the growing needs of society without strongly affecting the environment.

Following the Brundtland report, some of the major world conferences that debated on the importance of sustainability and proposed actions and solutions to issues of that moment, are highlighted in Table 1.

Table 1 The major world conferences on sustainability

Conference/Event	Declaration	Main highlights
United Nations Conference on Environment and Development (1992)	The Rio Declaration on Environment and Development	Principles four and five of the Declaration demonstrate the importance of international cooperation to solve socio-environmental problems, as well as the need to integrate social, economic, environmental and development issues into decision-making processes and the implementation of sustainability initiatives in all regions
World Summit on Sustainable Development (2002)	Johannesburg Declaration on Sustainable Development	The Summit discussed the disparities between developed and developing countries, as well as poverty, as crucial aspects for transformations towards sustainability at that time. In addition, the ideal of sustainability was presented as three supporting interdependent pillars: economic development, social development and environmental protection—at the local, national, regional and global levels
United Nations Conference on Sustainable Development—Rio + 20 (2012)	The Future we want	It is acknowledge "the need to further mainstream sustainable development at all levels, integrating economic, social and environmental aspects and recognizing their interlinkages, so as to achieve sustainable development in all its dimensions."

(continued)

Table 1 (continued)

Conference/Event	Declaration	Main highlights
United Nations Summit for the adoption of the post-2015 development agenda (2015)	Transforming our world: the 2030 Agenda for Sustainable Development	Sustainability is achieved through concrete strategies and actions. With its 17 sustainable development objectives and 169 well-specified goals, economic growth, hunger reduction and energy efficiency improvement, among others, are targeted through the five Ps: people, planet, prosperity, peace and partnership

3 Sustainability in Higher Education Institutions

For sustainability to be achieved globally, it is known that all stakeholders have their importance, and must contribute to this transition in the long term. Also, it is clear that HEIs operate as the primary drivers to support citizens in achieving sustainability, as HEIs have a history of influencing individuals and working for the benefit of society (Waas et al. 2010). Consequently, the urgent appeal for sustainable development initiatives that have been done by academics, governors, industry, and citizens, demands that HEIs assume their fundamental and moral responsibility to guiding society on the path to a sustainable future (Waas et al. 2010). Nevertheless, despite the global movement in the direction of sustainability, this idea, particularly in HEIs, remains in a stage of maturation of the learning process (Wright 2004; Lozano 2006; Velazquez et al. 2006; Waas et al. 2010; Filho et al. 2015). Hence, there is still much to learn and apply for the effective integration of sustainability to make HEIs, also from developing countries, leaders (Filho et al. 2015) and examples for other social areas (Lozano 2013).

3.1 Is There a Global Concept for Sustainability in HEIs?

According to Lukman and Glavič (2007), a description of "sustainable HEI/sustainability in HEI," should encompass the three domains of sustainable development understood by them: environmental protection, economic performance, and social cohesion, since sustainability needs to be present in every operation and strategy held by HEIs.

However, for Velazquez (2006), a universal definition for sustainable HEI is a complex task, since the term "sustainability" can mean different things for different people. Thus, each HEI must define its concept, according to its external and internal

factors of influence, in addition to its objectives and the literature that it assumes as the basis. Therefore, the author presents a general definition to describe a sustainable HEI:

> A higher educational institution, as a whole or as a part, that addresses, involves and promotes, on a regional or a global level, the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources in order to fulfill its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyles. (Velazquez et al. 2006)

Also, the transition from an HEI to sustainability involves all areas of activity and learning, teaching, operations, external engagement and research (Hoover and Harder 2015). In other words, an HEI needs to function in an interconnected way, where education, Institution operations, and research become interdependent aspects with the external community—local, regional and global (Cortese 2003).

In a sustainable HEI, in order that students' educational experiences are by the principles of sustainability (1) learning requires interdisciplinary teaching systems, dynamics, and analysis for all disciplines and professional training. Also, the context of learning (2) makes the interdependence between people and environment, values and ethics become a central aspect to be discussed in all disciplines, rather than isolated concepts offered in some courses. The (3) educational process emphasizes active and experiential learning, based on the analysis and resolution of real-life problems on campus and in the community. HEI (4) practices its ideals of sustainable development, making sustainability an integral part of its operations, planning, design and facilities, and investments attributing these efforts to its curriculum. Finally, HEI benefits society through (5) partnerships with communities to make them healthier, stable, economically secure and environmentally sustainable, which is crucial for HEIs to achieve sustainability since it is the ethical and moral role of HEIs to support the society that surrounds them (Cortese 2003).

It is essential to emphasize that every innovation such as sustainability, faces more problems when implemented in an organization (HEIs, in this case) and not in an individual, precisely because of the complexities that surround the given system. Thus, when innovation is homogeneously spread throughout the system, it is not only an innovation but also an integral part of the institution's daily and operational culture (Lozano et al. 2013). Further, academic recognition, about the importance of multidisciplinary and transdisciplinary teaching of research and interaction with citizens, is necessary to accelerate the changes in society needed to achieve sustainability in all decision-making areas.

4 Charters and Declarations for Sustainability in HEIs—Successful or Not Successful Initiatives?

Encouraged by the post-Brundtland moment, sustainability discussions also drew the attention of HEIs rectors and representatives, triggering the creation of many charters and declarations for HEIs signed as a form of commitment towards sustainability.

The following are charters and declarations of global repercussion: Talloires Declaration (1990), Halifax Declaration (1991), Agenda 21—Chapter "Universities, Sustainability and Businesses: A Common Agenda for 2030" (1992), Kyoto Declaration (1993), Swansea Declaration (1993), COPERNICUS Charter (1994), Declaration on HE for the Twenty-First Century (1998), Luneburg Declaration (2001), Graz Declaration (2005), Sapporo Declaration (2008), Turin Declaration (2008), COPERNICUS Charta 2.0 (2011), Treaty on Higher Education (2012), Commitment to Sustainable Practices of Higher Education Institutions (2012), and Nagoya Declaration (2014).

Despite the positive stimulus brought by charters and declarations for sustainability in HEIs through their signatures, together with the commitment to accomplish the actions reported in them, it was expected that HEIs would have advanced considerably in this bias, which did not occur as projected (Velazquez et al. 2005). The range of initiatives and practices proposed on these documents may have confused the creation of sustainable strategies by the signatory HEIs (Contreras 2002). Further, the changes and adaptations needed to integrate sustainability will not be identical for all HEIs, since they are embedded in different environmental, economic, cultural and social realities.

Alghamdi and den Heijer (2017) confirm the great significance of charters and declarations for sustainability in HEIs at first but point out that they were not useful for the operationalization of sustainability in HEIs. Consequently, the need to create a method or tool capable of measuring, monitoring and analyzing sustainable development initiatives in HEIs was affirmed. As a result, Sustainability Assessment Tools (SATs) were designed, and others adapted since the 1990s as a mean of accessing and supporting HEIs initiatives related to the sustainable commitment at charters and declarations (Shriberg 2002) as well as to be used to measure the effectiveness of their actions compared with other Institutions (Roorda and Martens 2008; Yarime and Tanaka 2012; Lambrechts and Ceulemans 2013; Gómez et al. 2015; Bullock and Wilder 2016; Alghamdi and den Heijer 2017). With that, SATs became perhaps one of the most important tools in the operationalization of sustainability, particularly in HEIs (Shriberg 2002; Alghamdi and den Heijer 2017).

Roorda and Martens (2008), and Urbanski and Leal Filho (2014), confirm the interconnection between the progress of different HEIs towards sustainability, with their participation in rankings of sustainability and other SATs through case studies. According to Fischer (2015), SATs, besides offering technical support to implement and monitor actions taken by HEIs to achieve their planned goals, can provide data (either in the form of indicators, bullet list or targets) based on how a sustainable HEI should be (Shriberg 2002; Lambrechts 2015).

Therefore, by participating in rankings of sustainability and SATs, Higher Education Institutions can establish performance standards; identify best practices and opportunities; create a dynamic and continuous process of improvement; establish procedures for the collection, quantification and dissemination of relevant information (Urbanski and Filho et al. 2014), contribute to the development of policies, assist in the goal of integrating sustainability, and strengthen ideals of transparency and communication (Lambrechts and Ceulemans 2013).

5 GreenMetric World University Ranking—An Overview

Universitas Indonesia launched in 2010 a ranking that later became known as "UI GreenMetric World University Ranking." The tool aims to promote and influence sustainable development practices in HEIs campuses, based on the concepts of environment, economy, and equity. The first concept covers aspects such as the use of natural resources, environmental management, and pollution prevention. The second encompasses profit and cost savings, while the latter is concerned with aspects of community and social education (Universitas Indonesia 2017).

Grindsted (2011) states that the WUR is the first attempt to create a ranking of global reach, which compares the behavior and commitments of HEIs concerning sustainability so that it permeates the various processes and sectors of an Institution.

The WUR was designed based on experiences and observation of leading rankings of sustainability in HEIs, such as the Holcim Sustainability Awards; the College Sustainability Report Card (Green Report Card); the Sustainability, Tracking, Assessment and Rating System (STARS); and the GREENSHIP (Universitas Indonesia 2016).

According to the criteria of the last ranking (2017), the WUR is divided into six indicators, each with a percentage weight: Setting and Infrastructure (15%), Energy and Climate Change (21%), Waste (10%), Water (10%), Transport (18%) and Education (18%).

From the studies of Suwartha and Sari (2013), Lauder et al. (2014), Fischer et al. (2015), and Ragazzi and Ghidini (2017), it is concluded that the WUR has become a globally popular SAT for several factors such as:

- It was created for HEIs from all countries;
- The design is objective, but at the same time is composed of indicators that encompass significant areas when classifying an HEI as being sustainable;
- The participation through the completion of the online questionnaire has been increasingly encouraging the participation of more HEIs since it makes the process more practical;
- The possibility of HEIs being classified according to their setting and infrastructure (rural, semi-urban and urban) makes the final score system fairer;

– The WUR can be used as a guideline by HEIs who wish to start incorporating changes to become sustainable, and for those already implementing sustainable actions, the WUR can also be used as a self-assessment tool.

In relation to HEIs participation increase in the WUR over the years, even with the variety of previous SATs, it is possible to confirm this growth, since in its first year (2010), 95 HEIs from 35 countries were present in the ranking, while in 2016, the WUR released the results of 515 Institutions from 75 countries (Universitas Indonesia 2017).

6 Benchmarking Four Best-Ranked HEIs and Four Brazilian HEIs from the WUR

The HEIs selected for the study were the four among the top ten from 2014 to 2017 and the four Brazilian HEIs that participated in the WUR within the same period as shown in Table 2. Therefore, the benchmarking was carried out based on the correlated analysis of the HEIs' scores by the WUR indicators and their annual sustainability reports. These are related to the success or failure of some sustainable development strategies that have been implemented and monitored during the 2014–2017 period according to the sustainability reports of each HEI.

Therefore, the results seek to clarify the following question: What are the benchmark differences and similarities between the four best-ranked HEIs and the four Brazilian HEIs of the WUR?

Finding 1—Setting and Infrastructure: Group 1 focuses on sustainable infrastructure solutions on their campuses such as, designs that consider sustainable and green certification policies, the use of recycled materials, and projects based on natural conditions for new constructions stand out from their benchmarks. However, regarding group 2, it was not possible to identify their benchmarks because, based on the sustainability reports' analysis, no related benchmarks were found between the four Brazilian HEIs.

Finding 2—Energy and Climate Change: With the highest percentage points weight (21%) of the six WUR indicators, the Energy and Climate Change benchmarks of group 1 pertain to the areas of energy consumption and carbon emissions

Table 2 HEIs participants of the WUR selected for benchmarking

Group 1	Group 2
Nottingham University	Universidade Federal de São Paulo
University of California	PUC do Rio Grande do Sul
Davis University of Oxford	Universidade de São Paulo
University of Connecticut	Universidade Federal de Pernambuco

reduction, investments in alternative technologies, and management and monitoring measures. In group 2, benchmarks also focus on practices to reduce energy consumption. Both groups invest in short-term changes, such as exchanging campus lighting to LED, installing motion sensors and switching to more efficient electrical equipment. In addition, group 1 invests in photovoltaic systems and other renewable energy sources; these HEIs have a specific monetary fund for investments in energy improvement and greenhouse gases emission reduction, and encouraging the development of research and projects by the students.

Finding 3—Waste: Similar benchmarks with management and monitoring actions, such as the installation of recycling bins on campus and the purchase of items with green certificated were observed in both groups. Group 1 HEIs have a waste management recycling program to monitor and improve the chain processes of organic and inorganic materials of their campuses. This effort is connected to the engagement of students and professors through participation in competitions, awareness campaigns and annual events aimed to reduce waste generation. On the other hand, awareness-raising efforts to reduce waste generation in group 2 are based on social media releases and informative posters, which does not guarantee the engagement of all stakeholders as it is not possible to know or monitor the effectiveness of this type of disclosure.

Finding 4—Water: Benchmarks related to this indicator in both groups focus on the management of old campus facilities by monitoring possible pipeline leaks and installing low flow fixtures, for example. Recycling water used for outdoor activities such as gardening and sidewalk cleaning is a highlight of group 1. Again, for both groups, the reduction of wasteful well water is made through awareness campaigns and direct actions, such as the installation of drinking fountains and water bottle refilling stations. However, unlike group 1, which carries out annual campaigns with student's participation, competitions between residences or campuses to reduce unnecessary water consumption, in group 2, the main initiatives are focused on informative emails and posters that, unfortunately are sometimes withdrawn by third parties without permission, as stated on a report of the "*Universidade Federal de São Paulo*".

Finding 5—Transport: Benchmarks of group 1 cover changes associated with the reduction of students and employees' vehicles, while offering convenient alternatives for the use of public transportation and bicycles. Through partnerships with companies and the city hall, HEIs' offer shuttle buses and discounts on intercity bus tickets, and bicycle rentals are available in adjacent localities. Other efforts are the events that occur throughout the year to raise awareness about the importance of cycling; race competitions with awards; and the increase of parking areas for bicycles on-campus. Finally, the replacement of campuses private vehicles fleet by ultra-low-emission vehicles is another important initiative. For group 2, the benchmarks focus on the reduction of the use of institutional vehicles, the prioritization of non-polluting fuels (ethanol) and campaigns to encourage cycling. Regarding the last benchmark, the Brazilian HEIs' sustainability reports did not link cycling campaigns with infrastructure improvements for bicycles on the campuses and surrounding areas, such as parking areas, bicycle lanes, or bicycle repair stations.

Finding 6—Education: both group 1 and group 2 presented the benchmark "inclusion of the sustainability theme in the curricula," but no evidence was found to confirm whether this is a compulsory or voluntary action of all courses offered by the HEIs. Further, group 1 actively invests on research and sustainable projects, where some HEIs have specific scholarships for this area, and others are prominent among HEIs that most published research in the fields of ecology, environment, agriculture, and animal and plant science. The promotion of interdisciplinary and interdepartmental collaborations is also a relevant benchmark for group 1 HEIs. Finally, sustainable campaigns and internal competitions engage students in an active and even more collaborative way on the sustainable efforts of their HEIs. For group 2, academic conferences that discuss sustainable themes and foster research in this area, as well as environmental awareness campaigns and events that engage both students and the external communities, are emphasized. For both groups, the support of digital platforms for the dissemination of the HEIs' initiatives was highlighted, as well as the invitation of collaborators, students, and other organizations to participate in events and campaigns.

6.1 The Related Benchmarks of the Selected HEIs from WUR

As clarified by Schofield (1998), the application of benchmarking in HEIs serves as a support for the clarification of questions, such as:

- How well is the university doing compared to others?
- How good, and in what areas, does the university want to be?
- Across the university as a whole, which part of it is doing best, and how do they do it?
- How does an institution improve its performance while retaining its unique features?
- How might an institution become better than the best in the context of its mission?

Based on an overview of the benchmarks found, most of the sustainable actions sought by the two groups focus on the indicator Energy and Climate Change, which may be connected with the fact that this is the indicator with highest percentage weight in the WUR total score (21%).

However, for the Setting and Infrastructure indicator, with a percentage weight of 15%, related benchmarks were not identified. The lack of benchmarks can also be correlated to the fact that it is an indicator with several specifications regarding the setting of a participant HEI (rural, semi-urban and urban), which consequently opens up a range of possibilities for the application of different sustainable initiatives in this sector.

The Waste and Water indicators have their related benchmarks in the area of management and monitoring, with various directional and short-term measures, but which can lead to significant improvements in waste and water reduction required for a sustainable, functional HEI.

When the benchmarks from the Transportation indicator of group 1 and 2 were compared, there was a reduction on related benchmarks. The same was acknowledged for the Education indicator, whose comparative benchmarks were limited to the "inclusion of sustainable themes in the curricula" of the courses and "the use of social platforms for community engagement." Therefore, it is understood that both HEIs groups focus their sustainable actions efforts on different ways, regarding Transport and Education indicators.

Finally, the final table of related benchmarks identified in the present study (Chart 1) can be used as a guide to assist other HEIs that wish to begin the transition process to become sustainable HEIs. Also, this final table encompasses initiatives understood as crucial for the first steps on strategies and actions of sustainable development, in addition to involving different realities making the benchmarks applicable for both cases, HEIs from developed and developing countries.

WUR Indicator	Benchmark	Initiative Example
Setting and Infrastructure	No Benchmarks found	
Energy and Climate Change	Actions to reduce energy consumption and carbon emissions in targeted areas	Installation of motion sensors in internal and external áreas of the campuses
		Purchase of energy efficient equipment (air conditioners and / or heaters)
		Periodic maintenance of electronics and household appliances
		Replacement of incandescent or fluorescent lamps for LED lamps
Waste	Management and Monitoring	Recycling and waste management program
		Installation of recycling bins on campus
		Priority to the purchase of items with green certificate
	Reduction of waste and recycling	Use of online media platform for awareness campaigns and engagement of students, professors and the outside community
Water	Facility management	Installation of low flow fixtures
		Adaptation of electrical devices and accessories to increase water efficiency
		Leak detection system
	Reduced consumption / waste of well water	Installation of drinking fountains and water bottle refilling stations
		Awareness campaigns on water consumption
Transport	Encouraging increase of cycling	Encouraging cycling through campaigns
	Reduction of HEI fleet of polluting vehicles	Replacement of campuses vehicles fleet by ultra-low-emission vehicles
Education	Courses curriculum	Inclusion of sustainability theme in curricula
	Communication and social medias	Digital media platforms for community and students engagement

Chart 1 Final table of related benchmarks between the WUR four best-ranked HEIs and the four Brazilian HEIs

7 Conclusion

The benchmarking, even though it was not created especially for HEIs, is an adaptable methodology of great value for the development of HEIs strategies that need to be economically, educationally, and environmentally efficient.

The HEIs from group 1, stood out for medium- and the long-term return of their sustainable development actions. Also, the direct participation of students in campaigns, research, interdepartmental partnerships, and competitions, creates a sense of belonging, and contribution to the HEI sustainable strategies. The last aspect of great relevance is the monetary funds for applying practices in specific areas such as waste and water management, infrastructure and environmental research, for example, as they make the HEI planning steps possible to be carried out.

On the other hand, the HEIs from group 2 have their sustainable development practices focused on monitoring and management of equipment related to energy, water, and waste sectors, with a short-term return, but with reduced coverage. There are also campaigns to raise environmental awareness among students, professors, and outsourcers, but mostly understood as passive, as they are carried out through posters, folders, and electronic dissemination, that is, without active stakeholder participation. Unfortunately, barriers such as the national budget crisis of 2015 have had a negative impact on the application of strategies of the Brazilian HEIs analyzed, which may also be a reality faced by other HEIs, especially in developing countries.

Finally, because it is possible to observe and compare benchmarks related to sustainability in HEIs, a topic of extreme relevance, the present study, and its methodology may support other studies with the same goal. Further, the results obtained and continued in a more detailed way can generate even more clarification regarding the first paths that can be taken by HEIs also from developing regions that desire to move towards sustainability, as well as the identification of barriers faced by HEIs in the integration sustainable development practices.

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Principles for Responsible Management Education: Sustainability and Ethics Information on Shares of Signatories Institutions

Paulo Roberto Cueto and Edelvino Razzolini Filho

Abstract The purpose of this paper is verifying, in the PRME (Principles for Responsible Management Education) educational signatory institutions, how the information related to ethics and sustainability are addressed and disseminated. For that, a documentary analysis of three Brazilian institutions (designated as "A", "B" and "C") were carried out through materials available on their websites, codes of ethics and reports sent to the PRME platform. The result was that the three institutions disseminate information differently from each other, just as the reports sent to the PRME platform between 2009 and 2018 do not have a specific standard. It was verified that those institutions need to evaluate the availability and connection of information related to ethics and sustainability among all organizations in order to show commitment to sustainable development. It was concluded that it would only be possible to achieve the established objectives by the PRME if the Institutions assume more effectively the principles in a truly responsible executive education. It was also concluded that both in PRME (chapter Brazil) and in the researched institutions, it is necessary for organizations to observe and evaluate how the availability and connection between information related to ethics and sustainability are being presented.

Keywords PRME · Sustainability · Sustainable development · Ethics · Decision making processes

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1 Introduction

Using human, natural, and economic resources in the best way is an objective that must be followed by humankind imperatively in present and future generations (United Nations 1972). Therefore, a way to prepare the present and future generations is by teaching how to act aiming at sustainable development in social, economic and environmental aspects. Education can influence the results that seek sustainable development and the dissemination of ideas and actions is essential to achieve better results and engagement of other organizations (Oliveira 2015).

In order for the practices to be carried out and disseminated, rules, communication platforms and partnerships are created to show the proposals made and the objectives reached by the organizations. In this context, the PRME (Principles for Responsible Management Education) emerges in 2007. The PRME is a platform that involves business education institutions and aims to promote the management skills of future managers based on sustainable development (UNPRME 2018).

Sustainable development is directly linked to ethics or, as Rodrigues (2016) points out, to the new ethics, which is focused on the existence of balanced relations between the human being and the rest of the planet. But how do the decisions and information related to ethics and sustainability are present in the educational institutions that are signatories to the PRME?

Ten years after PRME emerged, the way the platform influenced its participants, the actions taken, the criteria and the objectives achieved were verified. This research aims to verify, in the institutions that are signatories to the PRME, how information related to ethics and sustainability are treated and disseminated. More specifically, find out if the codes of ethics, the organization's Mission, official websites and course curricular structures emphasize ethics and sustainability.

2 Literature Review

To substantiate the research it is necessary to understand the effects caused to the organization by the decision to become an educational institution that is a signatory of the PRME. Therefore, the concepts and characteristics of ethics, decision making in organizations, sustainability and PRME itself are addressed.

2.1 Ethic

Although there are studies and articles dealing with ethics and morality as synonyms (Treviño et al. 2006), they have different concepts. As defined by Aranha and Martins (1993), moral is the set of rules that determine the behavior of individuals in a group,

while ethics is part of the philosophy that deals with the reflection on the notions and principles that reinforce life moral.

Ethics is formed in each individual in a different way, however Kohlberg (1969) studies proposed 6 stages of formation of ethical reasoning in three categories:

Pre-conventional level—egocentric individual

Stage 1—obedience to the rules (to avoid punishment)
Stage 2—submission to the group (for rewards and exchanging favors)

Conventional level—exterior-oriented

Stage 3—expectation of others (to avoid rejection)
Stage 4—fulfillment of duty (to avoid censorship/compliance with rules)

Post-conventional level

Stage 5—legalistic orientation (maintaining the common good by contracts and laws)
Stage 6—awareness or principles (valuing fidelity to choices above standards).

According to Treviño et al. (2006), most adults remain in the conventional stages (3 and 4) and stage 6 is considered "almost theoretical" because it is a rare evidence to be found.

Once an initial understanding of what is ethical is established and how people can take lines of reasoning from there, it is possible to insert the issue of decision making from the perspective of ethics, as discussed below.

2.2 Ethical Decision Making in Organizations

Individuals in an organization (for the most part) are concerned about what others think about them and comply with rules-based obligations or the fear of being reprimanded, and decision makers seek solutions that aim for organizational success, but suffer from the dilemmas of ethical issues (Pinto 2004). According to Cortés-Mejía and Moreno-Salamanca (2017) when a strategic action is taken at managerial level, the decision-maker usually holds a moral judgment of the possible consequences. They also describe that it is a daily task to understand the biases and factors that shape the way decisions are made, as they affect you and especially other people.

There is then a trend in behavioral ethics where individuals use predictable systematic ways to make ethical decisions and judge the decisions of others who disagree with benefits for all concerned (Bazerman and Gino 2012).

Regarding ethical behavior in decision making, a structure used to analyze individual ethical behavior is that of Rest (1986) based on four elements: moral conscience, moral judgment, moral motivation and moral behavior. Moral awareness is the first element in the decision-making process, where the individual identifies relevant moral issues within the context. The second element (moral judgment) refers to the moment after the decision-maker identified that there is a moral issue in some situation and this increases the possibility of opting for an ethical decision. Moral

motivation is the third element that refers to the mental reinforcement of deciding for the "best for all" while the fourth element (moral behavior) is the action itself (Rest 1986).

These elements form the ethical behavior of the individual in the organization and are influenced, according to Treviño et al. (2006), by other components such as moral disengagement (misconduct, lying, avoiding accountability for own acts, exposing inopportune comments (positive and negative emotionality, fear, guilt, shame, etc.), identity (traits that the individual brings with him/her before entering the organization), language, leadership and generates followers), as well as infrastructure, climate and organizational culture (pressure, goals, corruption, rewards, incentives, punishments, etc.).

Two other normative approaches to ethical decision-making are the utilitarian, which evaluates ethical decisions from the perspective of outcomes, giving less relevance to the middle processes (Bazerman and Gino 2012), while the deontological (or formalist) has the judgment based on the motive by which the person acts and not the consequences. For Reynolds (2006), formalists can observe the whole process in the way that utilitarians do, but utilitarians can not see in the same way as formalists, whereas the formalist approach is concerned with the details of ethical/moral aspects, the utilitarian approach is concerned with the outcome.

In order to assist in the determination of ethical behavior, organizations develop their own codes of ethics. Studies show that codes of ethics are formal and legal documents that describe organizations expectations regarding employee behavior, but unilaterally conceived as a way of managing organizational risk, generating a conflict of interest (Adelstein and Clegg 2016). Lere and Gaumnitz (2003) argue that the code of ethics often have no impact on the decision-making process.

Ethical decision-making processes are complex because they involve particular issues of each individual (who have their own ethics). Organizations can provide an environment that engenders ethical corporate behavior that values individuals ethical attitudes. In the meantime, it is up to decision-makers to seek moral choices from the community, trying not to hurt the individual ethics of the parties involved (Pinto 2004). For this, it is necessary to promote the qualification of these managers (considering the lack of qualified professionals in the market), since leadership is the differential in organizations that associate ethics, market growth and social responsibility (Dorneles et al. 2017).

Thus, when ethical decisions are made within the organization with the commitment to meet collective interests, without depreciating particular interests, higher levels of commitment from employees at all hierarchical levels are achieved, which provides better results for the organization.

Based on the understanding of ethical behavior in the decision-making process, where the question of sustainability is inserted, it is possible to discuss sustainable development.

2.3 Sustainable Development

As a response to the advent of industrialization, discussions on concern for the environment begin (ONUBR 2018). The human being realizes daily that the use of human, natural and economic resources in a conscious way is the only way to guarantee quality of life for this generation without harming future generations.

In this perspective of avoiding the degradation of the planet, the United Nations (UN) encouraged the study of the environment and development and published in 1987 the "Our Common Future Report" (Brundtland Report) which contained the definition of sustainable development as being the ability to "meet the needs of the current generation without compromising the ability of future generations to meet their own needs" (Agenda 2030 2018). In 1992, in Rio de Janeiro, the UN conference creates "Agenda 21" with the goal of promoting a sustainable development pattern for the new millennium. In the year 2000, the UN launched the Millennium Development Goals (MDGs) containing eight goals in the form of a commitment to quantitatively achieve better life for the century by creating strategies that include sustainability. In the same year, the "Global Economic Forum" was held, in which the Global Compact was created to align policies and business practices with values of human rights, labor relations, the environment and anti-corruption set out in ten principles to be followed (Pacto Global 2018).

It is necessary to clarify what the Principles for Responsible Management Education are, in view of the demands placed on organizations by minimizing the question of sustainability, which is a major objective of this text.

2.4 Principles for Responsible Management Education—PRME

In 2006, 60 university presidents, business school representatives and academic institutions gathered to implement a platform to promote responsible management education based on the UN Global Compact. In 2007, the "Principles for Responsible Management Education" (PRME) came out with six principles to be followed by institutions that opted to be signatories of this pact. There are (approximately) 16 thousand business and management programs in the world and today there are 726 PRME signatory institutions, 29 in Brazil (UNPRME 2018). PRME is the "largest platform for voluntary engagement of academic institutions to transform their teaching, research and leadership in support of universal values of sustainability, accountability and ethics" (UNPRME 2018).

The structure of the PRME is divided into chapters whose purpose is to disseminate the information of the platform. Each chapter is made up of two or more countries from the same world region, Brazil, due to geographical configurations and active network, is the only country to have an exclusive chapter created in 2013 (PRME Brasil 2018).

The six principles followed by the signatory institutions (UNPRME 2018) are:

1. Purpose—To develop students' capacities to generate sustainable value for business and society;
2. Values—Incorporate in curricular activities curricula and practices of sustainable values;
3. Method—Create structures, materials, processes and educational environments aimed at responsible leadership;
4. Research—Promote empirical research that advances the understanding of the impacts of corporations on society, environment and economy;
5. Partnership—Interaction between business managers to increase knowledge on the challenges of sustainable development;
6. Dialogue—Facilitate debate and dialogue among teachers, students, companies, government, consumers, media and other groups interested in sustainability issues.

Since the deadlines for achieving the MDGs date back to 2015, the SDGs (Sustainable Development Goals) are set, with a due date until 2030, of 17 targets for poverty eradication, social advancement and protection of the environment.

The methodological procedures adopted for this article are presented below.

3 Methodology

In this section of the article the methodology adopted for the accomplishment of the proposed objectives is defined, divided in approach, data collection and treatment procedures.

3.1 Research Approach

This research has the character of descriptive qualitative/quantitative study trying to understand how the information on sustainability and ethics are inserted in the websites and in the sustainability reports that are elaborated based on the decisions and actions of the signatory institutions of the PRME.

In 2018, there were 29 educational institutions that were part of the PRME platform (UNPRME 2018) and in order to achieve the proposed objectives, information were verified on three Brazilian educational institutions ("A", "B" and "C") that are signatories of PRME since 2008.

3.2 Data Collection Procedure

In order to execute this research, we opted for a documentary analysis to verify the decisions and actions taken by the organizations (with emphasis on sustainability and ethics), in their websites and in their reports prepared for the PRME platform. These reports are sent and made available on the platform every 12 or 24 months containing the actions performed during this period (UNPRME 2018).

According to Bardin (2004, p. 40), the purpose of documentary analysis is to treat documents to facilitate the reader's access to both information (quantitative aspects) and their relevance (qualitative aspects). In this way, it is analyzed where the themes of sustainability and ethics are inserted in the institutions. Documentary analysis is one of the types of content analysis that approaches bibliographic research, however it differs in that it uses materials that have not received analysis treatment, thus considered as primary sources (Sá-Silva et al. 2009).

To understand human behavior in the social sciences one must observe the behavior that occurs in the real world; create situations and observe the reactions and ask people what they do, did or think (Günther 2003). For this reason, in addition to the documentary analysis, the institutions were contacted to answer questions about the theme of this research.

4 Presentation and Discussion

In this division, the information obtained from the institutions regarding the Codes of Ethics, Sustainability Reports and Curricular Structures in the websites of each institution and in the sustainability reports sent to the PRME platform, is presented.

In order to find general information related to PRME, ethics and sustainability, the websites of each of the institutions (A, B and C) were accessed and, thus, the following information was found (Table 1):

- **Institution A**—on the homepage there is no mention of the PRME or sustainability, and the entity's Code of Ethics is not available;
- **Institution B**—it is possible to locate PRME information by following the pages "ABOUT INSTITUTION B", "SOCIAL RESPONSIBILITY" and PRME. Eight

Table 1 Information about PRME, ethics and sustainability

	A	B	C
PRME or sustainability		– About institution – Social responsibility – PRME	– On the homepage
Sustainability reports		X	X
Ethics code			X

Source Websites of institutions

annual reports on institution B results from 2010 to 2017 are available for access. However, the Code of Ethics is also not available.
– **Institution C**—has the PRME information on the homepage and link to sustainability by subdivision by areas (Academic, Social, Economic and Environmental). On the page of institution C are available the sustainability reports for 2014, 2015, 2016 and 2018 and there is a possibility to access the institution's Code of Ethics.

4.1 Code of Ethics and Mission of Organizations

Of the institutions surveyed, only institution C has the code of ethics available on its website. Institutions A and B were asked for information on the PRME and the availability of the Codes of Ethics through e-mail messages. Messages were sent to the official e-mail addresses of the institutions and the specific PRME responsible in both organizations, but no responses were obtained.

The institution C's code of ethics has 20 pages and had its last revision in December 2016, so it seems that it is updated frequently. It has the principles of the Global Compact and those of the PRME listed, has information that indicates a behavioral mark to be followed by all employees, but with the purpose of guaranteeing an ethical work environment with mutual respect between people and the staff of the institution. There is also a communication channel for opening illegal and violating conduct to be served by an Ethics Guidance Commission. In addition, the institution has developed a specific code of ethics aimed at business partners who are related to institution C.

Aware that the mission of an organization is a "concise statement of the purpose and responsibilities of the company towards its clients" (Ferreira 2016), it is verified on the websites of each of the organizations evaluated, if the mission of the institutions include references the words of ethics and/or sustainability. In institution A is "ethical principles", but not sustainability; in institution B there is the mention of "sustainable development" and in the principles of the institution are "ethics and integrity". And institution C, also finds in its mission the "sustainable development" and values the "sustainability and ethics".

4.2 PRME

Although Brazil has a regional chapter exclusively for national institutions since 2013, sustainability reports are not included in this platform. It has, therefore been found that these reports produced by the institutions can only be accessed on the worldwide PRME website (http://www.unprme.org/). Eighteen reports were found between 2009 and 2018 of the three institutions (A, B and C) according to Table 2.

Table 2 Sustainability reports

Year	A	B	C
2009		X	X
2010		X	X
2011		X	X
2012	X	X	X
2013		X	X
2014			X
2015		X	X
2016		X	X
2017	X		
2018			X
Total	2	7	9

Source http://www.unprme.org/

4.3 Sustainability Reports

The 18 sustainability reports found on the PRME platform (UNPRME 2018) between 2009 and 2018 are in English language and do not have a specific standard with respect to the information contained. The number of pages of each report varies between 9 and 155 pages (Table 3).

For that reason, it is necessary to accomplish the documentary analysis to extract information that can be related and compared between institutions. The way in which the reports were prepared differs from one another, Table 4 shows the reports that were developed exclusively on the sustainability theme and which are generalized

Table 3 Annual sustainability reports by number of pages

Year	A	B	C
2009		13	38
2010		80	44
2011		155	74
2012	9	81	64
2013		98	115
2014			111
2015		20	87
2016		24	97
2017	14		
2018			86
Total	23	471	716

Source http://www.unprme.org/

Table 4 Annual reports found on websites by type

Year	A		B		C	
	Websites		Websites		Websites	
	A	UNPRME	B	UNPRME	C	UNPRME
2009				Sustainability		Sustainability
2010			General	Sustainability		Sustainability
2011			General	General		Sustainability
2012		Sustainability	General	General		Sustainability
2013			General	General		Sustainability
2014			General		Sustainability	Sustainability
2015			General	Sustainability	Sustainability	Sustainability
2016			General	Sustainability	Sustainability	Sustainability
2017		Sustainability	General			
2018					Sustainability	Sustainability
Total	0	2	8	7	4	9

Source www.unprme.org/ and websites of institutions

annual management reports that address the organization as a whole, also involving sustainability.

The analysis of the terms sustainability, ethics and decision making were carried out in the reports sent to the PRME platform and were found as described in Table 5.

Since they are sustainability reports, the term "sustainability" is the most recurrent in 17 reports (out of 18). The word "ethics" appears in the background, while the term "decision making" does not appear with significant frequency although it is implicit in the reports because they are organizational strategies that guide decision-making and action on sustainability and ethics.

Compared to Table 3, there is no significant difference between the specific reports related to sustainability and management reports. This indicates that the annual management reports report sustainability and ethics-related actions similar to the specific sustainability reports.

4.4 Curricular Information on Websites

Searching the information on the institutions' websites it was verified within the curricular structures, modules, topics covered in the courses that each of the institutions makes available (within business schools), and relationships with ethics and sustainability were found.

Institution A has an undergraduate degree in Business Administration, 8 MBA courses, M.Sc. in Business Administration, M.Sc. in Business Administration, Doctorate in Business Administration and short and medium term courses (Table 6).

Table 5 Terms found by reports

Year	A				B				C			
	Pages	Sustainab*	Ethic*	Decision-mak*	Pages	Sustainab*	Ethic*	Decision-mak*	Pages	Sustainab*	Ethic*	Decision-mak*
2009					13	76	3	1	38	94	16	1
2010					80	275	15	2	44	102	22	2
2011					155	175	5	2	74	139	17	2
2012	9	39	10	0	81	98	2	4	64	112	26	3
2013					98	88	6	1	115	173	38	4
2014									111	168	35	4
2015					20	99	5	2	87	135	34	4
2016					24	128	4	0	97	90	21	4
2017	14	12	14	1								
2018									86	260	34	4

Source www.unprme.org/

Table 6 List of types, quantities of courses, and related subjects

A		
Type of course	Amount	Relations with ethics and sustainability
Graduation course	1 course	– 1 subject related to sustainability – 2 subjects related to ethics
MBA	8 courses	None
Academic Master	1 course	– 1 discipline related to sustainability and corporate social responsibility
Professional Master's	1 course	None
Doctorate degree	1 course	None
Short and average courses	4 courses	– 2 courses with 1 module each related to ethics and sustainability

Source Institution's website

Institution B does not have an undergraduate degree, but it has 16 types of specialization, 6 MBA courses, Professional Master in Business Administration and 29 short and medium term courses (Table 7).

Institution C has an undergraduate degree in Management Processes, 3 specialization courses, 33 MBA courses, a Professional Master's degree focused on sustainability and 43 short and medium term courses (Table 8).

The fact that some courses of the three institutions evaluated do not bring specific subjects or disciplines related to ethics and sustainability in their curricula, does not mean that during the courses the subjects are not addressed by permeating other contents. However, the dissemination of this information in the curriculum is a form of presentation that could give greater credibility to the concepts of sustainable ethical development in learning.

In Table 9 there is a compilation about the curricula information of courses and subjects related to sustainability and ethics on the institutions A, B and C. All institutions have courses that have no information about sustainability and ethics. Institution

Table 7 List of types, quantities of courses, and related subjects

B		
Type of course	Amount	Relations with ethics and sustainability
Postgraduate specialization	16 courses	– 6 courses with modules focused on sustainability – 1 course with a module focused on sustainability and ethics
MBA	6 courses	– 1 course with module "Sustainability and Corporate Social Responsibility"
Master's degree	1 course	None
Short and average courses	29 courses	– 1 course on "Corporate Sustainability Management"

Source Institution B website

Table 8 List of types, quantities of courses, and related subjects

C		
Type of course	Amount	Relations with ethics and sustainability
Graduation course	1 course	Informs that there is sustainability in the course but does not define in the curriculum
Postgraduate specialization	3 courses	None
MBA	33 courses	– 13 courses with the discipline of ethics and sustainability – 3 courses with the discipline of ethics and social responsibility – 1 course with the discipline of technological innovation and sustainability – 2 courses with the discipline of Sustainable Business Management – 1 course with *2* subjects related to ethics and sustainability
Master's degree	1 course	– 1 M.Sc. course with emphasis on sustainability
Short and average courses	43 courses	– 1 with Sustainability topic – 1 sustainability course – 1 with topic "Compliance and Corporate Sustainability" – 1 with topic of "Governance and Sustainability" – 1 with topic of "Beliefs and Sustainability" – 1 with topic of "Financial Sustainability"

Source Institution C website

Table 9 List of types, quantities of courses, and related subjects

	A		B		C	
	Quantity	A	Quantity	B	Quantity	C
Undergraduate	1	3 subjects			1	None
Postgraduate specialization			16	7 courses – 1 module	3	None
MBA	8	None	6	1 course – 1 module	33	20 courses – 1 module
Master's degree	2	1 none	1	None	1	1 course especific
Doctoral degree	1	None				
Short and average courses	4	2 courses – 1 tópic	29	1 course especific	43	6 courses – 1 tópic

Source Institution C website

A has undergraduate course with 3 related subjects. Institution C has a specific master's degree on sustainability. In the other offers, not all courses have subjects related to sustainability or ethics.

5 Conclusions

Evaluating the information on the institutions' websites there are other programs and actions carried out. Institution A, although it does not contain information related to sustainability and ethics issues in its website, is one of the departments of a university, while institutions B and C are organizations that are completely focused on management issues. Therefore, institution A is part of a university that has other departments, sectors and courses. In other websites linked to this university are other information directed to sustainability.

The information provided in an objective and centralized way in the organizations is capable of changing the perception of the employees and agents external to the organization. The contents in the websites with the maximum information relevant to sustainability and ethics (even through links from other sectors or departments of the institution) can positively change the vision of the institution that wishes to show the social responsibility and the sustainable development that they perform.

The availability of the Codes of Ethics, as well as its updating whenever necessary, can influence the ethical behavior of employees and stakeholders in organizations. This posture tends to reduce the dilemmas of ethical issues encountered in the decision-making processes cited by Pinto (2004), because creating an ethical environment can increase the commitment of the employees, achieving better organizational results. The information contained in the codes of ethics of organizations can influence the element of moral conscience described by Rest (1986), since they can help in the identification of moral issues relevant to the daily contexts and experiences of collaborators. This increases the possibility of ethical decision making.

The sustainability reports sent to the PRME should also be available in the Brazilian PRME chapter and not only in English but also in Portuguese. In addition to being available for access on the websites of the institutions themselves. The lack of standard and the lack of regularity between the information contained in the reports makes it difficult to analyze the actions performed.

Consequently, it is concluded that both in the PRME (chapter Brazil) and in the researched institutions, it is necessary for organizations to observe and evaluate how the availability and connection between information related to ethics and sustainability are being presented. It is also concluded that it will only be possible to achieve the objectives established by the PRME if the Institutions take on more effective principles in a truly responsible executive education. Sharing the most information to facilitate access will increase the organization's vision of commitment to sustainable development goals.

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The Potentiality of University Extension to Stimulate Sustainable Awareness and Ecosystem Valorization in Services, Territories and with Children and Their Relatives

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Abstract The University Extension Project "Baú de Histórias" acts in Santos municipality (São Paulo state, Brazil), in three sectors: health, education and social assistance. Students tell stories through dramatization through cooperative interprofessional practice, using residues to make the characters and the scenery. Objective: to present how the extension can create a sustainable awareness and stimulate services, territories, children and theirs relatives in vulnerable position, in general, to value the ecosystem where they live. Method: working topics that encompass sustainability, recycling and giving other meanings to the materials through playful activities. The results reveal the potential for interaction between: the university, territories, services and population by empowering children and their relatives as active subjects and multipliers of actions that transform their environment in a playful way. Consequently, the environment becomes more sustainable, less polluted and with more playful resources with easy access, promoting its health and development. Final considerations: the extension's practical experience is based on interprofessional education and integral and humanized care. Providing a different teaching-learning

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process, offering environmental awareness, social interaction and child stimulation, reflecting the playing process as facilitating resource, in addiction to empowering the population.

Keywords Education · Sustainable development · Children · University extension

1 Introduction: The Accessibility for the Act of Playing and the Sustainable Development in a Context of Social Vulnerability

The city of Santos, with 434 thousand citizens (Brasil 2017a, b), belongs to the Group 1 in the Social Responsibility Index of São Paulo. It is formed by cities that present high level of wealth, longevity and schooling. According to the Social Vulnerability Index from São Paulo, it can be noticed that a great part of the population live in areas with extremely low, very low or low vulnerability (São Paulo 2010).

However, the Slums, the Centre and the Northwestern areas of Santos are known and permeated by a higher level of vulnerability in relation to the other areas. Aspects such as bad living conditions and basic sanitation are taken into consideration. Vulnerability, for Galheigo (2011), is a concept used in different areas of knowledge and practices. It is related, in general, to situations of insecurity and the risk which exist in different dimensions of life.

Regarding the context of the city previously presented and after, the students of "Trabalho em Saúde" module in the Federal University of São Paulo *campus* Baixada Santista (UNIFESP/BS) visited the Family Support Center (CAF) "*Vim aqui só pra te ver*", the idea of structuring a University Extension Project emerged. The Family Support Center is located in the Northwestern area and they went there in 2010. The project's intention was to cooperate with the situation presented and to promote a sustainable action by giving another meaning to scraps thrown in the draining system of the region. The Family Support Center receives children and adolescents in a very vulnerable situation, who stay in the Centre after/before school or all the day long so their parents could work. It is a small place, with a poor structure and without any schedule of activities. The children/adolescents used to live near there, most of them in stilt houses in the Casqueiro river and they used to throw the garbage in the river, mangrove or in the draining systems around the place where they lived.

So the University Extension Project "Baú de Histórias", which works with scraps in need of sensory stimuli and social deprivation, was established in order to show them how to reuse and redefine those materials through playful activities based on people's imagination. The recyclable materials were also used in workshops after activities. Anyhow, the project aims children to give different uses to those materials.

It's important to point out that, in this article, the definition of scraps as a term referred to wastes with different types and origins was adopted (Melo et al. 2007).

The playful activities are based on the playfulness concept brought by Luckesi (1994):

> The idea of playfulness is in the people's imagination, it's totally subjective: It is what the man is throughout his life, the magic, the sacred, the artistic, the scientific, the philosophical and the juridical are expressions of the playful experiences that constitutes life. It means experiences like "come and go", "in and out", "expand and contract", "hire and fire", it is the creative construction of life while it is experienced.

It can also be said that:

> The playful allows a global development and a more real vision of the world. Through discoveries and creativity, children can express, analyze, criticize and transform the reality. If it is well applied and understood, the playful education can contribute for teaching improvement, in the qualification or critical formation of the pupil, and also to redefine values and to improve people's relationships in the society. (Dallabona and Mendes 2004)

Taking into consideration the context previously demonstrated, this article aims to present how the University Extension Project "Baú de Histórias" is able to create a sustainable consciousness by stimulating services, territories, children and their relatives, who are usually in situation of vulnerability so that they can valorize the ecosystem where they live.

2 The Extension Project

Baú de Histórias consists of a university extension project from the Federal University of São Paulo operating in Santos in three different areas: education, health and assistance. The extension works the development of a sustainable awareness by the use of playful activities and games with recycled materials, giving other purposes to the material that would be discarded. Therefore it is learned that the right disposal contributes to the city, as well as health, education and local environment. It is created, thus, a relation among sustainability, promotion of ecosystems, human rights and duties of each citizen.

The project provides teamwork experience through shared learning, focusing on the humanized attention and care of children in situations of vulnerability favoring its health and development. It also offers education in a playful way with current issues.

The extension is directly related to the formation process in the Interprofessional Education in Health following the pedagogical project of the *Baixada Santista campus*. The project's coordinators also learn with exchanges and through interaction with different practical scenarios.

The practices are divided in two parts: one in the university *campus* and another in fieldwork. The extension's members are divided in groups and they intercalate fieldwork and *campus* work weekly. A week in the fieldwork and the other on *campus.*

On *campus*, supervisions are established by the project's psychologist, students have the opportunity to talk about the intervention and make connection between theory and practice. The on-*campus* activities include: reading and discussing scientific papers; playful workshops realizations, planning and confection of resources

that will be uses in fieldwork; seminar presentations and scientific events participations. The schedule of the intervention structure steps that will be executed in the fieldwork are: starting activity, storytelling, free playing and final activity. Each stage is planned by filling up a chart in which the activity description, the goal, possible complications and the strategies to solve them must be included.

The interventions on the field happen weekly to facilitate the creation of links between extension's students and the institutions. They consist of theatricalised storytelling, games in group, activities and talks with professionals, children and those accompanying them, when possible. In the fieldwork, besides the planned interventions, the students also have meetings with service professional, promote workshops with recycled playthings and collect possible research information related to the project.

The project's main objective is to stimulate children and families in situations of vulnerability through the use of playful activities in the institutions that assist them. By working with different topics that encompass sustainability, recycling and the redefinition of the use of some materials, a sustainable awareness in services, territories, children and families may be created.

One of the prerequisites pointed by Rego (1990) is activities in group. According to him:

> The group work must be stimulated. For this purpose, it is always suggested to put together students who have more knowledge and those who have more difficulties. Hence, some will waste more time to execute the activities and learn. During this interaction and exchanges of experiences among the students, there is something which must be avoided: the creation and/or reinforcement of stereotypes of the students. An interesting suggestion is to change the role of the "tutor" in different groups, as well as to vary the formation of the different groups.

The university extension project, in its different contexts of application, provides playfulness and creativity stimulation, illustrating in practice that is possible to transform any material into a plaything. Besides stimulating a sustainable consciousness it also promotes the accessibility to play in vulnerable contexts where children live.

3 The Project's Placement Contexts

The project makes its interventions in three institutions in the city of Santos: Irmandade Santa Casa da Misericórdia de Santos, Basic Health Unit of Embaré e Family Support Center/Daycare center "Estrela Guia".

At Irmandade Santa Casa de Misericórdia de Santos, which is a hospital, the project operates its activities at the Pediatric Oncology and Burns Section. Because of the high risk of contaminations and infections involved in this areas, it is necessary to wear safety face protection, to do the correct hand hygiene, and also to clean the material that will be used for the storytelling. Therefore the resources employed must be well-chosen, including materials that allow easy cleaning, better conservation and hygiene, and they must also be resistant to the Quaternary Ammonium.

The extensionists may perform their dynamics in the rooms that accommodate one or two children; or in the Toy Room, where the pedagogues and volunteers use to stay. The extensionists only get inside the rooms whose doors do not have the isolation or contact restraining sign. In the Toy Library, on the other hand, the pedagogy professional gets involved cooperating to children's participation in the project's activities, such as facilitating relations not only among the children, but with other people inserted in the context as well as the professional team. There is also space destined to the doctors, nurses and healthcare professionals and cleaning staff. These professionals can follow the extensionists' movements and watch the storytelling while they are doing some procedures or cleansing. Moreover, the public in these health services is not restricted to the children and professionals, there are also adolescents and caregivers. Both children and adolescents use to be accompanied by parents or tutors, who end up participating in the interventions after all, whether in the storytelling or in the conversations.

In the Basic Health Unit of Embaré, the project's intervention happens while people are waiting in line for service and it takes approximately one hour. Since this is a location with a dynamic routine, the extensionists try to not interfere in the working process. When children are normally waiting for some medical consultation, they used to stay in a waiting room where the project's interventions are made. So the same activities done in other working fields as initial activity, storytelling, free playing and final activity happen, but the children would change during the period according their consultation. Children's companions, healthcare professionals and cleaning staff can interact during the storytelling and other activities.

In the Family Support Center/Daycare center the storytelling, the games and workshops normally happen outdoors. The work is done with most of the classes, reaching a variable number of (maximum) 70 children per intervention, aged 2–7 years. The schoolchildren wait for the project's extensionists. Then, the extensionists start with an initial activity with the intention to approximate and integrate the group. After that, the storytelling is presented. The kids often ask the extensionists to tell the story more than once. So the extensionists retell the story or invite the children to do that. The invitation allows children to reproduce their own version, contributing to the creation of connections between the children and the extensionists. It also contributes to stimulate their own creativity. After this moment, a "free time" to play is proposed. It consists of workshops about creating materials and games in group. The aim of the final activity is always to promote children's relaxation before the extensionists say goodbye for them.

Before making the workshops of recyclable playthings, we collect the materials with children's relatives, making them multipliers of the recycled practices executed by the project, thus expanding the sustainable awareness and re-signification of scrap metal for families. Inside the daycare a space named "Sucatoteca" was created, where the recycled playthings that children create are kept. This space provides a connection with the action's pleasure of giving another meaning for the materials. Furthermore, "Sucatoteca" allows the formation of a valorization sense and pride of the objects created by them. Most of the crated toys can also be taken home by the children, they ask to take them so that they can show their relatives and friends.

In order to maximize teaching and strengthen ties within the Family Support Center environment, the project extension workers participate in parent and teacher's meetings, explaining how the project works, showing some of the activities carried out during the interventions, and transmitting sustainable awareness to be practiced in their homes and performing activities that promote interaction among extension workers, parents and teachers. In this way, it is possible, to strengthen the bonds, multiply the knowledge of sustainability and also listen to those who are involved in the project.

4 University Extension and Public Policies

The University Extension Project "Baú de Histórias" is based on some current Public Policies such as: sustainability, health, children's right, human rights, social assistance and education.

It is fundamental that the current society is aware of the environment situation and participate in an active way with strategies to conserve and save it. The project aims, through the use of recycled material and playful activities, to raise children's awareness about themes that are, according to the environment and sustainability; preparing them to valorize the ecosystem in which they live. It is in consonance with the Action Plan for Sustainable Production and Consumption proposals (Brasil 2011).

This plan, gathers actions proposals to guide the society to reach sustainable development objectives. Among the priorities are the educational actions for the sustainable consumption that consists of the use of alternative forms to sensitize individuals, causing behavior changes and increasing the re-use of solid residues, reducing, consequently, the wastes' quantity in landfill sites (Brasil 2011).

The "HumanizaSUS", national policy of humanization (Brasil 2003), proposes innovative actions in the health system, defending a Single Health System (SUS). As Brazil is a very heterogeneous country, the system offers the same healthcare for everybody and pursuits to promote interaction among social, collective and subjective demands on health. The idea is to valorize the different subjects involved and encourage the individual's autonomy and protagonism, as well as the collectives here involved, increasing the co responsibility in the health production.

For the "HumanizaSUS" guidelines, to "receive" is to recognize the needs as legitimate and unique. The reception is constructed in a collective way depending on the need and it has the objective to build bonds of trust, commitment and a connection which must support the relationship between teams/services and children/relatives (social and affective network) (Brasil 2003).

The project turns the atmosphere into a healthier place welcoming health, assistance and education issues. In addiction, it provides good meetings for all the people involved. Prioritizing each child's singularity and process' complexity, the project uses the enlarged and shared clinic as a strategy for extensionists, complying one more guideline of "HumanizaSUS" (Brasil 2003).

The Continuous Education in Health refers to the learning at and with work, meaning a work discussion process as a way to transform subjects. Besides that, the education has a strategy to reorganize the work process. It can also be understood as a continuous process of collective construction and transformation where you acquire new knowledge, innovative and transformative practices that involve conversations, reflections, learning, dedication, exchanges, partnerships and commitments (Brasil 2004, 2007).

The Continuous Education in Health is present in extensionists' work process with different teams in the institutions. It is also present at the moment of the intervention, at the extensionists' contact with children/adolescents, distinct professionals and relatives. The same happens with the project's coordinator during project's supervisions, meetings and workshops.

The World Health Organization (WHO), OMS (2010), stimulates the expanded concept of health and attention focused on the person for the practical care, in an integral perspective that assumes teamwork and collaboration in practice for the development of the Interprofessional Experience in Health. It just happens through Interprofessional Education in Health. The project works articulating the process of formation with the services, the interventions and interprofessionals practices providing extensionists and partner institutions experiences in group while they work Interprofessional Education in Health. Shared learning and collaborative practices production allow extensionists to become constructors of new realities in health, future active professionals and a useful members of a team working with the Interprofessional Experience in Health.

The project proposes to develop the protagonism of the children respecting their context, desires, beliefs and opinions considering their rights and duties described in the Statute of the Child and Adolescent—ECA (Brasil 1990). Moreover, it promotes access to knowledge in a playful way, entertainment, access to health and communitary conviviality in partner institutions. No child is forced to participate in the activities proposed.

The Law of Guidelines and Bases of National Education understands that the education happens in all the contexts in which child in inserted, from the family to educational and social institutions. For this to happen different resources such as visual arts, music and theater can be used. Education should prepare the child to put its citizenship into practice (Brasil 2017a, b).

By acting in contexts with high social vulnerability, the extension project always reinforces the importance of bond formation between the services and their users. Empowering them in order to promote health and social participation as the Operational Standard of Assistance and the Singular System of Social Assistance suggest (Brasil 2005).

5 Sustainability in "Baú de Histórias"

The UN Agenda of 2030 announced in 2015, seventeen (17) Sustainable Development Goals (SDG) and one hundred and sixty-nine (169) targets to be accomplished. They consider that the Millennium Development Goals are integrated and inseparable merging in a balanced way to the sustainable development (ONU 2018).

Still according ONU (2018):

> More than half of the world's population now live in urban areas. By 2050, that figure will have risen to 6.5 billion people - two-thirds of all humanity. Sustainable development cannot be achieved without significantly transforming the way we build and manage our urban spaces.

Therefore, Goal 11 refers to making the cities and humans settlements inclusive, safe, resilient and sustainable. The University Extension Project "Baú de Histórias"'s main goal is to reduce, until 2030, the negative environmental impact per capita in the cities by reducing their residues and teaching how to do a correct waste disposal (ONU 2018).

It is known that the project's intervention is very little taking the extensive Agenda 2030 into consideration. However, the children's ease to learn mainly in a playful manner, transforms this action into a potential multiplier of the process of learning. It has the capacity to cooperate with the habits and customs transformation and hence disseminate a more sustainable consciousness than the past generations.

Family is the child's base of learning and must be the first institution to be engaged and then involve the rest of the territory. In this scenario, the project considers the child an important transforming agent with potential for being empowered as a participative and integrated manager. It seeks, thus, a more sustainable and healthier environment to possibly reduce the social inequalities.

Preparing the children to valorize the ecosystem is an urgent action to be executed regardless of macro policies and public actions. As members in the university context who know the critical situation of regions of vulnerability where the project is inserted, the project's tools are finding ways to potentialize child and its relatives. So it would be possible through playful intervention to bring a healthier child development. Meanwhile it is not possible to promote a bigger transformation in urban spaces, so the project acts with the possible mechanisms to do its part.

6 Construction of a Sustainable Network in Different Contexts

The improvements reached by the project are related to mentoring children, families and professionals involved to reuse and redefine scraps transforming them into playthings, avoiding scraps to be thrown in inappropriate places and also reinforcing environmental awareness.

These reused and redefined scraps are used to prepare the stories and to make playful activities. They are used to make the characters and scenarios. Each group of extensionists structure their intervention according to the institution they are going to, taking into consideration the field's features and their specific contexts. The activities planning is made focusing the demands of the public, which includes professionals and children. The demand may also be observed by the extensionists during the interventions. The issues addressed are, in general, oriented toward environmental care, health care and interpersonal relationships. In this way, values as equality, respect, fraternity and education are also worked in the project. So the project, whenever is possible, aims to improve the public's interaction and accession to the activities proposed.

The proposal to create toys and stories from recycled materials stimulates the creativity so that every type of material may be transformed and developed into something new. By means of recycling workshop executions, meeting participations, conversations with the professionals and activities in toy rooms, every person who is involved in the project becomes a multiplier of a sustainable awareness.

The main focus in the different contexts of acting is to include the child, family, professionals and extensionists directly in the transformation process of the scraps; being the child the main bond of contact and change. The inclusion allows, therefore, the formation of an environmental awareness and involves all the networks to work in favor of sustainability.

The sustainable education is a very extensive issue and it can be applied to various settings. The multipliers can, finally, spread the information and act towards sustainability inside and outside the institutions connecting this issue to other activities of their daily life.

7 Conclusion: Work With Children May Be a Key Point to the Sustainable Development of Cities and Communities

The playful is an important educative instrument and it is considered essential in the development of a child. It contemplates psychological, social, emotional and physical aspects. Besides that, it promotes the individual's autonomy and there is an improvement in its life quality. The child's action is reflected by the playing that encompasses the main elements of fantasy. When the child performs it different from its routine, it creates a parallel reality, in which the playful is processed. The project contributes, thus, to stimulate the playful and fantasy along with the creation of a more sustainable consciousness (Aguiar and Gomes 2011).

The storytelling in the University Extension is promoted in a more dynamic and theatralised way, in which the involved ones interact directly exercising their imagination and fantasy, being not only extensionists responsible for creating the stories, but also the public (children, teachers, nurses, relatives and employees) to whom the

intervention is planned. All of this allows the creation of a new perspective of the reality.

In the context of extension, learning is provided through the interaction between people and the social environment where they are embedded. The playful activities have an essential role in this process. Activities in group developed by the University Extension Project "Baú de Histórias", in turn, promote more interaction amid individuals, which facilitate the teaching-learning process.

Having said that the playful actions are essential for the teaching-learning process, the project uses the recycled materials and solid wastes as a pedagogical resource for learning and cooperates to the sustainable development. Taking as a starting point the importance of reusing materials for the construction of useful objects and the fact that "the recycled material is something that brings the transformation mark because it takes out of the context and gives the opportunity for unusual data that are produced by the own material, as well as what we project in it", the scrap becomes favorable to be re-signified (Machado 1999 apud Melo et al. 2007). Besides that, the project teaches the right way of discarding when the reutilization is not viable.

Through the re-signification, the scrap acts as a pedagogical resource, since that "its use has substantially this purpose, in other words, to raise the range of creative options in therapeutic relation, as of the communication principles" (Melo et al. 2007).

The SDGs are inseparable and complementary so the project acts indirectly in favor of more than one SDG. But the one that fits best is 'Goal 11—To make cities inclusive, safe, resilient and sustainable.'. Similar actions may be reproduced with the same objective, because from the performed interventions, there is a reduction in the amount of scrap thrown. This intervention allows institutions to build together a "Sustainable Network" with children from the different contexts. It contributes, consequently, directly to the objective of SDG 11, which is to reduce the negative environmental impact per capita of the cities until 2030, and it also gives more special attention to the city's residues.

In conclusion, children empowerment through the autonomy and the proper importance given them may be a strong change agent in the operated contexts. The project also presents an effective replicability potential, mainly due to the fact that it has a low price of implementation, that may contribute for reaching the Sustainable Development Goals brought in the UN Agenda of 2030.

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Scientific Dissemination and Environmental Education Focusing on Composting and Valorization of Coffee Grounds: Contributions and Challenges to the Achievement of the Goals 4 and 11 of UN 2030 Agenda

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Abstract Coffee grounds are a waste generated in different environments and capable of being valorized through composting. This research aimed to contribute to the dissemination and achievement of sustainable development goals 4 and 11 of the UN 2030 Agenda, through the identification, categorization and evaluation of literature produced to scientifically disseminate composting biotechnology and encourage

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its application. The key words “coffee grounds”, “composting”, “scientific dissemination”, and “vermicomposting” were selected for the bibliographic search in Portuguese, English and Spanish languages, without delimitation of the time horizon. The search of databases comprised periodicals of Capes, Google and Google Scholar. Literature was categorized as booklets or technical manuals. Results showed 31 manuals and 17 booklets about composting. Studies related to the scientific dissemination of composting, focusing on coffee grounds, are scarce, showing the importance of further studies on the subject. Research carried out in educational institutions requires more widely diffusion, so that public stakeholders can have access to this knowledge. Thus, the dissemination of composting in the form of primers and brochures may contribute to the inclusion of this sustainable practice in the life of people and institutions guaranteeing an incentive to sustainable consumption and making cities more inclusive and sustainable.

Keywords Coffee grounds · Composting · Scientific divulgation · Sustainability

1 Introduction

The earliest reports of coffee use date from Constantinople, now Turkey, around the year 1550, with the expansion of consumption during the seventeenth century in Italy, France, Germany and England. The popularization of the product arose during the nineteenth century, during which a process of dissemination of journals on European coffee shops was carried out. During the 20th century, coffee specialties such as Cappuccino, Latte, and espresso were popularized in the United States market with the emergence of specialty products in coffee (Café 2015).

According to the National Supply Company (CONAB 2016), there is an expectation for the production of 59.90 million bags of grain for the year 2018 in Brazil. This makes the country the largest producer of this agricultural commodity, with a production corresponding to more than a third of all the world production (Funcafé 2017).

The beverage manufacturing process generates a large amount of an organic solid waste, known as coffee grounds, which is normally discarded by consumers without proper appreciation. The shipment of this and other organic waste to landfill sites and dumps contributes to accentuate some sanitary and environmental problems, among which are the generation of greenhouse gases, such as methane, slurry, and the occupation of the physical landfill area, thus reducing its useful life.

In this sense, with the need to seek the precepts built by the Sustainable Development Goals (SDG), especially in relation to objective 4, which deals with quality education, and objective 11, which deals with sustainable cities and communities, the need for scientific dissemination of techniques that encourage the valorization of this waste is reinforced.

An alternative to the use and treatment of coffee grounds, and many other organic wastes, occurs through composting. This biotechnological technique corresponds to

the aerobic bio-oxidation process, which uses organic residues to generate a nutrient rich compound, through the action of decomposing microorganisms, which act under controlled conditions of temperature, humidity, pH, among other parameters. The product generated has the potential to increase agricultural productivity by reducing or even eliminating the use of industrialized fertilizers (MMA 2008).

Thus, it is important to disseminate scientific technical materials such as booklets and manuals presenting a more easily understandable language. This kind of dissemination is as a way to stimulate the knowledge of this biotechnology.

The incentive to scientific dissemination of composting as a sustainable practice in institutional environments has been gaining prominence, especially in relation to the actions that lead to the diversion of solid organic waste from landfills and dumps. This practice involves the awareness of employees, associates, and students through workshops and lectures that are related to the dissemination of the technique (Korres et al. 2013; Costa et al. 2016).

Different pieces of research carried out in educational institutions are very important because they bring with them the possibility of their use as tools for the development of broader actions that seek the establishment of sustainability in terms of organic solid waste management. In this context, the use of these instruments can leverage a more agile and innovative change process, as well as being closer to daily life, with greater potential for positive results.

The possibility of composting implementation in a domestic environment and in environments such as schools, public squares, research institutions and higher education among others, combines the pedagogical component as one of the dimensions to enhance alternatives that favor an education more committed to sustainable results (Chassot 2003).

In this context, the present study aimed to report the scenario of the production of scientific dissemination material highlighting the main contributions and challenges focused on the valorization of organic solid waste through composting, especially coffee grounds, in the implementation of objectives 4 and 11 of the UN 2030 Agenda.

2 Millennium Development Goals (MDGs) and Sustainable Development Goals (SDG)—An Agenda for Transforming the Relationship Between Man and Nature

Two important documents developed by the United Nations reinforce and contribute to the discussion on global environmental issues: the eight Millennium Development Goals, established in 2000 (UN 2000), and the 17 Sustainable Development Goals developed during the years 2013 to 2015 (UNDP 2015). All these objectives seek to put into practice local actions as a focus on the social, economic, and environmental pillars, which are the foundation of sustainable development.

In September 2015, the UN General Assembly adopted Agenda 2030 for Sustainable Development (PNUD 2015). At that event, 17 Sustainable Development Goals were proposed, with universal, transformative and inclusive characteristics, describing the main development challenges for humanity.

The purpose of the SDG is to ensure a sustainable, peaceful, prosperous and equitable life for all, both now and in the future. They establish environmental boundaries and define critical constraints on the use of natural resources. These objectives address a range of social needs, including education, health, social protection and employment opportunities, while combating climate change and promoting environmental protection (UNESCO 2017). The government, the private sector, civil society and the population must achieve these goals jointly. Given the current situation of environmental issues, it is expected that governments will take responsibility and establish national frameworks, policies and measures that will enable and guarantee the implementation of Agenda 2030.

Education for Sustainable Development (ESD) seeks to develop skills that enable people to think about the development goals by focusing on social, cultural, economic and environmental impacts using individual and collective perspectives. Thus, Educations for Sustainable Development is important because it allows people the capacity to analyze and take decisions in complex situations, such as socio-political processes, towards sustainable society where individuals have the chance to become holders with the power to change (UNESCO 2017). Putting the ESD concept into practice is a key strategy for expanding the development of competencies that make it possible to sustainable practices as a form of empowerment of young people and marginalized groups.

One of the goals of the SDG to be achieved by 2030 Agenda is to ensure that all students acquire the knowledge and skills necessary to promote sustainable development, including education for sustainable development and new lifestyles, human rights, gender, promotion of a culture of peace and non-violence, global citizenship and enhancement of cultural diversity for sustainable development.

In this context, it is possible to use the composting technique as a promising way to value the organic leftovers that would be discarded. The use of the educational means to disseminate this biotechnology contributes to the achievement of the objectives of the UN 2030 agenda, promoting the search for balance in the relationship between man and nature, thus contributing to the development of a sustainable society.

3 SDG 4, "Quality Education" and SDG 11, "Sustainable Cities and Communities"

The fourth SDG will contribute to the perspective that by 2030 the number of young people and adults have relevant skills, including technical and professional skills for employment, decent work and entrepreneurship, ensuring education as a fundamental human right and a basis for the achievement of other rights (UNESCO 2017).

Goal number four addresses quality education and affirms that inclusive and equitable education should be ensured in order to promote lifelong learning opportunities for all. In this sense, didactic materials produced with the purpose of scientifically disseminating the composting technique can subsidize the development of this knowledge, since they can be used as teaching-learning tools as well as scientific dissemination in non-formal education sites.

The SDG number 11 assumes that by 2030 the negative environmental impact per capita of cities will be reduced, including paying special attention to air quality, municipal and other resources management (UNDP 2015).

Thus, communities and their dynamics, such as decision-making, governance, planning, conflict resolution, alternative communities, healthy communities, inclusive communities, Eco-villages, transition cities, sustainable food, sustainable and resilient buildings and territorial planning are important in the discussions around SDG 11 (UNESCO 2017).

Considering this scenario, composting biotechnology appears as an important alternative for the sustainable application of organic waste and is also a way of training for young people and adults, generating jobs in areas where they can be applied, as well as diverting organic waste to a new utility, making the city more sustainable. Therefore, the dissemination of this practice and its methodologies is fundamental so that knowledge has greater reach in society.

4 Scientific Dissemination and Environmental Education: Contributions to a Culture of Change

Scientific dissemination is the activity of transforming scientific language into everyday language for a specific audience (Baalbaki 2014). For this author, it is an indispensable tool for the construction and consolidation of democracy and citizenship. Thus, democracy would only become possible through the understanding of science throughout society. In this way, disclosure would have the role of complementing formal education, and would thus take the place of an instrument for the democratization of education, since it proposes to bring scientific and technological innovations to society.

In Brazil, the strengthening of the solid waste legal remark was achieved with the institution of its regulatory framework, through the promulgation of Law nº 12.305/2010, known as the National Policy on Solid Waste—NPSW (BRASIL 2010). The NPSW discusses the principles, objectives, and instruments, as well as guidelines for integrated and solid waste management oriented towards to the generators, and public authorities' responsibilities and applicable economic instruments. Within this context, sustainable alternatives for the valorization of organic solid waste are still incipient, so that biotechnological solutions such as the composting technique appear as a way of valuing these organic wastes, which still end up being disposed off without proper attention.

The expansion of scientific and academic knowledge of sustainable practices such as composting is a tool for sustainability, and the dissemination of its use has been carried out in different ways. Thus, the use of the internet emerges as an alternative to publicize these initiatives, as it provides quick access to contributions from various disciplines and educational experiments. This contributes to the scientific dissemination, since it increases access to knowledge and understanding of the environment. However, without the interdisciplinary approach, it is not possible to study the interrelationships existing between living beings or to open the world of education to the community calling its members to action (Bueno and Arruda 2014).

When working with the composting technique there is an involvement and great application of concepts from different areas of knowledge. Research, such as the one that is presented here, seeks, classifies and organizes a series of scientific dissemination materials, in this case, specifically about composting, is a way of monitoring the evolution and the positive contribution for the dissemination of such important knowledge.

5 Methods

The study deals with documentary research, involving three methodological steps. The first, for the preparation of the cadastral form and the documentary survey focused on the proposed theme. The second included the reading, interpretation, description, ordering and systematization of the information obtained in the previous stage. The third one was focused on the analysis of the evolution of the material on the subject.

In order to search for the materials, the Portal of Periodicals of Capes, Google and Google Scholar were consulted using the following keywords, in Portuguese: "borra de café", "compostagem", "vermicompostagem" and "divulgação científica", in English "Coffee grounds", "composting", "vermicomposting" and "scientific dissemination" and in Spanish "borra de café", "compostaje", "vermicompostaje" and "divulgación científica" to evaluate the period covered by the materials.

The results of the search were ordered in tables in Microsoft Excel, the material being classified in manuals and compost booklets. The search was carried out in the Portuguese, English and Spanish languages, thus analyzing how the difference in language can exchange information about how the technique of scientific dissemination is carried out in each culture, concerning the theme.

6 Results and Discussion

Considering the search criteria, 48 materials were obtained between manuals and compost booklets, which were covered during the period from 1995 to 2018 (Table 1).

Table 1 Materials collected on compost publications covered during the period 1995–2018

Number	Type of material	Title of publication	Objective	Target audience	Way/Communication vehicle	Scale	Place of publication	Language	Reference
1	Booklet[a]	Cartilha de compostagem em escola	Disclose compost[c]	Child/School	Figures and texts/Physical media	Small	Brazil	Portuguese	Rodrigues (2009)
2	Manual[b]	Compostagem urbana	Teaching compost[d]	General	Figures and texts/Physical media	Small	Brazil	Portuguese	Da Silva (2011)
3	Manual	Compostagem doméstica de lixo	Teaching compost	General	Figures and texts/Physical media	Small	Brazil	Portuguese	Valente (2002)
4	Booklet	Compostagem lixo orgânico: pode reciclar?	Disclose compost	General	Figures and texts/Physical media	Small	Brazil	Portuguese	A Gazeta (2017)
5	Booklet	Guia de compostagem caseira	Teaching compost	General	Figures and texts/Physical media	Small	Brazil	Portuguese	Ribeiro (2001)
6	Manual	Manual prático: compostagem	Teaching compost	General	Figures and texts/Physical media	Small	Brazil	Portuguese	SMMA (2011)
7	Manual	Compostagem Doméstica, Comunitária e Institucional de Resíduos Orgânicos	Teaching compost	General	Figures and texts/Physical media	Small	Brazil	Portuguese	SESC (2017)

(continued)

Table 1 (continued)

Number	Type of material	Title of publication	Objective	Target audience	Way/Communication vehicle	Scale	Place of publication	Language	Reference
8	Booklet	O museu vai escola: compostagem	Teaching compost	Child/School	Texts/Physical media	Small	Brazil	Portuguese	UFJF (2010)
9	Manual	Olericultura orgânica: compostagem	Teaching compost	Farmers	Texts/Physical media	Large	Brazil	Portuguese	FAESP (2009)
10	Manual	Compostagem: produção de adubo a partir de resíduos orgânicos	Teaching compost	Farmers	Figures and texts/Physical media	Large	Brazil	Portuguese	SECTAM (2003)
11	Booklet	Compostagem	Teaching compost	Farmers	Figures and texts/Site	Large	Brazil	Portuguese	PTSPCC (2015)
12	Booklet	Compostagem laminar[e]	Disclose compost	Farmers	Texts/Site	Large	Brazil	Portuguese	Embrapa (2008)
13	Manual	Programa de olericultura orgânica	Teaching compost	Farmers	Texts/Site	Large	Brazil	Portuguese	FAESP (2006)
14	Booklet	Compostagem de carcaças e resíduos das criações na propriedade rural	Teaching compost	Farmers	Figures and texts/Site	Large	Brazil	Portuguese	PNMAII (2006)

(continued)

Table 1 (continued)

Number	Type of material	Title of publication	Objective	Target audience	Way/Communication vehicle	Scale	Place of publication	Language	Reference
15	Booklet	Utilização de Composto Orgânico na Adubação de Plantas	Disclose compost	Farmers	Texts/Site	Large	Brazil	Portuguese	CEPLAC (2012)
16	Booklet	Produção de fertilizantes a partir de resíduos orgânicos	Disclose compost	Farmers	Texts/Site	Large	Brazil	Portuguese	UCS (2009)
17	Booklet	Compostagem: como aproveitar os resíduos disponíveis em sua propriedade?	Disclose compost	Farmers	Texts/Site	Large	Brazil	Portuguese	UFOPA (2018)
18	Manual	Farmer's compôs thandbook	Teaching compost	Farmers	Texts/Physical media	Large	Chile	Inglês	FAOUN (2015)

(continued)

Table 1 (continued)

Number	Type of material	Title of publication	Objective	Target audience	Way/Communication vehicle	Scale	Place of publication	Language	Reference
19	Manual	New Jersey's Manual on Composting Leaves and Management of Other Yard Trimming	Disclose compost	Farmers	Texts/Physical media	Large	USA	Inglês	DES (2008)
20	Manual	Manure Composting Manual	Disclose compost	Farmers	Texts/Physical media	Large	Canada	Inglês	Alberta (2005)
21	Manual	Operational Manual on Composting for an Integrated Resource Recovery Center	Teaching compost	Farmers	Text/Physical media	Large	USA	Inglês	IRRC (2012)
22	Manual	How to Make Superior Compost	Teaching compost	Farmers	Texts/Physical media	Large	USA	Inglês	ComposTublr (2010)
23	Manual	Master Composter Manual	Teaching compost	General	Figures and texts/Physical media	Small	USA	Inglês	NYC (2015)

(continued)

Table 1 (continued)

Number	Type of material	Title of publication	Objective	Target audience	Way/Communication vehicle	Scale	Place of publication	Language	Reference
24	Manual	Composting: a household guide	Teaching compost	General	Figures and texts/Physical media	Small	Ireland	Inglês	Food West (2012)
25	Booklet	Everything you have always wanted to know about home composting	Disclose compost	General	Texts/Physical media	Small	USA	Inglês	DEC (2010)
26	Booklet	Composting	Disclose compost	General	Texts/Physical media	Small	USA	Inglês	DEP (2000)
27	Manual	Demonstrating natural recycling	Teaching compost	General	Figures and texts/Site	Small	Jamaica	Inglês	GOJ/CIDA (2008)
28	Manual	Composting goes to school	Disclose compost	Child/School	Figures and texts/Site	Small	Canada	Inglês	Alberta (1995)
29	Manual	Low Cost Composting Training	Teaching compost	General	Texts/Site	Small	USA	Inglês	Karanja (2005)
30	Manual	Manual for Composting at Domestic Level	Teaching compost	General	Textos/Site	Small	Nepal	Inglês	Nyachhyon and Malla (2005)

(continued)

Table 1 (continued)

Number	Type of material	Title of publication	Objective	Target audience	Way/Communication vehicle	Scale	Place of publication	Language	Reference
31	Manual	School Composting	Teaching compost	Child/School	Textos/Site	Small	USA	Inglês	Waste Management (2005)
32	Manual	Welcome to the world of vermicom-posting	Teaching compost	General	Figures and texts/site	Small	Canada	Inglês	Appelhof (2017)
33	Manual	Manual de compostaje doméstico	Teaching compost	General	Textos/Site	Small	Argentina	Espanhol	BAI, ORGANIKOARI (2005)
34	Manual	Manual de Compostaje	Teaching compost	Farmers	Figures and texts/Site	Large	Spain	Espanhol	Amigos de la Tierra (2008)
35	Manual	Manual de compostaje del agricultor	Teaching compost	Farmers	Figures and texts/Site	Large	Chile	Espanhol	Román et al. (2013)
36	Booklet	Ejemplos de buenas prácticas de compostaje y recogida selectiva de residuos	Disclose compost	General	Figures and texts/Physical media	Small	Spain	Espanhol	Comisión Europea (2000)
37	Booklet	Manual Hac-ercompost	Disclose compost	Farmers	Texts/Physical media	Large	Spain	Espanhol	Amigos de la Tierra (2006)

(continued)

Table 1 (continued)

Number	Type of material	Title of publication	Objective	Target audience	Way/Communication vehicle	Scale	Place of publication	Language	Reference
38	Booklet	Campaña de compostaje doméstico	Disclose compost	General	Texts/Physical media	Small	Spain	Espanhol	Cogersa (2017)
39	Booklet	Compostaje: fertilizante natural	Disclose compost	General	Texts/Physical media	Small	Colombia	Espanhol	Santa Fe Ciudad (2016)
40	Booklet	Instrucciones importantes para um mejor compostaje	Disclose compost	General	Texts/Physical media	Small	Honduras	Espanhol	Credia (2011)
41	Manual	Instructivo para la producción de Compost Domiciliario	Teaching compost	General	Figures and texts/Physical media	Small	Argentina	Espanhol	Silbert (2007)
42	Manual	Manual Básico para hacer Compost	Disclose compost	General	Texts/Physical media	Small	Spain	Espanhol	Amigos de la Tierra (2004)
43	Manual	Manual del buen compostador	Teaching compost	Farmers	Texts/Physical media	Large	Spain	Espanhol	GRAMA (2005)

(continued)

Table 1 (continued)

Number	Type of material	Title of publication	Objective	Target audience	Way/Communication vehicle	Scale	Place of publication	Language	Reference
44	Manual	Manual para el compostaje individual	Teaching compost	General	Figures and texts/Physical media	Small	Spain	Espanhol	GID (2012)
45	Manual	Manual de compostaje doméstico	Teaching compost	General	Texts/Physical media	Small	Spain	Espanhol	Alcolea and González (2000)
46	Manual	Manual de Compostaje	Teaching compost	Farmers	Texts/Physical media	Large	Colombia	Espanhol	Villada and Torres (2013)
47	Manual	Manual de compostaje para agricultura ecológica	Teaching compost	Farmers	Figures and texts/Physical media	Large	Spain	Espanhol	De la Puente (2005)
48	Manual	Manual práctico de técnicas de compostaje	Teaching compost	Farmers	Texts/Physical media	Large	Spain	Espanhol	Abarrataldea (2005)

Source Prepared by the authors (2018)

[a]Considered that the material is the one used with the focus to teach reading (Dicio 2009a, b, c, d)

[b]Considered those materials that contains the basic knowledge of a science, a technique, a craft: manual of the farmer, the carpenter (Dicio 2009a, b, c, d)

[c]Considered the act of making public, make known to all or the largest number (Dicio 2009a, b, c, d)

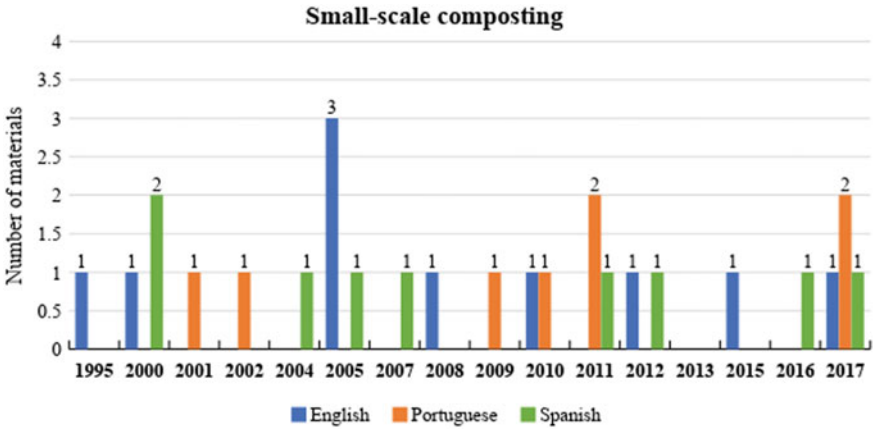
[d]Considered the act of giving instructions on something to someone, guiding in a precise way the steps to be followed by the person (Dicio 2009a, b, c, d)

[e]Lamellar composting is considered a directed process of decomposition of organic residues at the soil surface (Embrapa 2007)

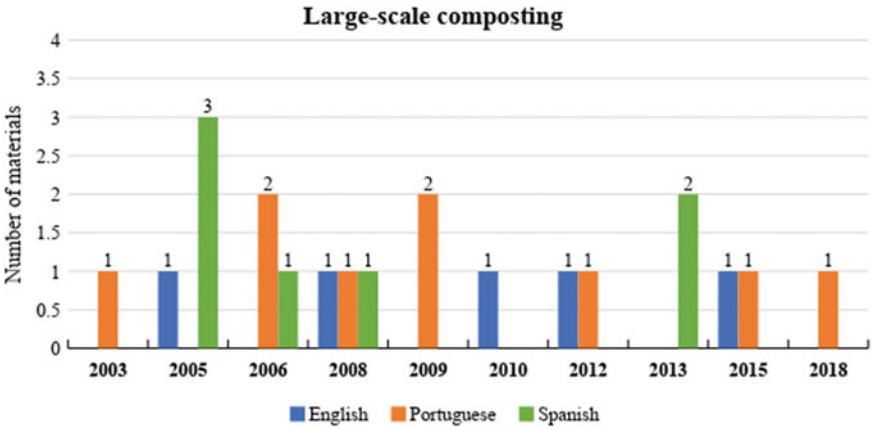
The materials found were analyzed and selected considering the three languages surveyed and the scale of the compost, small or large (Graphs 1 and 2).

Of the 48 papers selected, 27 were on the dissemination of small-scale composting and 21 on a large scale. It is also relevant the condition of Brazil, with 17 productions on compost, booklets and manuals, all in Portuguese language. The survey also shows 15 papers in English, from Canada and the USA, and 16 materials for Spanish-speaking countries, published in Chile, Mexico, Honduras and Spain (Graph 3).

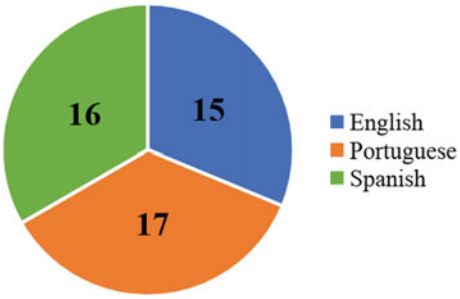
Of the total of English and Spanish language materials collected, ten and nine respectively, are focused on small-scale composting. However, for the Portuguese language, eight of the 17 papers are aimed at the same scale, demonstrating that both



Graph 1 Manuals and booklets on small-scale composting. *Source* Prepared by the authors (2018)



Graph 2 Manuals and booklets on large-scale composting. *Source* Prepared by the authors (2018)



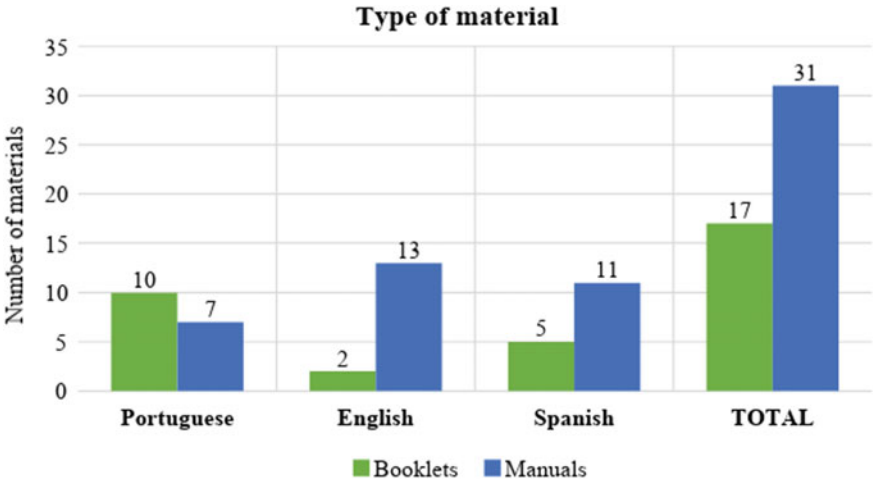
Graph 3 Number of materials selected per language. *Source* Prepared by the authors (2018)

the small and the large scale are being contemplated with the production of scientific dissemination materials.

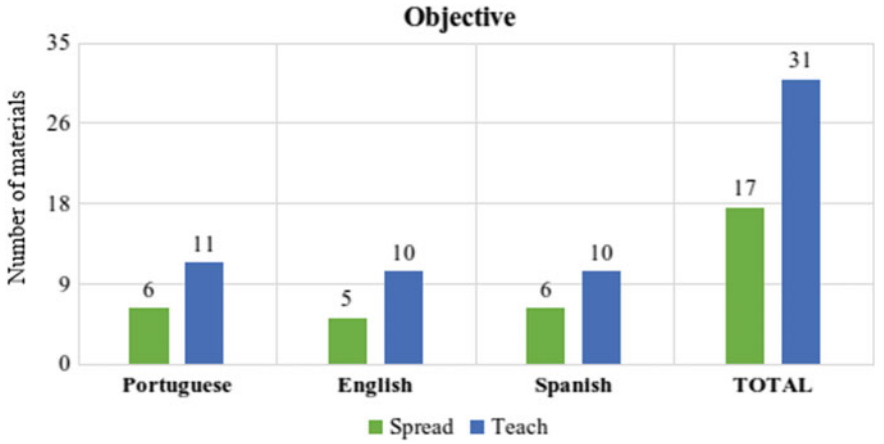
Evaluating the minimum points of the graphs, it is possible observe there are periods without production in a given category, and the time interval without registration reached 5 years, between 1995 and 2000, evidencing a lack of knowledge transmission by this source.

It should be noted that within the total of materials found in the searches performed, 17 are booklets while the remaining 31 are manuals. Most of the booklets were produced in Portuguese language, with 10 productions, and the largest portion of manuals in English with 13 materials (Graph 4).

Of all the materials produced, it was verified that 31 of the 48 have an emphasis on teaching composting and 17 have the focus on disseminating composting, regardless of the target audience. Looking at the amount of materials produced in each of the



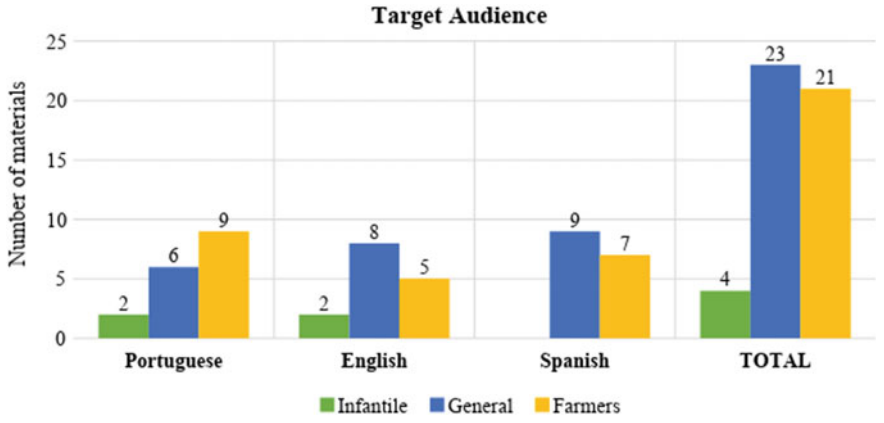
Graph 4 Composting materials categorized according to type of publication and language. *Source* Prepared by the authors (2018)



Graph 5 Compost manuals and booklets categorized according to their objectives and languages. *Source* Prepared by the authors (2018)

three languages it is noted that the distribution between the objectives "teach" and "disseminate" is similar (Graph 5).

From the total of materials found it is noticed that 23 have the target audience as general people, 21 give emphasis to rural producers and 4 have a focus on the children's audience. Thus, demonstrating that there is a greater concern with the adult public, whether rural producer or not. Results could not point any material for scientific dissemination in Spanish-speaking countries on this theme aimed at the children's audience, requiring an investment with an emphasis on this public (Graph 6).



Graph 6 Composting manuals and booklets categorized according to the target audience and language. *Source* Prepared by the authors (2018)

Although there are records of scientific research that evaluate the composting of coffee grounds associated with other organic wastes (Adi and Noor 2009; Fonseca 2012; Zibetti et al. 2015) the results show that no work was found that specifically reports adding value to coffee grounds by means of composting and its registration in the format of manuals or booklets of scientific disclosure, whether on a large or small scale. This underscores the importance of scientific dissemination and environmental education focusing on composting and valorization of coffee grounds is a challenge and can contribute to the achievement of the goals 4 and 11 of UN 2030 Agenda.

7 Conclusion and Recommendations

The dissemination of acquired knowledge about the environment, circular economy and sustainability has intensified with the help of the media. Among these media is the internet, which manages to bring a great amount of information to all parts of the globe. Composting biotechnology appears as a way to reuse and value organic waste generated in different environments. This technique has received great prominence, being disseminated in several ways, mainly through the internet.

Analyzing the bibliographic survey found in the searches with the afore mentioned languages and key words, it is noticed that for the adopted timeframe of 25 years, materials in the Portuguese language presents the greater number of materials. For this language, most scientific technical production has the priority of informing the public that perform the composting on a large scale, that is, producers and companies with large generation of solid organic waste.

For the English language, of the 15 works, 10 are focused on the small scale, that is, showing greater concern about composting with small amounts of waste, for example, in residences and households, contributing to the construction of more resilient cities and accordance with UN 2030 Agenda.

In the Spanish language, there is a spreading among its speaking countries. Spain demonstrated great prominence, with the production of 10 works of the 16 in this research. Among the 10 works, seven have focused on large-scale composting, demonstrating as well as in English, greater concern in the audience related to family environments and, or with small numbers of people. These results reflect the efforts that have been directed toward building a more conscious and sustainable society.

In all languages, it has been noticed that the main form of dissemination varies according to the target audience. If the focus is large-scale producers, the main dissemination is through the internet, which can reach several locations at the same time. However, when the focus is small scale, institutional or school environments, the main form of dissemination is the delivery through physical media.

Several institutions have practiced composting, allied to the maintenance of vegetable gardens, with excellent results for the integration of students, employees and collaborators, helping in the environmental awareness of its users. Many of these organizations are organic solid waste generators and the adoption of sustainable

practices for their management is necessary. The increase in the generation of these residues seems to be a tendency to be maintained or even extended in school institutions, so the treatment of these organic plants internally in their place of generation stands out as an efficient tool of decentralized solid waste management.

One of the difficulties in regard to the proper management of organic products is the path they should go through for their management, often mixing with other types of waste and making it unfeasible for organic and other recyclable waste such as plastic, paper, metals, etc. In this way, integrated waste management from the point of generation represents a greater probability of reuse, since it promotes a more efficient segregation of the materials and even the possibility of adding value by the generators themselves.

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Bioethical Reflections on the UN 2030 Agenda and its Repercussions for Teachers' Health

Ivaní Nadir Carlotto and Maria Alzira Pimenta Dinis

Abstract The goal of this study was to identify connections between bioethical principles, the goals set by the United Nations (UN) 2030 Agenda for Sustainable Development, and the foundations for health promotion (HP), particularly when applied to university professors. In its Sustainable Development Goal (SDG) 3—"to ensure healthy lives and promote well-being for all at all ages"—the 2030 Agenda allows for a reflection on the connections between bioethics and HP. Bioethics and HP both value the interactions between and focus on individuals and, in this approach, the drawing of connections between these topics and the 2030 Agenda presents itself represents a way to stimulate and develop useful measures involving health, well-being, quality of life, and happiness. The results suggest that concepts such as respect for personal dignity, care, protection, sustainable actions, prosperity, peace, partnership, and solidarity were reported by professors surveyed on these topics, with impact on seeking health-related measures able to promote individual and collective well-being, quality of life, inclusion and social justice, principle which are related to bioethics and HP, and the foundations of which are clearly correlated with the 2030 Agenda.

Keywords UN 2030 agenda · Bioethics · Health promotion · Higher education · Sustainable development

1 Background

In 2015, the United Nations (UN), in partnership with governments, civil society, and other stakeholders, began the Millennium Development Goals (MDGs) project to achieve transformative Sustainable Development Goals (SDGs) as part of their

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global course of action for eradicating poverty, promoting prosperity and well-being, protecting the environment, and tackling climate change (UN 2015). The principle of dignity is the flagship of this initiative and is part of a new sustainable development agenda.

Concerning the development and maintenance of an environmentally conscious and integral understanding of health, SDG 3 focuses on broad issues and covers all areas of action within health care. The initiatives associated with this SDG involve the reduction of maternal and infant mortality rates, decreases in sexually transmitted infections such as the human immunodeficiency virus (AIDS), as well as in rates of tuberculosis, malaria, viral hepatitis, and neglected tropical diseases, the prevention and reduction of substance abuse, improved ethics, equity, accessibility and universality of access to health services, the reduction and prevention of mortality from cardiovascular diseases and trauma, and the establishment of local and global partnerships for risk reduction and management.

A direct relationship can be established between this objective and education-based objectives within the framework of the 17 SDGs, since health, like education, can have an interdisciplinary and transdisciplinary dialogue with several areas of knowledge (Carlotto and Dinis 2017).

Bioethics is included within this interface, since the principal theory of the goals defends bioethical principles so that human beings may enjoys life with dignity (Beauchamp and Childress 1979).

Bioethics elucidates the ethical problems that arise in public health, health care, and health research. Bioethics is not an empirical discipline, but a normative one. As a normative discipline, bioethics examines what "ought to be," which often differs from what, in fact, "is." Bioethics is not a code of precepts, but it is a discipline that consists of analytical activity and is based on principles and ethical criteria meant to guide practices in the different fields of health.

Bioethical analyses are carried out on the basis of fundamental values such as respect for human beings and their ability to make decisions for themselves based on their values and beliefs, the well- being of people and populations, and justice. These analyses must take into account specific contexts and particular situations, identify all of the morally relevant elements, and seek coherence (PAHO 2012).

In order to achieve and promote progress, the role of bioethics must be clarified for the public at large. A campaign on this topic must precisely explain the applications of bioethics in the different areas of health care and ensure a political commitment to integration ethics in health.

Several mechanisms have been proposed to incorporate ethics into the different fields of health care in a substantial and systematic way. These mechanisms include the strengthening of bioethical tools and emphasizing the application of bioethical analysis, prioritizing the training of policymakers and staff members of government health agencies, continuing to identify and assess existing tools, focusing on activities meant to effectively meet specific health needs, creating and strengthening national and regional networks, and developing a common agenda that integrates the different efforts in progress so that those involved can make progress (Garrafa 2005).

To carry out these tasks, the Pan American Health Organization (PAHO 2012) has proposed to strengthen the coordination between regional bioethics programs, the Ethics Unit of the World Health Organization (WHO), regional bioethics collaboration centers, and the Bioethics Program of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). The PAHO/WHO is in agreement with UNESCO on the importance of having independent, multidisciplinary, and multicultural bioethical commissions that may serve as advisory bodies, contribute information to decision-making processes, and lead public debates on bioethics topics. The PAHO has proposed to combine efforts with UNESCO to support national bioethics commissions (PAHO 2012; UN 2015).

A broad look at these interrelationships reveals their interconnection with health promotion (HP), the definition of which is founded on the broad concept of health from an ecological, integral, and sustainable perspective.

Currently, the idea of health promotion involves a series of values: life, solidarity, equity, citizenship, sustainable development, autonomy, and participation, among others. It requires a series of strategies to formulate healthy public policies, manage public and private resources, and refocus health services through an ecological lens.

HP refers to the strengthening of individual and collective capacities in order to fortify the way in which different organizations address the multiple health-related factors in their communities in a way that builds autonomy among individuals in terms of habits, lifestyles, and the environment. The role of HP is to make it so that health-related measures are planned and operationalized based on basic bioethical principles associated with respect for autonomy and the well-being of individuals and populations (Carlotto and Dinis 2018a, b).

Bioethics as a Reflective and Inclusive Tool in Health Promotion for Teachers in Higher Education: Alignment with the 2030 Agenda.

From a global and political perspective, the objectives defined by the Ottawa Charter (WHO 1996) are the guiding axis regarding HP. HP is considered an essential component of life and is a process by which all people can achieve higher levels of autonomy and competence to manage their health (Allegrante 2015; Dias and Gama 2016; Kerr 2012; Stokols 2013).

Thirty years ago, the Ottawa Charter for Health Promotion (WHO 1996) retrospectively recognized the need to provide people with tools to empower them to manage and improve their health and well-being, thus ensuring healthy and sustainable environments. In 2016, the Ninth Global Conference on Health Promotion in Shanghai (WHO 2015), the theme of which was "Health Promotion: Sustainable Development Objectives," reaffirmed the timely and necessary commitment on the alignment between policies and actions associated with HP as established by the Ottawa Charter. The theme "Health for All" encourages the involvement of all individuals in a new global partnership in order to achieve this transformative agenda. Typical examples of HP intervention strategy programs are represented in context of education. This initiative initially referred to as "Healthy Schools," though it is now known as "Health Promoting Schools," and has spread to university systems known

as Health Promoting Universities, or HPUs (Joh 2017; Reilly 2011). Through HP measures created in these contexts, specific plans and policies have been established as connections between education and health, thus catalyzing actions relevant to the operationalization of HP.

Universities are essential organizations for HP—not only as contexts aimed at improving well-being but also as multisectoral health partners that contribute to the development of citizenship and social change. Investments in HP and salutogenesis in the context of higher education (HE) are valuable given the specificities that are characteristic of this sector. Dooris et al. (2012) proposes that the analysis of this perspective needs to consider the multiplicity of roles that universities play—as centers of learning and development, as stimulators for creativity and innovation, as sites in which citizenship is developed, and as mobilizers of resources, investments, and local, regional, national and global partnerships. This increasing commitment to the incorporation of health and well-being into higher education strengthens and reinforces the development of sustainability-based academic measures and activities (HEFCE 2014), thus broadening and supporting the salutogenic focus advocated by HP. The concept of sustainable development encompasses environmental, social, and economic policies. These policies are related to health in that they support the search for the improved quality of life and well-being of societies and environments. This definition highlights the invaluable relationship between health and sustainability that, in an academic context, promotes universities' growing commitment to sustainability by fostering evidence-based health care measures guided by salutogenesis (Dooris et al. 2017, p. 242). Teaching as a profession, while often analyzed under the aspect of stressors and malaise, is a vocational activity with immense positive professional return and with an evident link to HP. Due to the correspondences between teaching work and HP, it is possible to apply the HP concepts and proposals recommended by the HPU/WHO to teaching as a profession. The idea of approaching health from the perspective of health promotion allows us to anticipate situations and change courses of action healthily in all fields of study and policy (Li 2017; Luken 2016). These ideas are also defended by bioethics.

In this context and conceptualization, bioethics presents itself as a reflexive, mutually shared and interdisciplinary tool that focuses on the adequacy of actions that comprise life and citizenship. In the context of HE and professor health, the principles are strictly related to HP (Dooris 2005).

Coughlin (2008, p. 9) and Dooris et al. (2017) emphasize that the ethical principles and values involved in HP in the context of teaching and bioethics do not apply solely to the biomedical field. Concepts such as solidarity, public trust, autonomy, resilience, individual and community well-being, global health, shared commitment, inclusion and environmental/sustainability health are used to define bioethical practices committed to the complexity of current events and the search for balanced answers to the conflicts presented (Garrafa 2005, p. 130).

2 Methodology

The study had a cross-sectional design with a quantitative and qualitative approach and was exploratory and descriptive in nature (Prodanov 2013). The population was composed of professors from higher education institutions (HEIs) in the Brazilian state of Rio Grande do Sul (RS). They were selected via random, non-probabilistic sampling out of convenience (*openepi* = 95% CI (%), $n = 1400$ individuals). Data was collected between March and July 2017. The study was approved by the Research Ethics Committee of the Clinical Hospital of Porto Alegre (HCPA), by the Ethics Committee of Fernando Pessoa University (UFP) in Porto, Portugal, and via CAAE Registry No. 550666168.0000.5327.

For data collection, an online survey was built and hosted on the Survio© platform and then sent to the participants via e-mail. Leaders of each HEI had been contacted previously to present the study objective and obtain approval for the survey. All of the respondents were informed about the need for their approval via the Informed Consent Form (ICF) that accompanied the protocol.

The statistical analysis of the results was performed with the aid of the *R* statistical software environment (*R* Development Core Team), version 3.3.1. (2015), as well as through the cross-checking of survey data and the conceptual frameworks of the Health Promoting Universities (HPU)/World Health Organization (WHO). Qualitative and dissertation data were treated using content analysis as per Bardin (2009). The data were collected through the application of 1400 questionnaires, each of which contained 35 questions. Each question had five possible answers on a Likert scale to which the following values were attributed: 1 point—I don't know about this; 2 points—I know a little bit about this; 3 points—I know a moderate amount about this; 4 points—I know a lot about this; and 5 points—I am fully aware of this or know everything about it. The instrument was an adaptation of the WHO protocol/HPU Toolkit of the University of Central Lancashire in Lancaster, UK, the use of which was expressly authorized by its creator, Professor Mark T. Dooris. The toolkit includes a research tool that enables HEIs to analyze and reflect on their perceptions of health, sustainable development, and well- being in their core businesses and organizational culture.

A significance level of 1% was adopted, and hypotheses whose descriptive value (p-value) was lower than 0.001 was rejected; varimax rotation with factorial load retention >0.40 was used; the factor analysis and principal components analysis (PCA) with an eigenvalue higher than 1.0 was applied to identify groups or groupings of variables, and thus to understand the structure of a set of variables and to show the relations between them, reducing the data set to a more manageable size while retaining as much of the original information as possible. Cronbach's alpha (acceptable index > 0.60) ensured the internal consistency of the instrument used.

3 Findings

The general profile of the sample points to the following data: 14% of the professors ($n = 199$) were admitted to HEIs surveyed in the early 2000s, 87% of which ($n = 1219$) were linked to private HEIs. Of the sample population, 76% ($n = 1070$) were female, and 53.7% ($n = 752$) were between the ages of 46 and 55. When asked about their fields of expertise, 67% of respondents ($n = 943$) reported health sciences, followed by engineering at 10% ($n = 142$) and humanities at 7% ($n = 109$). The level of schooling varied only slightly: 75% ($n = 1046$) had doctoral degrees while 19% ($n = 266$) had master's degrees. In addition, 60.3% ($n = 845$) had 15 to 20 years of teaching experience, and the weekly workload was 40 h for 26.2% of respondents ($n = 368$), 20 h for 16.1% of respondents ($n = 226$), and 30 h for 13.5% of respondents ($n = 189$). Of the 1400 professors surveyed, 79.5% have a working relationship with only one educational institution ($n = 1113$). Table 1 shows the sociodemographic characteristics of the professors included in the study.

Through the applied factorial analysis and the Varimax® Rotation, it was possible to extract six principal components, as shown in Table 2.

Table 3 shows the higher factor loads that emerged from the extraction of each

Table 1 Sociodemographic characteristics of teachers

Characteristics	Respondents	
Age	*n*	%
26–30 years	106	8
31–35 years	143	10
36–45 years	215	15
46–55 years	752	54
+55 years	184	13
Marital status		
Married/companion	1080	77
Separated/divorced	159	11.8
Single Children:	156	11
Widowed	3	0.2
Level of education/schooling		
PhD	1046	75
Specialist	35	2
Master's degree	266	19
Postdoctoral degree	50	3
Other training	3	1
Gender		
Male	330	24
Female	1070	76

Table 2 Estimated six principal components after Varimax® Rotation with Kaiser normalization for the answers to the questionnaire adapted to the Brazilian reality Toolkit Self-Review Tool

Question (Q)	Principal Components (PC)						Variability ratio
	PC1	PC2	PC3	PC4	PC5	PC6	
Q8	**−0.578**	0.17	0.186	−0.329	0.095	0.328	0.622
Q10	**−0.645**	−0.18	−0.175	**0.482**	0.002	−0.161	0.737
Q11	**0.587**	**0.405**	0.038	−0.283	−0.378	0.189	0.769
Q13	**0.572**	0.37	−0.014	−0.299	−0.268	0.097	0.635
Q16	**0.826**	0.32	0.007	0.003	0.358	−0.11	0.924
Q23	**0.812**	0.069	0.049	0.094	0.339	−0.134	0.808
Q24	**0.786**	0.309	0.015	−0.064	−0.195	0.063	0.76
Q26	**0.827**	0.163	0.187	−0.194	0.263	0	0.852
Q28	**0.855**	0.253	−0.065	−0.004	−0.177	0.036	0.833
Q31	**0.847**	0.331	0.054	−0.042	−0.1	0.114	0.854
Q32	**0.895**	0.206	0.081	−0.115	−0.039	0.032	0.866
Q19	0.037	**0.602**	**−0.569**	−0.154	−0.127	0.013	0.728
Q21	0.253	**0.776**	0.109	−0.155	−0.134	−0.014	0.719
Q22	0.313	**0.719**	−0.295	−0.033	−0.176	0.028	0.735
Q25	0.068	**0.626**	**0.528**	−0.298	0.01	0.15	0.787
Q27	0.164	**0.757**	0.217	−0.342	−0.021	0.02	0.765
Q29	0.334	**0.8**	0.104	−0.001	−0.207	0.077	0.811
Q30	0.306	**0.847**	0.06	−0.15	−0.056	0.005	0.841
Q33	0.379	**0.814**	0.03	−0.088	0.026	−0.024	0.816
Q6	−0.265	0.174	**0.648**	−0.064	−0.145	0.101	0.555
Q7	−0.187	0.177	**−0.662**	−0.028	−0.104	**0.409**	0.684
Q9	0.344	−0.085	**0.602**	−0.028	−0.258	0.154	0.579
Q18	0.104	−0.132	**−0.659**	−0.385	−0.056	0.033	0.615
Q35	0.361	0.304	**0.631**	−0.272	0.03	0.032	0.697
Q15	0.044	−0.21	−0.055	**0.703**	**0.423**	0.076	0.727
Q20	−0.202	−0.201	0.167	**0.764**	0.001	0.126	0.709
Q34	−0.061	−0.38	−0.072	**0.751**	0.354	0.023	0.843
Q14	0.022	−0.106	0.096	0.334	**0.764**	−0.089	0.724
Q17	0.179	−0.391	−0.208	0.122	**0.716**	−0.049	0.758
Q1	−0.139	0.104	0.045	0.162	0.268	**0.618**	0.513
Q2	0.099	0.055	0.01	0.202	−0.009	**0.61**	0.426
Q4	−0.099	0.122	0.102	0.275	0.066	**−0.497**	0.361
Q5	0.012	−0.382	−0.181	−0.09	−0.274	**0.548**	0.563

(continued)

Table 2 (continued)

Question (Q)	Principal Components (PC)						Variability ratio
	PC1	PC2	PC3	PC4	PC5	PC6	
Number of items Eigenvalues	11 7.341	9 6.02	7 3.069	4 3.007	3 2.384	5 1.796	
Variance (%)	31.084	25.491	12.994	12.734	10.092	7.603	
Cumulative variance (%) α	21.18 0.802	38.48 0.925	47.74 0.638	56.33% 0.823	63.66 0.765	69.2 0.752	Average 0.8

Table 3 Categories that emerged from the questionnaire/six principal components

Categories/principal components	Higher factor load	Number of variables in principal component (PC) composition
01—Programs and activities to support health and sustainable development	0.895	11
02—Facilities and environments conducive to HP/Information and Communication Technologies (ICTs)	0.847	9
03—Development of actions of health and well-being at work through a comprehensive and integral approach/Bioethics	0.648	7
04—Key contacts/support services/dissemination of institutional research on health and sustainability	0.648	4
05—Referrals and clarifications of health problems/accessibility	0.764	3
06—Strategic planning/impact assessment/partnerships	0.618	5

component and the number of variables that formed each component. The extracted components are directly proportional to the original categories of the Toolkit Self-Review Tool, which served as the theoretical basis for this work.

4 Discussion

According to the Ottawa Charter, health is considered a multidimensional (physical, mental, emotional, spiritual, social) resource for life. The focus for the establishment of an ecological paradigm in HP is not only to identify needs, changes in behavior, and disease prevention, but also to promote and strengthen assets and resources for health, well-being, and prosperity (Dooris et al. 2012; Doran 2017; Fielding 2012). HP values the interactions of the individual with social environments and, in this approach, ecological models represent a possibility for the development of health-related measures in a holistic, sustainable, and salutogenic way, thus stimulating positive aspects involving ethics, well-being, quality of life, and happiness (Dooris et al. 2017; McLaren 2015; Oluwanasu 2017).

The primary objective of HP for teachers in HE is to combine these models with empowering health-related actions that investigate and determine gaps in which HP can, through interdisciplinarity, strengthen relationships and result in improved health, well-being, and quality of life for teachers, indicators which are relevant in public health. The university environment can be understood as its own social system, with its interrelations between the parts and the whole. This system is complex and dynamic, with elements affected by feedback cycles. When applied to professor health, this theory illustrates that healthy structures (e.g., the adoption of a strategic plan and committed management) are a precondition for healthy processes (e.g., effective communication, which is a precondition for health outcomes and results that are determinants of health) (Dooris et al. 2012; Carlotto and Dinis 2019a; Dooris 2016; Peirson 2011).

The results of this study show that, in addition to the principles of HP usually identified in the literature, such as equity, interdisciplinarity, participation, and holism, additional principles involving HP for teachers in HE was identified. Concepts such as solidarity, the public's trust, empowerment, resilience, individual and community well-being, global health, shared commitment, and environmental health/sustainability were evoked by the professors studied, and were found to impact overall health, individual and collective well-being, life, inclusion and social justice (Ginja 2017; Mehtala 2014; Scholmerich 2016).

Universities serve as places of research and learning and, when they focus on sustainable development, they stimulate HP activities. However, the spread of ecological models of HP as a principles-based interdisciplinary activity may reflect on the HP teacher in HEIs, and, in doing so, contribute to the establishment of qualified processes in HP for teachers. Within this perspective, interdisciplinarity becomes a tool for the recognition of shared goals, as well as of the need for plural knowledge, inclusion, and reflection.

In addition to the established formulation - charity, non-maleficence, justice, and respect for autonomy (Beauchamp and Childress 1979), underlying references such as solidarity, shared commitment, and health sustainability were evoked, resulting in a positive impact on HP at the individual level and the collective level, as well as on quality of life, inclusion, and social justice in the university environment. The

principles of bioethics and ecological models are integrated in the sense of working toward the construction of a more humanized HP model and assuming the application of health care in HEIs in an interdisciplinary and socially responsible way (Golden 2015; Reddy 2017; Zhang 2016).

By valuing and understanding interrelationships, interactions, and synergies in the university environment, which are ideally derived from interdisciplinary practices, a clear commitment is conceived with HP in higher education. Stimulating healthy working and learning environments leads to sustainable development in educational processes and the exchange of knowledge, as well as an increase in health and well-being, thus reinforcing commitments to teachers' health, sustainability, and equity. In this way, we sought to draw connections between ecological models of HP and teacher health, and to reflect on how it is possible to contribute to stimulating adequate and inclusive health-related measures for teachers in an academic setting while viewing health as an integral part of culture, structure, and university processes (Carlotto and Dinis 2018a).

The limitations of this study include the need for public policy formulation and morally justifiable decision-making assistance for HP for teachers from an ecological perspective as well as for the integration of health into professors' routines in an interdisciplinary way that identifies opportunities that support well-being and commitment to the health of teachers. It is important to apply an ecological and salutogenic approach in HE through the evidence-based research and actions. It is also important to recognize HP for teachers in HE as an investment and resource necessary to strengthen positive assets for planned health actions (Carlotto and Dinis 2018b).

5 Conclusions

HE is important. Universities function as places of research and learning and, ideally, of sustainable development, and they are able to stimulate health promotion activities. In this proposal, bioethics is treated as an analytical and principle-based activity that seeks to reflect on the teaching of HP in HE, thus contributing to the construction of qualified processes of actions in teacher health, with due conceptual clarity that characterizes this process (PAHO 2012). The 2030 Agenda and the SDGs provide a good foundation for these tasks in that they respect bioethical principles and health promotion actions with a salutogenic approach.

Possible practical implications include the need for public policy formulation and morally justifiable decision-making assistance for HP for teachers following an ecological approach; integrating health and teaching staff, identifying opportunities that support well-being and commitment to teachers' health, fostering an ecological and salutogenic approach in higher education by promoting evidence-based research and actions, and recognizing HP for teachers in HE as an investment and resource necessary to strengthen positive assets for planned health actions (Carlotto and Dinis 2019b).

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Sustainability of Sufficiency-Based Schools

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Abstract Sufficiency Economy Philosophy (SEP) is an approach used to achieve sustainability in Thailand. SEP shares the same goals of balanced development as the United Nations Sustainable Development Goals. It consists of 2 foundations (knowledge and virtues), 3 principles (moderation, reasonableness, and prudence), and 4 balanced outcomes (economy, society, environment, and culture). SEP focuses on developing people's quality, particularly a sufficiency mindset. Therefore, it is important to cultivate this mindset at an early age. The SEP movement in Thai education started in 2007. Currently, there are 742 Best Practice Sufficiency-based schools and 205 Sufficiency-based Learning Centers that successfully foster the sufficiency mindset. By implementing the whole school approach, SEP is used in all school activities and administration. In particular, these schools use action-based learning, questioning, reflection, and role modeling to nurturing the SEP mindset. In this case study research, ten Sufficiency-based Learning Centers were studied in 2018. Interview, document analysis and observation methods were used. Approximately 13 persons/stakeholders were interviewed in each school. In order to sustain the cultivation of the SEP mindset in schools amidst replacement of school principals and others changes, the findings show that it is important to integrate SEP learning activities with class subjects, thus becoming a part of typical curricular learning. Continuous SEP training and involvement of teacher leaders, all school personnel, student leaders, new school principals, and Educational District superintendents are the key success factors for sustainability of the cultivation of the SEP mindset.

Keywords Sufficiency economy philosophy · Education for sustainability · Sustainable development

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1 Introduction: Sufficiency Economy Philosophy (SEP) in Schools

People everywhere face shared problems regarding environmental deterioration, conflict, and a gradual decline in cultural heritage and spiritual values. There is unbalanced development among the social, environmental and economic or material dimensions of living. In Thailand, SEP principles bestowed by the late King Bhumibol of Thailand have been applied as a systemic process to restore balance in developing the country.

"Sufficiency Economy" is a philosophy the King bestowed on his subjects in 1997, at the time of the Asian Economic Crisis. Nevertheless, when tracing back, many royal pronouncements made on various occasions over the past three decades, and King Bhumibol's royal development projects over the past six decades, all contain SEP elements. SEP is considered as an approach to sustainable development, aligned with the United Nation's Sustainable Development Goals (SDGs). SEP is a philosophy and a decision-making framework that can drive human behaviors. It can be applied by anyone at any level, so their behaviors are reasonably suitable, in moderation, and with planned risk management and prevention to enable sustainable development, while balancing economic, social, environmental, and cultural outcomes in the globalized world. In order to do this, the two main prerequisite conditions for these behaviors lie in human development, comprising of knowledge and moral development.

SEP shares many similarities with the main concepts of international approaches to developing sustainability, such as focusing on balanced development, responsible consumption, green growth, respecting biodiversity, and cultural multiplicity. In addition, SEP has its own special contribution to make of a complete and holistic framework of decision-making mechanisms (prudence, integrity, reasonableness and moderation, for example), instead of focusing on just one or a few decision-making elements.

In Thailand, the 2001 National Basic Education Core Curriculum started to include one single subject based on SEP, which is the Society, Religion and Culture subject (economics studies). However, early SEP attempts on development via curriculum, lesson plans and teaching aids bore no fruitful result. In 2007, the UNDP produced a national human development report on Thailand (UNDP 2007), focusing on Sufficiency Economy and human development. One of the six recommendations from this report emphasized the need to upgrade the quality of education, including both content and pedagogical methods, to fulfill the key preconditions of knowledge and virtues for the successful operation of SEP. Expanding the application of Sufficiency principles in the management and administration of schools is also recommended. This triggered the SEP education movement in Thailand. In order to be truly sustainable, cultivating a SEP mindset in Thai younger generations had to be started. In 2007, 135 'SEP prototype' schools were established. They helped design the SEP curriculum, and entered the process of evaluation for the purpose of accreditation as a sufficiency school.

In 2008, the National Basic Education Core Curriculum in Thailand placed desired characteristics of Sufficiency in learners as objectives for the first time. In order to cultivate sufficiency mindsets and characteristics that enable students to live in accordance with SEP, a whole-school approach has been implemented. The approach is to involve all functions and activities in the school, including school management, learning activities, and community relations, in a fostering the process. School management has to integrate SEP to model sufficiency behaviors in both school duties and personal lives, as well as promoting stakeholder participation. In terms of learning, enabling environments are crucial. The physical environment includes learning stations, which are separate areas set aside inside or outside the classroom, specifically designed for group interactive/action-based learning. A learning culture including learning techniques, such as questioning and reflection, extra-curricular activities, and role modeling are also critical. Finally, the student environment at home and in the community also needs to be considered, involved, and changed in order to create sufficiency-inducing surroundings to cultivate and sustain sufficiency mindset for students.

Thai sufficiency-based schools are part of a global movement toward incorporating sustainability into education. Examples of similar movements include sustainable schools in New Zealand, Sweden and China (Henderson and Tilbury 2004), and a governmental sustainable school framework in Britain (Scott 2009), and the UN Decade of Education for Sustainable Development (DESD) during 2005–2014 (Wals 2012). The United Nations' Global Action Program on Education for Sustainable Development continues the work of the DESD under the aegis of Agenda 2030.

Currently, of Thailand's approximately 40,000 primary and secondary schools, some 21,000 have been certified as having integrated SEP into their teaching, and there are now some preliminary results. The first accreditation level was initially co-designed and used in 2007 by the Sufficiency School Center and the Ministry of Education, with the Ministry managing accreditation since that time. SEP-accredited schools can further qualify to become the next level of Sufficiency Education Learning Centers (SELCs), which offer advice, mentoring and coaching to applicant schools to help them become SEP-accredited. In 2018, 205 schools have been accredited as SELCs. SELC accreditation is managed by the Ministry of Education. In addition to the two formal certification levels, the Sufficiency School Center, Foundation of Virtuous Youth, developed a "best-practice" status, which has served to help sufficiency-based schools at the initial certification level to improve and sustain their quality of learning activities and management. There are currently 742 best practice sufficiency-based schools.

Change Management approaches used in implementing sufficiency schools are also important. Generally, the educational policy, projects and activities are generated from the Ministry and communicated to schools. The sufficiency school movement (driven by a committee) and a special unit within the MoE coordinated with all units and levels within the Ministry to support and monitor systems. The objectives of the movement, aligned with the 2008 National Basic Education Core Curriculum, used a bottom-up approach. That is, the process started from human development, focusing on developing competency of school principals, teachers, and student leaders through

workshops and camps. The Ministry of Education includes the sufficiency school program in the career advancement portfolio of school personnel as an incentive, and train school superintendents to assess schools for sufficiency school accreditation. Thanks to using the bottom-up approach and an incentive system, the change has expanded accordingly, and has had a chance to sustain itself.

There is a Ministry of Education policy to rotate school principals every four years among schools. This provides a challenge to schools accredited as sufficiency-based, since the new principal may not be familiar with SEP.

In some sufficiency schools, new headmasters often fail to continue the sufficiency momentum, since they also want to implement their own new initiatives. When this happened, the quality of the sufficiency movement reduced. The sufficiency spirit was not kept up. Therefore, it is important to study the SEP educational processes that can be sustained, and key success factors. Hopefully, this will provide guidelines of SEP educational management for sustainability for educational institutions, relevant organizations, and agencies both in Thailand and abroad.

2 Sustainability of School Initiatives and Interventions

Hargreaves (2007) defined sustainable education change as development, which allows newly-evolved learning to continue and receive financial support and resources. At the same time, the change does not negatively affect the school environment and education system. From the organizational perspective, Avery (2005) provided three criteria to identify sustainable organizations. First, they continue to deliver consistently strong performance. Second, they demonstrate a capacity to endure numerous difficult economic and social situations. Third, they maintain a leadership position in their relevant sector. Therefore, in this study, the definition of sustainability in sufficiency-based schools is that the SEP mindset is continuously implemented in a school. When facing a crisis such as a change of school principals who do not support SEP, the school can still maintain the cultivation of an SEP mindset. The result is demonstrated in students' sustained SEP mindset.

Previous studies on sustainability in school initiatives have typically regarded the process of maintaining school initiatives as an end stage of the program. However, waiting to build sustainability planning at the end might not provide sufficient time to deliver effective sustainability efforts. Sustainability planning and monitoring needs to be continuous throughout the process for it to be successful. Therefore, recent approaches to sustainability have also called for implementing a sustainability plan into earlier program development stages (Fagen and Flay 2009).

The change in the school may not be sustainable, possibly because of failed leadership, and pressure of other competing initiatives from external systems. Therefore, school development should not depend on one person or one single factor. Sustainability demands the competence and involvement of the main stakeholders of the school (Giles and Hargreaves 2006). Datnow and Stringfield (2000) suggested that the maintenance of efforts to implement school changes depend on educators at var-

ious levels (i.e., state, district, reform design team, school, classroom, individual) to have the same goals and work together. Datnow and Stringfield (2000) identified factors that are important for the sustainability of school change as (1) the fit of the "rationale" of the change and that of the local change agents; (2) obtaining political support; and (3) integrating changes into daily lives at the school. School personnel viewed the changes and received benefits as having met the school's original goals. In schools that had sustained the change program, there was generally a positive acceptance of the program based on a belief that the education change formed a part of a broader concern with student welfare and improved student outcomes (Harvey and Hurworth 2006). High quality professional development was continuously provided at each school (Yonezawa and Stringfield 2000). Benitez et al. (2009) identified a strong relationship with the Educational District Authority as one of the important factors for the sustainability of changes in educational institutions.

An educational change will be more sustained if priority is given to the *capability building of teachers*. First, allowance needs to be made for the transfer or resignation of trained staff through continuous professional development (Benitez et al. 2009; Elias et al. 2003). A strong and resilient teacher culture and a distributed leadership culture throughout the school will smooth changes in the event of staff replacement. In addition, having secondary change agent teachers as part of the bigger team, who are accepted by colleagues for support and advice, ensures the longevity of school change (George et al. 2007; Bambara et al. 2009). Second, continuous professional development by the principal and teachers should be institutionalized, and used to build collective knowledge (Hargreaves 2007). Development methods include coaching, knowledge sharing, extensive orientation for new staff, formal and informal/buddying with experienced colleagues, and training within the school or the external network (Goodson et al. 2006; Jacobson 2011; Bezzina 2006). Studies have reported that professional collaboration can support school personnel in developing, applying, and sustaining new competencies (Brownell et al. 2006), and provide the emotional support needed for team members to persevere during difficult times (Bambara et al. 2009). This is particularly so when team members reflect and think critically about their practice and see the results of their efforts (Gersten et al. 2000; Brownell et al. 2006). This will create change at the individual level and change organizational culture (Copland 2003).

The sustainability of school change also depends on the ability of the school to engage stakeholders across the school community, and the capacity of the principal to *devolve responsibility* effectively for the initiative's implementation across middle leadership (Harvey and Hurworth 2006). Distributed leadership also implies a need for rich expertise with approaches to improving teaching and learning among staff. This demands that all who work with students need to engage in the development of the necessary professional competencies to consistently deliver on the program's promise (Copland 2003). Along with the support of the principal and other key school leaders, the change team can also be associated with the learning areas relevant to the program. But they also generally hold positions of responsibility that provide them with a higher degree of influence.

In Thailand, a qualitative study of nine Sufficiency Educational Learning Centres (SELCs) (Bunkua and Chinprahut 2014) reported five key SELC practices, which were school management of sufficiency learning; sufficiency-based learning curriculum; wide-ranging school activities encouraging sufficiency habits; outcomes at the individual and organization/community-level; and expansion of the sufficiency-based program to other schools and communities. Internal factors of schools, such as faith and understanding in sufficiency principles and their application, and shared characteristics based on SEP, are found to be more important than external factors. Therefore, schools probably should be focusing on developing such internal factors to ensure the sustainability of the SEP change effort.

In addition to internal factors, external factors such as *the external coach*, who has a role to play during the transitional phases of a new principal, can be important. The coach can observe, coach and advise. When teachers felt that they were losing momentum under the guidance of a new principal, they could approach the external coach to intervene, and bring life back to their school change process (Lambert 2007). A change in principal may require an increase in external assistance during the transition period (Lohrmann et al. 2008). Bunkua and Chinprahut (2014) found that strong community support for the continuity was also important to sustain the initiative.

A change in *district or administrator priorities* is also a challenge to the sustainability of school change. This is commonly reported as a barrier to the sustainability of school change (Sindelar et al. 2006; Furney et al. 2003). Strong indications of political support for school reform, and having the initiative a priority for high-level politicians and bureaucrats is important. With such championship, it may be felt that the program is likely to be sustained and is more than a 'one-off' intervention (Harvey and Hurworth 2006). After the review of literature on sustainability of school change, next the Thai Sufficiency Educational Learning Centres, which are the main focus of this research, will be discussed.

3 Sufficiency Educational Learning Centres in Thailand

Sufficiency Educational Learning Centres (SELCs), the highest level accreditation type of sufficiency-based schools, provide encouragement and mentoring to other schools. The Ministry of Education describes SELCs as schools that assist other schools wishing to qualify. They are self-reliant models of best practice in integrating sufficiency principles into whole-school activities. SELC staff and students offer coaching and supervision to others. SELCs host study tours and workshops to teachers, school administrators, and student leaders, from within Thailand and abroad. An essential assessment indicator to qualify as a SELC is evidence of having assisted at least one other school on its path to becoming sufficiency-based.

4 Assessing Sustainability of Sufficiency-Based Schools

Qualitative research was conducted to study the sustainability of SELCs to facilitate expansion of SEP promotion in education in 2018. The research objectives include:

(1) to assess the continuity of key practices in cultivating SEP mindset in the SELCs, particularly after the change of school principals
(2) to identify the Critical Success Factors in managing SELCs sustainably.

We selected 10 SELCs, ensuring variation in school type and size, rural/urban, Buddhist/Christian/Muslim, Thai/other races, wealth. Data sources were documents, school visits, school meeting observations, and interviews with school leaders, administrators, teachers, students and community members. Documents analyzed include movement toward SEP in school reports, schools' training and development documents, schools' quality assessment reports, schools' project reports and documents, school curriculums, and teaching plans. The characteristics of the 10 SELCs studied are shown in Table 1. There were a total of 14 new principals at these schools.

5 Sustainability of SELCs

The findings are presented into two parts: (I) the sustainability of the key process in cultivating SEP mindset in educational institutions; and (II) Critical Success Factors influencing the sustainability cultivating the SEP mindset.

I. *The sustainability of the key process in cultivating SEP mindset in educational institutions*

Five key SELC practices include school management of sufficiency learning; sufficiency-based learning curriculum; student development activities encouraging sufficiency habits; personnel professional development; and sufficiency-based program expansion to other schools and communities (Bunkua and Chinprahut 2014). The study examined the sustainability of these five key practices in the SELCs studied.

1. SEP School management

The majority of the new principals still managed the school in accordance with SEP, though their involvement varied. Their involvement included continuing having SEP as part of the school vision (PM3, SC2, SC3), providing advice, budget and support, while delegating direct authority regarding SEP to teacher leaders and or deputy principals by three secondary school principals (SC1 1st[1], SC2 2nd, SC4 1st). More hands-on leadership was found from three new principals. Evidence of the high

[1]This means the first new principal of that school.

Table 1 Characteristics of 10 SELCs

School name	Region	Grade	Size	No. of personnel (approximate)	No. of students (approximate)	Community-level socioeconomic status	Year to be SELC	No. of principal change/year
PM1	North	Kindergarten to G6	Small	10	100	Low to middle	2011	1 (2016)
PM2	South	Kindergarten to G6	Small	10	130	Middle	2011	1 (2016)
PM3	Central	Kindergarten to G6	Large	50	720	Middle	2011	1 (2016)
PM4	Northeast	Kindergarten to G6	Medium	40	980	Middle	2011	1 (2016)
SC1	North	G7–G12	Medium	60	900	Middle	2011	2 (2015, 2017)
SC2	Northeast	G7–G12	Medium	65	730	Low to middle	2011	2 (2012, 2014)
SC3	Northeast	G7–G12	Large	80	1190	Low to middle	2015	1 (2016)
SC4	South	G7–G12	Extra large	180	2560	Middle	2011	3 (2012, 2015, 2017)
SP1	Central	Kindergarten to G9	Medium	20	350	Low to middle	2015	1 (2016)
PS1	Central	Kindergarten to G12	Extra large	180	2830	Middle to high	2011	1 (2010 after SELC assessment)

involvement of new management includes working alongside with the SEP teacher leaders (SC2 1st), having the teachers explain how they integrated SEP in their daily lives during every school meeting (PS1), and new initiatives in driving SEP in community relations (SC1 2nd).

However, there was a lack of continuing support for SEP from a few new principals. There was no specific policy in driving SEP (PM1). The initial pressure on new principals also came from the other policies from the Ministry of Education such as increasing academic test scores, or other new Ministry's projects (PM2, SP1). The PM4's new principal only turned around to support SEP after he gained more misunderstanding of SEP. The SC4's second new principal assigned responsibility for budget in school to the academic deputy, who did not focus on SEP. The reduced management support, especially the budget, affected other key processes of SEP mindset cultivation, with an exception of the SEP curriculum, which is discussed next.

2. SEP Curriculum

All schools continued integrating SEP in all subject areas as part of the curriculum. The teachers considered this integration to be their normal daily teaching lives. Therefore, the SEP integrated curriculum should be considered as one in which the cultivation of the SEP mindset is sustained. However, some students commented that SEP in the curriculum had less impact on their behaviors than student development activities, which were more action/experience-oriented.

Extra development in integrating SEP in all subjects during the time of new principals was reported in four schools. For example, SEP was increasingly used in classes by all teachers at PM2, PS1, and SC4 (2nd). During the time of the SC2's second new principal, the cross-subject lesson plans were linked to SEP learning stations (one station per each class level). During the time of the SC4's third new principal, there was a new SEP subject for Grade 7 students (new students to the school).

3. SEP student development activities

When changing to a new principal, the majority of schools continued SEP-based student development activities, and a few improved and developed new initiatives even further, with the exception of PM1, PM2, SP1, and SC4. SEP student development activities normally comprise (a) SEP learning station activities, (b) SEP student leader development activities, (c) SEP student camps, and (d) other activities.

All the schools except PM1 and SP1 continued conducting activities at SEP learning stations. There were improvements in several: PM3 and SC3 improved existing stations; PS1 developed new learning stations; SC1 started inviting community members with local wisdom to be station trainers; and a policy for all SC2 teachers to work together to develop a cross-subject lesson plan, integrated with the learning station activities (one lesson/one station for each class level).

With the exception of PM1, PM2, and PM4, schools sustained SEP student leader development activities. SEP student camps continued, except for PM1, PM2, and

SC4. At SP1, the SEP student camp was integrated with new activities from the Ministry. While SC4 faced the same situation as SP1, the second new principal did not allocate the budget to the SEP student camp, but only to the new activities imposed by the Ministry.

In terms of other SEP-integrated activities at all schools, SEP was continuously integrated into other activities, and with activities from the new policy of the Ministry of Education. There were new improvements at a few schools such as newly added activities to promote SEP personal characters at PS1 and SC2; the second new SC1 principal taking teachers and students to community learning centers; and a study visit to the royal development center at SC2.

When looking into the new principals who reduced SEP student development activities (PM1, PM2, PM4, SP1, SC4), reduction of most activities was the result of the change in school administration, policy and budget. Therefore, SEP student development activities were less sustained than the curriculum. Discontinuation of the SEP student camps (PM1 PM2 and SC4) resulted in a lack of knowledge transfer from senior to junior students and consequently less opportunities for future SEP student leaders to practice and develop. The new PM4 principal decided not to receive study tours coming to see the SEP learning center for some time, resulting in limited opportunities for SEP student leaders to practice presenting and guiding visitors. The SP1 principal reduced the number of hours students spent at learning stations in order to attend more tutoring for the national exams, stopped receiving study tours to the SEP learning center, and did not maintain the learning stations.

4. Personnel development activities

The majority of new principals continued to develop school personnel on SEP. The main development approach was SEP "train the trainer" workshops for existing and new SEP teacher leaders organized by the Sufficiency School Center, Foundation of Virtuous Youth (no registration fee required). Other additional approaches of development were also continually utilized. However, there were problems at PM1 and SC4, where the number of SEP teacher leaders reduced.

New principals at five schools (PM2, PM4, SC2, SP1, PS1) continued to develop existing SEP teacher leaders, through SEP workshops by the foundation. Other development methods included being external guest speakers, and assessors for the SEP school accreditation (PS1); and SEP training organized by the Educational District Authority (SP1). The second new SC2 principal sent the SEP teacher leaders to be part of the working group running workshops with the foundation, to do a study visit at external learning centers, and to be trainers for Educational District Authorities and external organizations.

There was also continual development of new SEP teacher leaders. Three schools continued to send their new SEP teacher leaders to be trained with the foundation (PM2, PM3, SC1). Other additional development approaches included buddies between the existing leaders and the new ones (SC3); the SEP leader for each subject area developing the new leaders (SC2); learning through participating in managing the SEP learning stations (PM4); and a study trip to the royal development centers

(SC1). PS1 appointed the heads of each class grade and the heads of each subject area to be new SEP teachers' leaders, whose skill was developed via presenting to external visitors who came to visit the school.

However, problems still persisted at PM1 and SC4, where the number of SEP teacher leaders dwindled. At PM1, there was development of new members by working with the SEP teacher leaders and other teachers. But this was not sufficient, since in the last 3–4 years, six (out of ten) teachers, who drove SEP in the school since the beginning, retired. At SC4, after the second new principal retired, some teacher leaders at the subject group level withdrew, since they were not truly interested in integrating SEP into the subject. Those staying were not truly leaders and were not participating in the activities of the SEP learning center.

In PM4, SC1, SC2, SC3, SC4, PS1, all teachers attended annual SEP development workshops, conducted by SEP teacher leaders. Other development channels included training with the Educational District Authority (PM3, SP1); training with the Foundation (SP1); and the second new principal encouraging all teachers to create innovations in SEP (SC2).

There was a variety of developmental approaches for new teachers. New PM3 and PM2 teachers attended workshops by the foundation or took students to the foundation's student camps. Other new teacher development approaches included training by SEP teacher leaders (SC2); workshops by the Educational District Authority (PM3); training by the SEP regional network (PM2); and existing teachers developing Knowledge Management and acting as role models and coaches (SP1).

5. Network expansion

In most cases, the new principals continued the school's relationship with the local community, with the exception of PM1 and PM2. The second new SC1 principal increased visits to the community, took teachers and students to do a study tour of community learning centers, and invited people with local wisdom to be trainers at the school. The third new SC4 principal established the new SEP subject for Grade seven and invited people with local wisdom to be trainers.

The new principals of six schools continued to expand the cultivation of the SEP mindset within the school network, especially increasing study tour visits from network members. There were also instances of the school principal and teachers being guest speakers (PM3, PM4, SC1, SC2, SC3, PS1) and assessors in the SEP in the education movement (SC1). An exceptional case was found with the third new SC4 principal, who developed members of the school's network in the district authority to be 100% SEP accredited. However, four new principals reduced the opening time for visits for various reasons. For example, the PM1 principal felt that the school's SEP learning stations were not ready. The PM4 principal lacked understanding of SEP at first, thinking that it was only an agricultural matter. The PM2 and SP1 principals followed the pressure of the ministry policy, such as requiring students to spend time preparing for exams.

In sum, the majority of the schools in the study sustained their key processes in cultivation of the SEP mindset in students, especially in the SEP curriculum process

and the personnel development process. This is partly because the schools in this research have been SELCs for a long time (eight schools since 2011, two schools since 2015). Therefore, SEP mindset cultivation may have become part of the school culture, especially among teachers. And this provided them with some immunity from negative change, especially when new principals interfered with the cultivation of the SEP mindset.

II. *Critical Success Factors influencing the sustainability of SEP mindset cultivation*

Two factors were common to all schools: (1) workshops/camps of SEP teacher leaders and student leaders by the Sufficiency Education Center, Foundation of Virtuous Youth; and (2) professional development activities for SEP teacher leaders.

Four factors influenced eight schools: (1) school principal training, (2) new teacher development, (3) Dissemination knowledge to other teachers, and (4) teacher collaboration.

Three factors influencing five schools were: (1) SEP student leaders, (2) the cooperation of all parties, including the school principal, teachers, students, and the community, and (3) the school principal having the correct understanding from previous positions with sufficiency-based schools. One interesting case of another success factor is at SC2, where the sustainability effort came from the Educational District Authority and the educational superintendent in terms of providing budget and public recognition.

6 Discussion and Conclusion

First, during the change of school principals, the majority of the interviewed schools still continued five key processes necessary for sustaining the cultivation of an SEP mindset. The only key process that was sustained at all schools was the integration of SEP into the curriculum. This might be because it could be carried out by teachers without additional budgeting, or support from school principals, since the SEP curriculum was already integrated in the daily work of the teachers. This is in line with the argument by Datnow and Stringfield (2000) that integrating change structures into the daily lives of the school community is important for the sustainability of school change.

In a few schools, key processes negatively affected by the change of the school principal were school management, SEP student development activities, and network expansion. School management was affected, especially in the areas of policy and budgeting. This is similar to the notion offered by Bambara et al. (2009), who suggested that factors negatively affecting the sustainability of change in schools include the policy and management system regarding time and resources used. Furthermore, the reduced SEP budget in turn negatively affected SEP student development activities (action/learning station-based), and network expansion (receiving visitors to SEP learning stations). These require funding to implement or maintain the relevant

physical environment. Professional development was the second least affected by the change of principals, because of the training support the foundation (no registration fee required) provided for SEP teacher leaders, who then could implement SEP, train, and coach the rest of the school. However, a few schools faced the loss of experienced SEP leaders due to staff turnover and retirement. This interfered with succession of teacher leadership.

Second, the first important key success factor was the implementation of the whole school approach, involving participation from key stakeholders. This finding supports the idea of Dharmapiya (2014) that the SEP movement in schools should incorporate SEP in all activities by all actors within the school. Sustainability requires the involvement and ability of the key school stakeholders (Giles and Hargreaves 2006). The focus on internal key stakeholders (teachers, students, principal) is also aligned with earlier SEP school research (Bunkua and Chinprahut 2014) and of Lambert's (2007) work, which stated that roles previously performed by only school principals should be delegated to others.

The findings here also highlight the importance of development/training of SEP teacher leaders, SEP student leaders, other teachers, new teachers, and new principals. This supports the argument that continuous learning and mutual support among colleagues is essential for the sustained cultivation of an SEP mindset within a school. A culture of professional development is established through constructive/collegial learning in the school and in its network (Goodson et al. 2006; Jacobson 2011; Bezzina 2006), and through teachers finding suitable leaders (Jacobson 2011). Importantly, these findings reinforce the argument that planning for the sustainability of a school's culture change needs to be part of the earlier stages, rather than only toward the end of program development (Fagen and Flay 2009).

One school managed to maintain its SEP culture thanks to the influence of the Educational District Authority and educational superintendents. This aligns with the findings of Datnow and Stringfield (2000), who suggest that efforts to implement sustained school reform are more likely to be effective when educators at various levels (i.e., state, district, reform design team, school, classroom, individual) share goals and work in concert. In addition, the support from Educational District Authorities and educational superintendents seemed to be more influential than other external stakeholder groups (i.e., parents, the local community). This might be because the school had to directly report to the Educational District Authority and educational superintendents. Furthermore, the institutionalized SEP school accreditation system at the Ministry of Education and the 2008 National Basic Education Core Curriculum (defining SEP characteristics as one of the aims of education), may foster the resilience of the program. In sum, sustainability should start from the inside, but external support, if gained or developed, can act as another level of safety-net for the sustainability of cultivating the SEP mindset. Therefore, most schools had the ability to maintain their culture of cultivating SEP amidst the unclear or unsupported policy from new school principals.

This might temporarily sustain the change while waiting for the new principal to develop the correct understanding from the annual development course/program of the Sufficiency School Center, Foundation of Virtuous Youth. This is also in line

with the argument by Lambert (2007) and Lohrmann et al. (2008), where external assistance may be required during the transition period. The schools continued SEP activities by themselves while waiting for the new principal, who may have implemented other policies initially and later came around to supporting SEP. Or in the worst case, temporary sustainability may be needed until the replacement of this principal with a new incumbent.

7 Implications for Policy

The current study leads to the following policy recommendations:

1. Selection criteria of new SELC principals should include knowledge, understanding and intent in supporting and driving SEP in educational institutions. New SELC principals should come from a school that is a SELC or Best-practice sufficiency-based school.
2. New principals of the SELCs and Best-practice sufficiency-based schools should attend the SEP Development Program, delivered by qualified trainers from the network of the SEP movement in education.
3. The Ministry of Education should provide training for SEP teacher leaders to drive SEP in educational institutions, especially on the topics of leadership and communication.
4. The Ministry of Education or relevant agencies should create self-study materials for school personnel regarding cultivating the SEP mindset in educational institutions and integrating SEP into lesson plans. This can be computer-based training, internet learning, video clips, and manuals in order to support the development of school principals, teacher leaders and teachers.
5. The Ministry of Education or relevant agencies should have a policy and conduct a reaccreditation assessment of SELCs.
6. The Ministry of Education should provide training to educate school superintendents in fostering SEP in educational institutions, by collaborating with qualified trainers from the network of the SEP movement in educational institutions. This is because it was found that many incoming superintendents did not have enough knowledge to continue this set of responsibilities.
7. Educational District Authorities should assign responsibility clearly to new school superintendents to support and encourage SEP in educational institutions, especially in the case of transfer or retirement of school superintendents.
8. Educational District Authorities should have key performance indicators in the process of driving SEP in educational institutions, to assess quality of schools in their own area.
9. The Ministry of Education or relevant agencies should support SEP regional networks, which coordinate among areas in order to support the network movement in that region. It is also useful to identify network members in that region who

are Subject Matter Experts in driving SEP in educational institutions in order to be a team of trainers and experts.

8 Managerial Implications

The managerial implications of this study of the sustainability of SELCs are:

1. SELCs and Best-practice sufficiency-based schools should do a forecasting analysis of retirements and personnel resignations, in order to have sufficient preparation for the development of new SEP teacher leaders.
2. SELCs and Best-practice sufficiency-based schools should organize a teacher development system in order for teachers to be able to apply the SEP in their daily lives. This will enable them to see results and have faith and effort to maintain the sustainability of the SEP mindset in their school amidst various changes that may happen.
3. SELCs should provide all teachers in the school with knowledge in order for each teacher to write a SEP-integrated lesson plan (at least one plan per teacher). Encouragement is needed for all teachers to link their curriculum plans to SEP learning stations/SEP student development activities.
4. SEP teacher leaders should try to practice SEP in their own lives and teaching, and see changing results in students. This is in order be able to gain credibility so they can confidently teach and coach other teachers in the school.
5. Sustainability resulting from the strong development of personnel within the school is truly sustainable. Based on our research, the origin of the development came from the Sufficiency School Center, Foundation of Virtuous Youth, which has continuously conducted principal/SEP teacher leader/student leaders training every year. But in order to increase self-reliance and true sustainability, networks of schools should have the ability to provide these programs for themselves, and be less dependent on the foundation.

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Recognizing Sustainability in a University Campus Through a Green Trail

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Abstract The Campus I of the University of Passo Fundo has historically been known for its diversified and lush green area, making it a leisure place for the community of Passo Fundo and region. This vegetation provides scenic spaces, allied to forest fragments with endangered species, representing a true living laboratory. Being used as didactic material by several courses and groups of the community, developing socio-cultural responsibility, valuing the natural environments and seeking for preservation toward sustainability. The objective of this work is to create a green trail project with the intention of instigate environmental education where the user can recognize the native, exotic and fruitful species found there. Carrying out the trail together with other sustainable approaches, in this case, the definition of a route for an internal bicycle lane on the campus and identification points of tree species, which have information boards and QR-codes for more information. Being the university an example of socio-cultural responsibility in the preservation and conservation of environments, providing the integration of experiences between teachers, students and the community, in teaching, research and extension. Encour-

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aging the construction of sustainable paths, it improves the quality of life of users, as well as the design towards sustainable development.

Keywords Environmental preservation · Sustainable development · Preservation areas · Green areas · Education

1 The University of Passo Fundo

The University of Passo Fundo (UPF) was founded in 1968, facing a reality, in that time, that higher education was not very popular in the interior of the state, and existed only in a few cities (Universidade de Passo Fundo 2019a). The migration process of the rural communities to the cities gave strength to a "search of alternatives that turned possible for young people to continue studying and contributed decisively to the development of the region" (Universidade de Passo Fundo 2019a). Because of this search, the University nowadays is made of, besides the Campus of this study, of other six *campi*, in the cities of Carazinho, Casca, Lagoa Vermelha, Palmeira das Missões, Soledade and Sarandi, what makes the importance of the University to the micro-region stronger.

As for its institutional conformation and planning, the foundation of the UPF was possible by the incorporation of existent higher education centers, but that did not follow a model of university organization (Guareschi 2001). The planning of the University initially began with a plan of a University City, with infrastructure for a residential and an education zone, but the plan was never materialized (Guareschi 2001). In addition, according to Guareschi (2001), part of the plan was incorporated to its consolidation, that began in the years of 1970.

Since back then, because of the impossibility of the plan execution, the University conformed itself as an educational space, but open to the community, as a big green area. In this area, the educational buildings are located, as well as Areas of Permanent Preservation (APPs) and green open spaces.

Since the implementation of the Campus I, in 1973, the planning of a physical expansion required focus on the planning of new buildings, the road system and the environmental preservation (Melo et al. 2018). The matter on the APPs was incorporated, where areas of big agricultural production were transformed in a big wooded area, which is considered an urban park, open to the use of the community. The Fig. 1 represents the environmental transformation of the area, made possible by this planning.

2 The University Areas of Permanent Preservation

According to Freitas et al. (2013), "the Areas of Permanent Preservation (APP) have an environmental function of preserving the natural resources, biodiversity, the genic flow of fauna and flora, the soil and the well-being of the population",

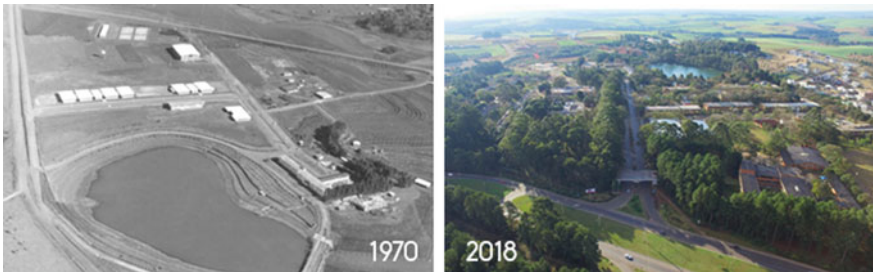

Fig. 1 Transformation of the agricultural production área to a big wooded área

usually they are located in water course areas, terrains with declivity higher than 45° and on the top of hills (Freitas et al. 2013). Brazilian law classifies the APPs as a "protected area, covered or not by native vegetation, with the environmental function of preserving water resources, the landscape, geological stability and biodiversity, easing the genic flow of the fauna and flora, protecting the soil and guarantee the wellbeing of the human population", being a very similar description to the previous cited. The preservation of these areas guarantees that future generations might enjoy their environmental in general.

Brazilian reality on APPs is complicated, because, according to Freitas et al. (2013), even though the areas are legally protected, the farming occupation and urban expansion go through them. That is why it is so important that Campus I is preserved. Beyond the environmental question, studies show that "human beings evolved in natural environments and developed an innate tendency to respond positively to natural settings" (Wilson 1984, 1999 apud Carrus et al. 2015), besides the "psychological restoration, as conceived by different authors in terms of stress reduction (Ulrich et al. 1991 apud Carrus et al. 2015) and recovery of directed attention (Kaplan and Kaplan 1989 apud Carrus et al. 2015)".

University of Passo Fundo's Campus I is characterized by the Fig. 2, where the educational buildings blocks are located, highlighting the identification of the buildings by the blocks, as well as the vegetation masses and other green areas.

The study area, in the Campus I, includes five wooded areas and lakes located according to Fig. 3, highlighting blocks K, L, Q, M and P, where the APPs are located. Besides the areas with bigger green density, it is observed that the afforestation of the road system contributes for the formation of several green corridors, connecting the areas in question. The species that occur mostly are Eucalyptus, Cypress, Purple Ipê, Yellow Ipê, Araucaria, Canafistula, Pinus, Grevillea, Tipuana, Japan Grape, Cedar e Jacaranda. The extinction threatened Corticeira, Araucaria, Açucará and Xaxim (Melo et al. 2018) stand out. Although considering the current preoccupations around the exotic species invasion in natural habitats, "identifying the ecological determinants that make environments more or less invasive is crucial for predicting the spatial distribution of exotic species and managing biodiversity conservation. It is also of fundamental importance the understanding constraints on and factors supporting biodiversity" (Peng et al. 2019). Thus, it is necessary that, in habitats where

Fig. 2 Illustrated volumetric map of the UPF. *Source* Universidade de Passo Fundo (2019b)

Fig. 3 Map standing out the study perimeter and the interest green areas. *Source* Authors (2019)

this situation occurs, the situation must be managed to guarantee the perpetuation of biodiversity. Peng et al. (2019) declares that the relation between the number of native and exotic species are negative at smaller sizes, and positive at bigger sizes. Thus, it is interesting to highlight that, according to Fuller et al. (2007) *apud* Carrus et al. (2015), biodiversity increases the psychological benefits associated to "the green experience".

This way, the importance of the area is strengthened, creating a natural scenery that allows users to enjoy an ambient with native and exotic species, with an improved microclimate and green connections among the buildings.

It is possible to conclude that, beyond the social role of the Campus, the coexistence of distinct species demonstrates the importance of collective work among culture, history and biodiversity.

3 The Use of Campus I as a Study Object

The UPF Campus I's flora has been monitored since 2012 by studies that analyze the species and their growth, cataloging them as native or exotic species, highlighting the ones that are threatened of extinction. This study produces a monitoring report, made by the own University, and is kept as a data source. These studies are coordinated inside the University, by investigation projects that involves teachers and students from different courses. The study and cataloging allows the University to function as a living laboratory and a unique source of data, because it allows the understanding of the functioning of a whole living system, like as the existent in the APPs.

These studies form a data source, this way, beyond the monitoring of the species, it is also sought to understand the relation between users and the environment, by interviews and surveys.

Further than the studies for data collection, the University also encourages the creation of projects that seek for alternative and sustainable solutions, for example, the mobility question. The ideas contest from the Architecture course of the UPF called "*Desafio das 8 Horas* (DA8)" (8 h challenge), in 2015. Its proposal was to create a cycling system, that would connect the original complex of the Engineering and Architecture Faculty (FEAR) to the new building. Which, if implemented, "would serve as a pilot plan to a whole cycling system, that would reached all the campus, focusing the efficient and zero emissive transport, that is possible by the bicycle" (Melo et al. 2016).

The University also publishes weekly an informative of the existent vegetation species in the Campus on their social network, with the intention of democratizing the information for all the community that accesses Facebook, by a spreading project called "*Árvores UPF*" (UPF Trees) (Facebook 2019). There are informations around the popular name, scientific name, photos, flowering, fruiting, ecological importance, family, origin and uses. The publication of this material is possible by the existence of the project "*Preservação Sustentabilidade da Vegetação Arbórea*" (Preservation

and Sustainability of the Tree Vegetation", that cataloged the species in the campus, also developed in the University.

The application of a survey around the users "knowledge on green areas", allowed to state that, although the main part of the interviewed knew how to recognize and see the difference between a native or exotic species, 62% of the participants could not cite an endangered of extinction species. The trail would act in the educational field, making popular the information of the species and highlighting the importance of the preservation.

It is shown that 75% of the users prefer green areas to non-vegetation areas (6%), and 18% prefer the mixed areas. Besides that, 98% of the interviewed think that vegetation brings health benefits and promote sensations such as wellbeing, air quality, calm, tranquility, comfort, equilibrium and self-esteem. As for the participants of the ecological trail, 97% of the interviewed believe that, because of the trail they would get more knowledge, improving their academic formation. Because of that, it is perceived the demand of environmental education actions.

The existence of forest fragments areas inside the Campus encouraged the ecological trail project, with the objective of taking actions of environmental education, giving to the participants several experiences of living with different vegetation spaces, allowing biodiversity and stimulating the users to get to know the many native, exotic, fruitful species found there, besides, developing sociocultural responsibility, enriching the natural environments and seeking their preservation.

4 The Trail Proposal

Considering the fact that the UPF's Campus I is known by its lush green area, the studies of a trail proposal began, encouraging environmental education and creating, this way, a direct way of relating the community to these green areas, in a conscious manner and seeking sustainability through two different trails showed at the Fig. 4.

Planning a trail should take into account various social and infrastructure aspects of the site, be carefully located, constructed and managed in a way that allows the conservation of natural resources and the maintenance of contacts with nature. According to Lechner (2006), these aspects include elements such as landscape, cultural and educational opportunities, access to areas for hiking, camping, and support to management activities. Regarding local infrastructure, some restrictions should be considered with environmental zoning, visitor safety, presence of rare or threatened species, fragility of the ecosystem and evaluation of its impacts.

In this context, a proposal was made for an educational trail for the central area of Campus I of the University of Passo Fundo with the possibility of involving students, teachers and the local and regional community, since the use of the university area is also considered by users as an Urban Park.

Therefore the starting point is in the central area at the "Meeting Point" (73% of the interviewed cited it as an important place) with an explanation of the activity in a panel and board, where a short and long track is presented. In this way, the user can find

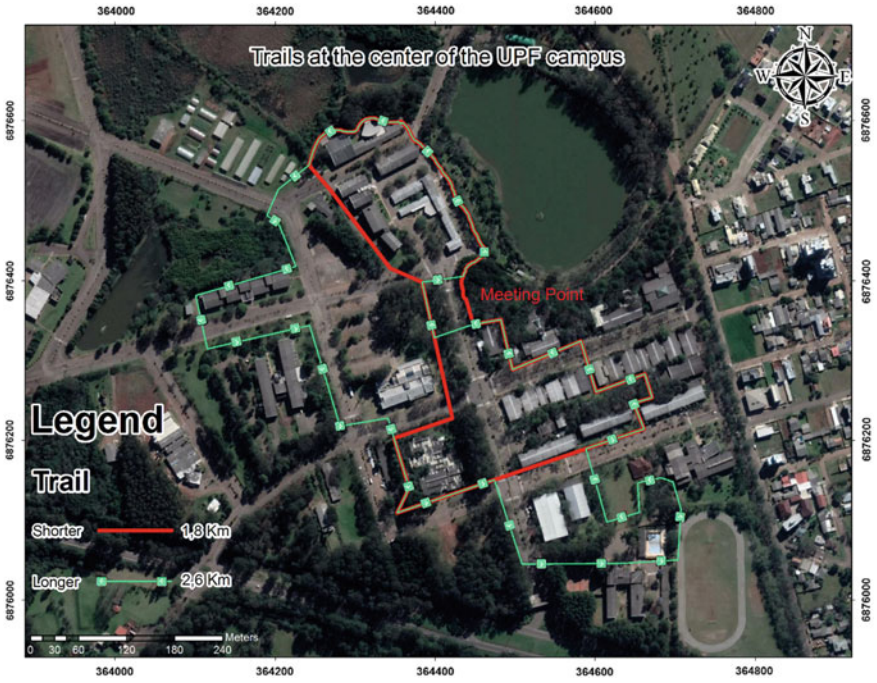

Fig. 4 Trails proposal at the center of UPF Campus I. *Source* Authors (2019)

different environments, with native and exotic vegetation, paved areas, lawns, woods, wetlands area and lakes, including passing through an area of permanent preservation. The trail can be accompanied by a monitor or made individually following the signs with the identification of the tree species on the panel and can be accessed for more details through a QR-code, as seen as on Fig. 5.

The presentation of the trail begins with a native species threatened with extinction, following an exotic one with a wide canopy, continues along the Ipês road, having as a stopover point the area of contemplation and spirituality. It follows to another block where there is a forest between the buildings with diverse species, soon it passes to the block of the library where the araucarias forest can be identified along with exotic alimentary and ornamental species, following to the center of acquaintanceship where the population uses as an area of leisure, with a large garden predominating species of great size, allowing to visualize the surroundings under a shaded, but open area. You can continue through the native fruit forest, arriving in a area of permanent preservation with wetland and a reforestation of araucaria through the lake area, a former zoo, and returning to the central area.

As for the longer trail there is the possibility of passing through other buildings and sports area finding a greater diversity of environments with trees in different stages of development, as well as the connection with the areas of permanent preservation.

Fig. 5 Explanation board and QR-code panel present around the trails. *Source* Authors (2019), Facebook (2019)

The trails are an important means of contact of the man with the natural environments, proving to be a viable alternative to make environmental education in a sustainable way and stimulate the human sensibility, allowing the preservation of the natural environment. Several authors refer to the use of ecological trails as a way to promote pedagogical activities in the diffusion and practices of environmental education as a tool to change paradigms in benefits to the use of natural resources (Carvalho and Boçón 2004). (Silva and Figueiredo 2011; Eisenlohr et al. 2013; SILVA et al. 2016).

Ecological trails constitute adequate spaces for the practice of environmental education programs (Eisenlohr et al. 2013). Environmental education programs.

According to Eisenlohr et al. (2013) the ecological trails are suitable places to practice Environmental Education programs. Where educational actions should contemplate the whole universe of academics, from the undergraduate to elementary and fundamental levels, with the proposal of promoting moments of reflection and behavior change over the respect and value of the natural environment regarding the perspective of inserting and applying the sustainable development objectives (SDO) by disseminating knowledge.

5 Conclusions

By evaluating the importance of the University of Passo Fundo to the development of the region and the positive impact of its physical space on the local microclimate, generating objects of environmental studies, besides the exploitation of the space as a leisure area by the community, it is perceived that the valorization of the area relates directly to its importance.

The Campus I vegetation meets an important role in the cultural, educational and historical rescue, as well as in the transition from the natural to the built environment.

The green areas and their use as an urban park strengthen the valorization of the Campus.

Idealizing the trail means to reinforce the relationship between man and nature. Besides that, it allows interaction between biodiversity and environmental preservation, and, moreover, transmitting environmental education, a very important factor in the awareness of the population around environmental matters. The University has its sociocultural role again represented, once the trail allow the contact among teachers, students and the community.

Through the teach, research and extension, it is possible to integrate an active learning with social responsibility and environment, by encouraging the construction of sustainable paths, improving the users quality of life, as well allowing the development of the design towards sustainability.

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The 2030 Agenda for Sustainable Development in Brazil's Government: An Exploratory Approach

Teresa Villac and Maria Cecília Loschiavo dos Santos

Abstract This paper analyzes the initiatives devised by the Brazilian Government directed at the implementation of the 2030 Agenda for Sustainable Development. The National Commission for the Sustainable Development Goals was created to internalize, disseminate and give transparency to the process of implementation of the 2030 Agenda in Brazil. It is an exploratory study that examines the aims, principles, composition and actions of the National Commission. The purpose of the paper is to present the adequacy of the global goals in relation to the national reality and to reinforce the importance of the 2030 Agenda for the Brazilian society.

Keyword 2030 Agenda for sustainable development · Brazil's government

1 Introduction: The 2030 Agenda for Sustainable Development and the Brazilian Government

This paper analyzes the initiatives devised by the Brazilian Government directed at the domestic implementation of the 2030 Agenda—Sustainable Development Goals (SDGs), through the work carried out by the National Commission for the Sustainable Development Goals, established in 2016.

The relevance of the topic stems from the fact that SDGs are still not widely disseminated in Brazil and have in themselves a considerable potential for altering the Brazilian development model, historically focused on economic growth (Veiga 2015), insofar as the 17 goals brought by the 2030 Agenda can guide the formulation and achievement of national public policies more in line with the principles and rights set forth in the Brazilian Federal Constitution of 1988, such as the right to a healthy environment, to dignity, education, health, among others.

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Indeed, regarding environmental and social issues, a country's high gross domestic product does not ensure the absence of damage to nature in its territory, the full enjoyment of the right to health and an adequate living standard with fundamental human rights for all. The Sustainable Development Goals alter the structuring logic of the national economic system and are fundamental to guarantee a concept of development more in consonance with the republican principles and environmental ethics.

This is, thus, an exploratory study (Yin 2015), based on secondary data, and presents a critical analysis of the initiatives adopted by the Brazilian Government regarding the domestic implementation of the Sustainable Development Goals. In this context, the relevance of ecological citizenship for the effectiveness of this national public policy will be highlighted. Among the possibilities of domestic action to implement the SDGs (actions carried out by the business sector, states and municipalities or organized collectivities, among others), this research focuses on the role of the Brazilian Federal Government as the driving force behind the establishment of new paradigms for the dissemination of the SDGs throughout the Brazilian territory, engaging different social actors, through public policies.

2 The National Commission for the Sustainable Development Goals

Based on the delegation of powers by the Federal Constitution, a National Commission for the Sustainable Development Goals was established by the Presidency of the Republic (Decree 8,892/2016).

The Commission has three aims: to internalize, disseminate and give transparency to the implementation process of the 2030 Agenda in Brazil. This triple objective demonstrates the importance conferred by the Decree to social participation and to the republican and democratic ideals in the formulation of this public policy at the national level.

Its integration into the structure of the Secretariat of Government of the Presidency of the Republic denotes the relevance accorded to the Commission, which is co-chaired by its members in equal representation, has an advisory nature, and whose premises are: coordination, mobilization and dialogue among Brazilian federal entities, as well as with the civil society. Its competencies are broad, beginning with the elaboration of a public policy for the domestic implementation of the Sustainable Development Goals in Brazil, followed by its monitoring and its evaluation. The latter, although not expressly outlined in the above-mentioned Decree, is an inexorable premise for the effectiveness of the Commission's initiatives.

There is also a provision calling for the formulation of inputs for sustainable development discussions in national and international forums, which allows for the interpretation that the academic and scientific sectors should also be involved. The expansion of the governmental dialogue with the academia stands out as salutary

and necessary, providing outflow and concreteness to the social function of scientific knowledge (Bourdieu 2004) to the benefit of society and the environment, from a non-hermetic and segmented perspective which can enable a greater exchange between diverse fields of knowledge and the Brazilian public administration.

Similarly, by means of civic political action, collectively organized, civil society must act to engage the Commission in active listening (Carvalho 2004), in the construction of knowledge, and in the definition of priorities, courses of action and its corresponding implementation plans, that are socially responsive and in consonance with the Brazilian constitutional ideology.

In this sense, it should be noted that the Federal Constitution of 1988 sets forth fundamentals and principles that should stand as the foundation and guide of national public policies, in addition to being in keeping with the Sustainable Development Goals. We draw attention to the values contained in the Constitution: citizenship, the dignity of the human person; the social value of work and free enterprise; political pluralism; the creation of a free, fair and supportive society; national development, eradication of poverty and marginalization, reduction of social and regional inequalities, promotion of the common good, without prejudice.

In examining the Commission's governance model, six out of the sixteen members belong to the federal public administration, while eight are representatives of civil society. The Commission includes one representative from the Secretariat of Government of the Presidency of the Republic; one from the Office of the Chief of Staff of the Presidency of the Republic; one representative from each of the following Ministries: Foreign Affairs; Social and Agricultural Development; Planning, Development and Management; and Environment; one representative of the state and district levels of government; one of the municipal level of government, and eight representatives of civil society.

Representatives from civil society and from states and municipalities were selected through public notices, with the collaboration of a panel of specialists in sustainable development, for a two-year term.

Permanent technical advice from the Institute of Applied Economic Research (IPEA) and the Brazilian Institute of Geography and Statistics (IBGE) is also contemplated.

The state and municipal representatives are collective entities, namely the Brazilian Association of State Entities for the Environment (Abema) and the National Confederation of Municipalities (CNM). Representatives of civil society are divided into four non-profit associations: Brazilian Institute for Quality and Productivity (IBPQ), General Union of Workers (UGT), World Vision, and the Abrinq Foundation for the Rights of Children and Adolescents (Fundação Abrinq), two institutions encompassing teaching, research and extension programs: the National Association of Directors of Federal Institutions of Higher Education (Andifes) and the Brazilian Academy of Sciences (ABC), and two representatives of the productive sector: the National Confederation of Industry (CNI), Ethos Institute of Business and Social Responsibility (Ethos).

Considering research conducted by IBOPE (CNODS 2018), 49% of respondents never heard about the Sustainable Development Goals; 38% have heard about the

concept but are unaware of its meaning; 10% have some knowledge on the subject, and only 1% have enough knowledge on the subject. The challenges are, therefore, immense.

In this sense, the Commission structured its actions into two thematic axes: communication actions and mobilization actions. The first axis involves the dissemination of SGDs nationally, while the second focuses on raising awareness among public managers, leaders, and civil society organizations.

In addition, the following lines of action were established:

a. Launching of a Plan of Action by the National Commission for the SDGs;
b. Mapping of the relationship between the public policies currently in effect in the Ministries and the 2016-2019 Multi-Year Plan with the SDGs;
c. The adequacy of the global goals in relation to the national reality;
d. Definition of national SDGs indicators;
e. Development of tools/platform for dissemination of SDGs;
f. Processes and initiatives for the internalization/localization of the 2030 Agenda throughout the national territory.

The lines of action defined by the Commission are of great magnitude, not only in terms of the broadness of their scope, but also regarding the still predominant unawareness of the issue in Brazil, the territorial extension of the country, regional, economic and social diversities, imbalances between urban and rural areas, as well as the national political organization of a federative nature.

3 Challenges to the Implementation of SDGs in Brazil

The conformation of civil society in organizations and collectives geared towards environmental preservation (SOS Mata Atlântica Foundation, Socio-Environmental Institute—ISA), and the unprecedented recognition in the Brazilian Constitution of 1988 that environmental preservation is a right to all and a duty to the State, together with the existence of a Ministry for the Environment,—which institutionalized the topic in the federal government sphere—, were fundamental actions for the gradual constitution, in the social body, of new ethical values with respect to the predatory relationship man-nature (dos Santos 2014).

In this context, the breadth of themes addressed in the SDGs is a very positive factor towards the continuation of the dissemination of ecological awareness to a greater social extent and in the public and private sectors of Brazil. The implementation of the SDGs cannot be disconnected from the provision of the necessary minimum structure to the public environmental oversight agencies, strict environmental legislation for damages to the environment, as well as coordinated efforts between the municipal, state and federal levels, avoiding a retrogression of rights.

Towards this objective, including the Sustainable Development Goals as a subject in programs of undergraduate and graduate studies of different fields of knowledge, as well as the dissemination of the topic in academic researches, in an interdisciplinary

approach, will contribute to community strengthening of SDGs in Brazilian society and public governmental policies.

Our study aimed to encourage this debate and reinforce the importance of the diffusion of the subject SDGs in Brazil and, as future studies, will be deepen the aspects related to implementation of this public policy by federal government, by constituting research groups, debates, forums and academic researches.

It is a long process, one that demands planning, structured actions, budget provision, social monitoring and civic participation. The core, it seems to us, is the assumption of environmental ethics as a structuring paradigm of the actions carried out by the Brazilian public and private sectors and academic contributions.

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School of Nature Conservation: An Experience in Education for the Sustainable Development of the Northern Coast of the State of Paraná, Brazil

Solange Regina Latenek dos Santos, Liz Buck Silva, Ricardo Aguiar Borges and Eloy Fassi Casagrande

Abstract Originally, the Atlantic Forest Biome occupied an area of 130,973,638 hectares, equivalent to about 15% of the Brazilian territory. Due to the exploratory development in the country, there are only 7% remaining of this vegetation, which still suffers from degradation. In this context, inserted in one of the last continuous remnants of Mata Atlântica, are the municipalities of the north coast of Paraná, inhabited by thousands of people. The existence of protected areas in the region (Conservation Units) and the desire for territorial development are sometimes seen as antagonistic and generate conflicts of interest and paralysis of actions. This article brings some results from the School of Nature Conservation, an experience developed with young residents of the region in order to build a network of actors to promote the dialogue between nature conservation and sustainable development. The document describes the context of local conflicts and the immersion-based educational methodology in Conservation Units used by the project to mobilize the community, researchers and managers of conservation units for dialogue and the collective construction of a map of wealth that promotes the sustainable development for the region, taking into account cultural and environmental demands.

Keywords Environmental education · Conservation units · Sustainable development

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1 Introduction

The Atlantic Forest is one of the richest forests in diversity of species on the planet, and this biome covers an area of about 15% of the total national territory, where about 70% of the Brazilian population lives. Today, only 12.4% of the forest that originally existed still exists, and of these remnants 80% are in private areas (SOS MATA ATLÂNTICA 2019).

The ecosystems that make up the Atlantic Forest biome play a very important role in maintaining and balancing for all forms of life that inhabit them, including humans, who benefit directly from water supply, fertile soil, food pollination, medicines, whether comfort, protection against extreme events, the provision of resources and the generation of urban resilience, which fosters development. However, for these benefits to be provided, natural areas in good repair are necessary.

In a report on this subject, the Gazeta do Povo newspaper stresses that "Every May, when the Atlantic Forest Day is celebrated, Paraná appears in the not-so-honorable ranking of states that devastate what is left of this type of native forest. Every year, positions take turns - Bahia and Minas Gerais alternate the front—but Parana always shows its presence, as in the most recent Atlas of Remnants, where it is in the third position. Currently, Paraná is the one that mostly overthrew Atlantic Forest in Brazil" (Gazeta do Povo 2019).

The United Nations declaration on Agenda 2030 for Sustainable Development states in its paragraph 33 that the new agenda recognizes that economic and social development depends on the sustainable management of our planet's natural resources, deciding to conserve and sustainably use the oceans and seas, freshwater resources, as well as forests, mountains and arid lands and protect biodiversity, ecosystems and wildlife (United Nations in Brazil 2015).

These data illustrate the importance of the biome for the maintenance of life and, at the same time, how nature conservation has been neglected in recent decades by some sectors of society. Traditional development based on deforestation of native forests, conventional agriculture that poisons soil and food, settling large enterprises that disrespect nature and culture, pollution and burial of water springs, still generates many expectations of growth at any costs, or immediate solution to the Brazilian social illness.

In an attempt to ensure a minimum genetic bank and the benefits generated by nature to maintain quality of life, the creation of Conservation Units through governmental or private initiatives has been an attempt to curb deforestation and its consequences by legislating on some of the remaining of Mata Atlântica that remained in the state of Paraná. However, the implantation of protected areas is cited by plots of politicians, community leaders and residents of the most preserved regions of the biome as impediments to traditional development, due to restrictions of land use and occupation. On the other hand, historical lack of effective community participation in the planning and implementation of different categories of Conservation Units in Brazil fuels rumors, concerns and animosities in the territory, generating

conflicts that are perpetuated even in the present, when community participation is more effective, but still carries impressions of the past.

A protected area, when it is created, cannot be thought of as an island isolated from the rest of society or from the rest of the territory, since the creation of a CU has effects not only for the environmental and natural dimension, but also for the economic dimension, social, demographic and cultural aspects of a given region (Marinelli et al. 2011).

Studies carried out by the Society for Wildlife Research and Environmental Education (SPVS) in the Guaraqueçaba Environmental Protection Area (APA), visiting one thousand households, pointed out important factors that motivated the elaboration of the initiative described in this article. Among the results pointed out by the reports of this NGO with more than thirty years of uninterrupted action, the last twenty in the APA of Guaraqueçaba, stand out the lack of knowledge about nature conservation, more specifically about the operation and purposes of Conservation Units and of research involving biodiversity. At the same time, the data showed great concern among families regarding the generation of regional opportunities and training for young resident people.

The School of Nature Conservation initiative is based on the public use of Conservation Units (CU) on the northern coast of the state of Paraná, based on theoretical and practical training in the form of immersions in the Atlantic Forest for young residents of the region, aiming to promote knowledge and the dialogue between communities, researchers, managers of conservation units and the Public Power for the conservation of nature and caiçara culture, mitigating conflicts and seeking collective solutions for sustainable development.

2 Methodology

The methodology of this initiative was developed by the Society for Wildlife Research and Environmental Education (SPVS) with the support of the Boticário Group for the Protection of Nature Foundation (FGB). The development of the methodology sought to meet the goals to transform our world encouraged by the United Nations in Brazil, especially those focused on Quality Education, Drinking Water and Sanitation, Decent Work and Economic Growth, Sustainable Cities and Communities, Responsible Consumption and Production, Action against Global Climate Change, Life in Water and Earth Life.

Using satellite images and the ArcGiz software, the limits of the Natural Reserves of the Natural Heritage (RPPN) of Águas and Guaricica, as well as the Biological Reserve (ReBio) Bom Jesus, Conservation Units located in the rural area of the municipality of Antonina, Paraná. Using the ArcGiz geoprocessing tool, it was possible to identify the communities located directly in the vicinity of these reserves, and to undergo a personal visit to each one of them to identify families with young people from the age of fourteen who were invited to attend on a specific date with

transportation support to get to know more deeply the initiative previously explained during the visit, and then register to participate in the training.

Of the fifty-two young guests, forty-seven came on the appointed day and made their entries to participate in the formations, which were offered intensively over the next five saturdays. At the time of enrollment, the initial indicators were collected from the application of personal questionnaires, previously tested in a pilot group. The questionnaires were elaborated in order to investigate the environmental perception about ecosystem services and previous knowledge about conservation of nature and conservation units, so that it could be compared later with indicators collected in the same way at the end of each module of the formations.

The modules took place within the Conservation Units of the region, prioritizing immersion in protected areas and living with the people who work as researchers, inspectors and managers. This action was thus determined to meet the demand pointed out by surrounding communities in relation to promoting the transparency of management actions and management of reserves.

The modules of the formations were chosen to bring elucidation and knowledge about the themes related to nature conservation and sustainable development, as well as for young people to know the possibilities of study and related work. The methodology of the classes was theoretical-practical, previously planned and executed by specialists in the areas. Physical structures and research equipment already installed in reserves such as auditoriums, trails, carbon measurement plots, ecological restoration areas, native seedlings nurseries, trap cameras, bird monitoring equipment, GPS, projector and computers were used in the development of modules that addressed:

- Conservation of Nature: concepts, importance, confronted problems, society-nature relationship, climate change, Brazilian environmental legislation, National System of Conservation Units (SNUC).
- Atlantic Forest Fauna: main species, identification, relationships with the forest, threats, traditional knowledge, monitoring methods and research carried out in the region.
- Flora of the Atlantic Forest: main species, traditional knowledge, identification, relationships with the fauna, indices of deforestation and ecological restoration projects carried out in the region.
- Sustainable Development: concepts, reflections on traditional development and local opportunities for sustainable development, production of nature, regional entrepreneurship, Agenda 2030, life plan and mapping of natural and cultural wealth.
- Boarded Lesson: Navigation through the bay with landscape analysis and application of the knowledge acquired for the development of the “17 objectives to transform our world”, visit to the conservation project of the purple-headed parrot for nests monitoring and conversation with researchers and community involved with the project on Rasa Island, Guaraqueçaba, Paraná.

During the training sessions, students were able to exchange experiences with each other and with experienced researchers in the region on the landscape, Brazilian environmental legislation, biodiversity and local culture, as well as on regional

entrepreneurship and opportunities for sustainable development, taking into account the potential of the Atlantic Forest and Protected Areas in all spheres. They were also able to meet and follow the work of the managers of the Conservation Units of the Northern Coast of Paraná and other collaborators who work in the area, besides living with researchers and their research. The lectures, workshops and experiences in natural areas took place in Conservation Units, where space provides the necessary environment for immersion in Nature Conservation, such as trails and other equipment, providing contact with preserved areas, experiences of restoration of degraded environments, installed researches and people working in the environmental area.

After each of the modules, the students had one week to run local research on the topic and to develop a practical activity, the results of which were shared at the beginning of the next lesson, when impact indicators were collected. Six months after the completion of the modules, the students were interviewed and the impact of the initiative in relation to the perception about nature conservation, the look on the territory and the possibilities of sustainable development were again evaluated.

3 Results

The forty-seven young residents of the rural area of Antonina, Paraná, who enrolled participated in the theoretical-practical training until the end, making a total of forty-four hours of course. These students have shown that they do not want to leave the area when they finish their studies because they are very attached to their family and friends. They also showed that they are not interested in extractive activities and do not practice hunting, although they report that the practice was carried out in the past by some member of the family in 20% of cases.

It was observed that, before the formations, the public was unaware of the definition and purpose of the Conservation Units of the region, especially in the case of the RPPN category, which, because it is managed in a particular way, generates even more doubts in the direct environment. The general idea about a "fenced area to let the bush grow, where human presence is forbidden" prevailed among the participants in the initiative. The expression "nature conservation" was associated mainly with prohibitions, with direct benefits only for the protected of fauna and flora, without positive impacts to society.

Initial indicators also led to non-recognition of regional scenic beauties, since projected local images were attributed to other states or countries, as well as the lack of knowledge of ecosystemic services generated by protected natural areas, such as water consumed by the communities and its relation with the conserved forest.

After the training, the indicators brought an 80% increase in knowledge about nature conservation and the consequent inclusion of the theme in the community's choices, especially in a way related to sustainable development. This fact also appeared in the voluntary organization of groups engaged in the organization of the public use of hitherto unmanaged tourist spots for nature conservation and local development. Indicators presented a 40% increase in knowledge related to native

fauna and a 100% increase in knowledge related to how their monitoring is carried out. As for the native flora, there was a 60% increase in knowledge related to the Ombrophylous Dense Forest ecosystem and 80% related to ecological restoration, carbon stocks and climate change. These issues raised a lot of interest in the students about the benefits generated by the forests for the communities and the local work opportunities related to the production of native seedlings for restoration and meliponicultura, which generated two other workshops later offered in partnership with universities and community.

Increased knowledge about the characteristics of biodiversity, climate and local landscape was one of the focus of formations, promoting affection and belonging, to strengthen the desire for sustainable territorial development, when this knowledge is taken into consideration by the communities in their choices.

Triggered over life planning and regional entrepreneurship, 90% of young people stated that they had their sight modified about the landscape and that they can now visualize local opportunities and development from the nature conservation, involving tourism, outdoor sports, willingness to contemplate the nature and enjoyment of these spaces, the desire to undertake in a sustainable way in the region in adult life, the desire to continue studies in different areas such as photography, design, engineering, education and biology for the conservation of the natural spaces of the coastal region. Five local young residents gave immediate continuity to their studies within the environmental area, while ten of them had opportunities for internships related to the environment in the region for having taken the course.

Promoting immersion in conservation units and dialogue among all local actors has improved relationships, promoted the formation of a network for sustainable development and reduced conflicts between nature conservation and development.

4 Conclusions

Depletion of natural resources and the negative impacts of environmental degradation, including desertification, droughts, land degradation, fresh water shortages and biodiversity loss add to and exacerbate the list of challenges facing humanity. Climate change is one of the greatest challenges of our time and its negative effects undermine the ability of all countries to achieve sustainable development (United Nations in Brazil 2015).

The creation and management of protected areas are essential tools to safeguard biodiversity and quality of life, with the participation of communities at all stages of the process so that there is no conflict and the sustainable development of the region is contemplated, benefiting mainly the environment of the Conservation Units.

The study carried out by Gurgel (2009) demonstrates that the great majority of land use and the exploitation of natural resources allowed in Brazilian Conservation Units predicts and potentiates activities that contribute to the generation of income, employment, increase of quality of life and development of the country, without prej-

udice to environmental conservation, stating that the conflict exists only in relation to the pseudodevelopment based on exhaustion of natural resources.

For example, in the case of Esteros de Iberá—Argentina (Jimenez 2018), analyzing situations of conflict between territorial development and similar nature conservation in other parts of the world, it is observed that the use of education actions aimed at the conservation of nature and cultural value of a given territory bring opportunities to local communities, considering that the existence of protected natural areas, occurrence of rare species, restoration actions and ecotourism can be propellers of sustainable development, thus allying conservation with economic growth and improvement in quality of life.

The Nature Conservation School as conceived is an initiative that proves that education and opportunities for dialogue and exchange of knowledge are essential to create spaces for the collective planning of sustainable development for the benefit of all.

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University and Community Engagement: Toward Transformational Sustainability-Focused Problem Solving

Hock Lye Koh and Su Yean Teh

Abstract University community partnership is a key to sustainability. Anthropogenic activities coupled with natural hazards, environmental degradation and climatic shocks can generate local risks and undermine community resilience, well-being and sustainability. As an important element in sustainability, communities should be educated about the impacts of natural and anthropogenic hazards and be prepared to mitigate or adapt to these hazards and risks. University should devise curricular and pedagogy to deliver sustainability learning outcomes (SLOs) to serve the society. Universities play two important roles: (1) Equip students and educators with SLO-based sustainability competences and capability (SCC) and (2) Educate the public on mitigation and adaptation concepts and measures. These SLO and SCC enable university to effectively connect with community to empower the attainment of the United Nations' Sustainable Development Goals. Universities have the unique characteristics, infrastructures and social responsibility to transform university community towards true sustainability through problem-based, solution-oriented and action-motivated projects. This paper advocates strong university community partnership based upon experimental pathways empowered by SLO and SCC. The connectivity between the three pillars of sustainability, i.e. environment, economics and society is illustrated by case studies aimed to support community employment opportunity (SDG8) and to promote social inclusiveness (SDG11), while conserving the environment and water (SDG6). It presents examples, experiences and aspirations on strengthening beneficial partnerships (SDG17). The goal is to empower climate change mitigation and adaptation (SDG13) including the preservation of coastal resources such as mangroves (SDG14, SDG15), through quality education and research (SDG4).

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1 Introduction

Sustainability is a rapidly evolving concept in higher education institutes (HEIs). Facing a steep learning curve, sustainability in higher education (SHE) is a long arduous process that requires perseverance, creativity and innovation. The establishment of the European School of Sustainability Science and Research (ESSSR) and the Association for the Advancement of Sustainability in Higher Education (AASHE) is a good indicator of this emerging trend. ESSSR and AASHE, in conjunction with the International Journal of Sustainability in Higher Education (IJSHE), have provided valuable information and deep insights on the development of SHE worldwide, helping to enhance sustainability in higher education and sustainability in general. HEIs play a particularly important role in Education for Sustainable Development (ESD). They prepare the students for employment and more importantly, they prepare the students for a future that is still unknown. Therefore, it is crucial for HEIs to provide deep learning experiences that develop *critical thinking, problem solving, creativity and innovation skills, collaboration skills, contextual learning skills, self-direction, as well as communication skills* (Iliško et al. 2014, p. 100). For the students to develop such skills, HEIs need to create an environment in which the action, challenges and opportunities based on real-life interactions are present. This implies that higher education (HE) must go beyond the confinement of traditional lecture rooms and into the community (Leal Filho and Pace 2016). This paper advocates strong university-community partnership to promote sustainability in public and in HEIs. It is essential for HEIs to have a clear vision of SHE and a workable mission on how to achieve this by unambiguously defining their sustainability learning outcomes (SLOs) (Hill and Wang 2018). These SLOs must be supported by viable SLO-based competences and capability (SCC) that HEIs develop among their students and educators via effective curricular and pedagogy. Some HEIs, such as the University of Vermont (UVM), adopt a model in which SLO is a university-wide requirement. However, most HEIs, such as Universiti Sains Malaysia (USM), are not yet ready to embark on this ambitious goal. Instead, a "second-best" alternative model is adopted in which SLO elements and SCC can be embedded into stand-alone courses, such as Environmental Modelling (Koh 2004) taught by the authors or any natural resources courses. Traditionally, issues and research involving the environment and natural resources (ENR) formed the backbone of contemporary sustainability. This paper provides case studies and examples to illustrate how stand-alone SLO and SCC have been the key contributors to the success of several research and consultancy projects in ENR undertaken by the authors in partnership with community in the past two decades. These research and community projects have contributed to the achievement of several United Nations' Sustainable Development Goals (UN SDGs). This model of university community partnerships is certainly transferable and scalable, given enough incentives and collaborations with ESSSR and AASHE.

2 Sustainability in Higher Education SHE

The notion of sustainability is built upon the definition of the term "sustainable development" as laid out by the Brundtland Commission (WCED 1987), hereafter called the Brundtland 1987 report. The Brundtland 1987 report defines sustainable development as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". Many HEIs adapt this Brundtland 1987 report to develop their own definitions of SHE. At UVM, for example, SHE is defined as "*the pursuit of ecological, social and economic vitality with the understanding that the needs of the present must be met without compromising the ability of future generations to meet their own needs*".

2.1 Implementation of SHE

It has been generally accepted that sustainability is rooted in the two fundamental principles of (1) balancing between the three pillars of "Environment, Society, Economics" and (2) equitable and fair distribution of interests and responsibility between "the current and future generations" (Koh and Teh 2019a). Sustainability (or sustainable development) is a concept deeply rooted in the continuity of human-nature ecosystem. It is intended for guiding human activities and behaviours towards a future secured in the renewability of natural resources critical to the vitality of the human-nature ecosystem. Since the Brundtland 1987 report, various definitions of sustainability have been proposed by diverse entities, including corporations and HEIs, to suit their respective objectives and to drive the actions that follow (Dale and Newman 2005). The self-interested structures of some HEIs may, however, preclude them from a firm definition of the term "sustainability" (Farley and Smith 2014). The definitions of sustainability implicitly consider human-nature ecosystem with complex, interconnected and vulnerable components that connect current and future generations, in ways that are not yet clearly understood. Hence, sustainability must embrace complexity and uncertainty as a guiding principle in the search for integrated and holistic solutions. That the actions of the current generations will affect the well-being of the future generations is beyond doubts. However, understanding how the current and future generations are interconnected through the human-nature ecosystem remains a daunting challenge. To meet this daunting challenge, HEIs must fulfil a major task of providing quality education and research with clearly defined SLOs. HEIs are duty bound to equip future leaders, citizens and community with the vision and mission to achieve the UN SDGs, sometimes referred to as the UN 2030 Agenda.

3 Sustainability Learning Outcome (SLO)

3.1 Stand-Alone Course-Based SLO

Since the Brundtland 1987 report, it was common for some universities, including USM, to incorporate sustainability elements into stand-alone courses that were deemed sustainability-related, such as environmental modelling taught by the authors (Koh 2004) and ENR courses. In the 1990–2005, sustainability had a predominant skew towards concepts rooted in the ENR. It paid less emphasis on concepts related to poverty, hunger, health, education, equality and social justice. These universities in the 1990–2005 did not clearly define its SLOs in its mission statement to highlight its importance. Clearly, curricula rooted in ENR are rich in examples of sustainability and sustainability-related courses (Reid and Petocz 2006) and would provide a solid foundation on which to build SHE. Despite the absence of institutional incentives and framework, the seminal SHE initiatives in the 1990–2005 to incorporate sustainability elements into curriculum were primarily driven by the individual course instructors, acting independently. They shared like-minded interests in sustainability-related issues primarily oriented to ENR. The stand-alone ENR-based SLOs were intuitive, were not explicit and had the tendency to be narrowly confined to ENR. These stand-alone SLOs had served and delivered good learning experiences to students and educators. They paved the foundations for building university-wide SLOs in the twenty first century, guided by the seventeen SDG targets listed in the UN 2030 Agenda, which were not even known then. Some case studies and examples of stand-alone SLO-based research and consultancies undertaken by the authors primarily on ENR will be briefly described in later sections to highlight the daunting sustainability challenge encountered then and now.

3.2 University-Wide SLO Requirement

It was, however, uncommon for teaching and research universities with multiple faculties and schools, such as the USM, to mandate a university-wide requirement in sustainability. In most cases, this mandate is beyond the financial and technical ability of most universities. UVM adopted a university-wide sustainability requirement in 2015. This adoption by the UVM provides an exemplary illustration to convey instructive narratives for other HEIs seeking to integrate a SLO-requirement into their respective university curriculum. In a rapidly changing world with high demand for work-ready graduates, general learning outcomes (GLOs) tailored for the market place has become increasing important for university mission statements and the actions that follow. The presence of SLO mission statement in either "general" education or "liberal" education is not unique, but it is certainly not common (Natkin 2018). And exploring the importance of "general" versus "liberal" education in delivering GLOs and SLOs is a compulsory task for academics, given the

current scenario of market-oriented vision and mission. Liberal education encourages an appreciation of knowledge, an ability to think and solve problems and a desire to improve society. General education advocates for practical education that prepares students to enter the workforce upon graduation (State University 2018). A "hybrid" education model is possible, perhaps even desirable, the discussion of which is beyond the scope of this paper. As a state land-grant HEI, UVM has been a leader in the teaching and research of ENR-related issues and programs (Sullivan 2018). These programs played a leading national role in adopting an interdisciplinary approach to educating the next generation of ENR practitioners (Kaza 2012). The goal of the general education sustainability requirement at UVM was to embed sustainability throughout the university curriculum and to encourage the faculty within the disciplines to teach sustainability under a disciplinary-specific framework. The UVM spent the 2014–2015 academic year developing a convincing argument that sustainability is an interdisciplinary concept that allows for each respective discipline to introduce and reinforce ecological, economic and social sustainability topics in a unique and discipline-specific manner (Hill and Wang 2018). This practical approach to SHE appears to be attractive as it is implementable for many HEIs.

4 Sustainability Challenges in HEIs

University-wide curricular change such as mandating university-wide SLOs is a daunting and complex process for most HEIs. The complexity of educational systems, the various levels of decision-making on educational policies, and traditional curricular structures are still presenting challenges for learners to develop (and transfer) competences in SD. Indeed, fast, effective and institution-wide change towards ESD in HE is always catalysed by legislation that spurred HEIs to address their inertia and disciplinary traditions (Leal Filho and Pace 2016). Decades of advocacy by many to promote liberal studies as part of university-wide curriculum (AASHE 2007) have influenced many institutions' and instructors' approach to general education, including the UVM and the authors. The "Essential Learning Outcomes" (Freeland 2009) includes knowledge, skills and values components that influenced the framework for UVM's sustainability general education requirement. At UVM, sustainability is a natural part of general education, and not just an imperative in certain academic units such as ENR studies (Fien 2002; Reid and Petocz 2006). It is the combined responsibility of faculty and administration to shape the student sustainability experience. Faculty must overcome potential conflicts between faculty and administration through open and transparent dialogues. This is important as the traditional general education course-based model does not serve the interdisciplinary SLO-based requirement. UVM's sustainability transformation began with the Student Government Association (SGA) passing a resolution in 2010 supporting "*the creation of a university-wide sustainability curricular requirement for all incoming undergraduate students at the University of Vermont*". The way the UVM has taken to overcome the daunting challenges encountered in SHE and SLO is commendable.

4.1 Developing SLO-Based Competences

As a centre of higher learning that connects community together, university has an important and vital role in equipping students and educators with SLO-based competences and capability to critically reflect on and creatively respond to the complexities and uncertainties of the future (Mader and Mader 2012; Ryan and Tilbury 2013). To educate and engage the public on the means and tasks to mitigate and adapt to these complexities and uncertainties is a key responsibility of a university. The goal is to produce future communities that are SLO-driven with the motivations and capability to balance the three pillars of sustainability i.e. viable economic growth with inclusive social development and continuing ecological vitality. Yet, the implementation of SLO-led education at the institutional level remains a daunting challenge (Hill and Wang 2018).

A lack of convincing and compelling theoretical framework for understanding sustainability challenges has led to a myriad of categorizations for SHE competences and capability that are elastic and blurry (De Kraker et al. 2007), and has created barrier to effective curriculum and pedagogy development. HEIs may define competences and capability as a loose combination of knowledge, skills, attitudes, attributes, ethics and values, in an ad hoc manner. This ad hoc formulation of sustainability competences may impede development of curriculum and pedagogy appropriate for sustainability-focused programs. To overcome this shortcoming, SLO-based competences and capability (SCC) deemed essential for SHE should be clearly defined as a compulsory part of a university SHE missions statements.

5 SLO-Based Competences and Capability

Koh and Teh (2019a) developed a simple and pragmatic framework to characterize three SLO-based competences and capability: Skills, Spirituality, Strategy critically needed to address the challenges confronting the three sustainability pillars consisting of the environment, the society, and the economics. “Skills” include higher order skills such as critical system analysis, holistic decision making and effective communication. “Spirituality” seeks to cultivate the respect for the spirituality of human-nature relationship. “Strategy” empowers the capability to engage diverse stakeholders across multiple disciplines in knowledge co-creation, systems transformation and problem resolution, through transdisciplinary and holistic approaches. Illustrative examples will be provided in later sections to demonstrate how these three SCC were needed and involved in several ENR projects undertaken by the authors. To extend this utilization of the three SCC in overcoming the true sustainability challenge will need further efforts. Cultivating spirituality in SHE will facilitate the creation of an inclusive society that values nature and that respects equitable distribution of wealth and responsibility between the current and future generations.

However, the goal of incorporating the three pillars of sustainability holistically into a university-wide sustainability curriculum poses a greater challenge as this may require and may lead to profound changes (Venkataraman 2009), mandating significant allocation of resources. Complete transformation of traditional HEI towards SLO-based SHE is virtually impossible in the short-run, given financial constraints. As a workable alternative, Cotton et al. (2009) highlighted the practicality of the so-called "second-best solutions" by integrating SLO concepts within the current framework of traditional course-based curriculum. The integration of SLO-based SCC into traditional HEI curriculums that are course-based could usher in transformative change in curriculum and pedagogies in the *long run* and could serve as initial steps towards SLO-based SHE (Mochizuki and Fadeeva 2010). The following section provides examples to illustrate how SLO and SCC were crucially involved in performing research and community outreach for two goals: (1) mitigating the environmental impacts of a large-scale shrimp aquaculture in Malaysia and (2) the preservation of coastal resources at local and international levels subject to the impact of climate change. Integrated with strategic capability, STEM (Science, Technology, Engineering and Mathematics) had played a crucial role in providing deep knowledge, insights and convictions in achieving the two goals mentioned above and will continue to support the UNSDGs (Teh and Koh 2020).

6 Applications of SLO and SCC

6.1 Large-Scale Shrimp Aquaculture in Malaysia

Shrimp, particularly the Tiger prawn (*Penaeus monodon*), has been farmed for centuries in many regions in Asia, where it is in high demand, mostly around mangrove habitats with abundance of brackish water suitable for shrimp cultivation (Braaten and Flaherty 2000). Efficient and well-managed aquaculture plays an important role in catering to the growing demand for seafood proteins (SDG2) and helps to conserve valuable marine resources by reducing overfishing (SDG12). Moreover, aquaculture creates meaningful employment for community (SDG8). However, aquaculture has a substantial impact on the aquatic environment (Boyd and Tucker 2000; Boyd 2003), with water pollution around the aquaculture farms (SDG6) as a top concern (Schulz et al. 2003). Converting mangrove habitats into intensive and extensive aquaculture farms can create severe environmental degradations affecting both life below water (SDG14) and life on land (SDG15) (Koh and Teh 2019b). Hence, large-scale intensive aquaculture presents opportunities and threats to the three pillars of sustainability, demanding tradeoffs and fulfilling some SDGs (2, 8, 12) while hazardous to other SDGs (6, 14, 15). Fulfillment of the three pillars of sustainability is a daunting task but, may be possible with good aquaculture management. This university community aquaculture research project presents a good learning experience for stu-

dents and educators in SHE to utilize their SLO and SCC in seeking holistic and action-oriented solution.

Effluent waters from modern intensive shrimp aquaculture contain elevated levels of pollutants such as biochemical oxygen demand (BOD), phosphorus, ammonia, nitrate, and organics (Flaherty et al. 2000). These environmental hazards must be managed properly with low-energy and low-maintenance technology (SDG7) if shrimp aquaculture is to achieve sustainability. Constructed wetlands or sedimentation ponds of adequate capacity have been shown to be capable of significantly reducing levels of these pollutants. Modern shrimp farms typically use aerators to maintain appropriate dissolved oxygen (DO) levels. Natural reaeration is insufficient to maintain DO at levels above 5 mg/L because of the high shrimp density, exceeding 5 kg/m^3, and low rate of water exchange. Well-managed shrimp farms can yield 20–30 metric tons per ha per crop of three months, with power consumption of up to 30 hp per ha needed to maintain adequate aeration. On a per hectare basis, shrimp farming appears to be more productive than cattle farming. However, both create their own share of environmental hazards and tradeoff, which is beyond the scope of this paper.

Discharge of effluents from intensive aquaculture farms into a river can pollute the receiving river and exert negative impacts on the aquatic ecosystem. A large shrimp farm of 1000 ha divided into 630 ponds of 1 hectare each was established along the estuarine river known as Sg Setiu in the state of Terengganu, Malaysia. The farm was a subject of significant consultation among multiple stakeholders such as local communities, NGOs, the authors and government agencies in charge of the environment and rivers. The critical review was mandated by the Environmental Impact Assessment Regulation under the Malaysia Environmental Act 1974. The review critically evaluated options and tradeoffs to achieve a holistic solution. Revolving around several SDGs such as SDGs 1, 2, 6, 8, 14 and 15, the review seeks to achieve a consensus to holistically balance the three pillars of sustainability consisting of the environment, economics and society. The resolution of the potential conflicts between the three pillars demands substantial SLO-based SCC. Technical skills in water quality simulations in conjunction with effluent management are tools that were used to address the adverse environmental impact. Holistic STEM skills are needed to critically evaluate viable options and tradeoffs based upon simulations of impacts of shrimp farm effluents on the environment (Saremi et al. 2013) and to recommend appropriate mitigation measures. Strategic capability is crucial in guiding and reaching the desirable outcome of multi-stakeholder engagement. Spirituality, shaped by cultural values and beliefs, is essential to reflect on and arrive at action-motivated solution from a multitude of potentially conflicting choices. For water quality assessment, an in-house two-dimensional water quality simulation model codenamed TUNA-WQ was used (Chong et al. 2017). With partnership among various STEM disciplines, the model was calibrated and verified with primary and secondary data on hydrology, meteorology, effluent and river water quality in Sg Setiu. This project provided invaluable opportunity and experience for students and

educators to: (1) Learn about engagement with multiple stakeholders for resolving potentially conflicting issues involving multiple SDGs and (2) Learn to apply their SLO and SCC for conflict resolution towards action-oriented solution.

6.2 Preservation of Coastal Resources

Coastal zones are highly productive in providing valuable ecosystem services and in supporting vibrant economic development (Romañach et al. 2018). However, they are constantly threatened by anthropogenic activities, environmental degradation and climatic shocks (Koh et al. 2018). These hazards confronting coastal zones can result in deterioration of water quality and impairment of ecosystem services, amounting to billions Malaysian Ringgit annually (Koh and Teh 2019b). The hazards of climate change on coastal resources must be adequately mitigated (SDG13) to allow future generations to have similar access to these resources. STEM (Science, Technology, Engineering and Mathematics) plays an important role in providing deep knowledge to support these research (Teh and Koh 2020) and to devise effective mitigation and adaptation measures to reduce the risks associated with these coastal hazards induced by climate change (SDG14, SDG15). However, STEM must be integrated with government, industry and community for effective governance and implementation of viable solutions for reducing risks via partnership (SDG17) and collaboration (Koh and Teh 2019c).

This horizontal integration demands SLO-based SCC including (1) technical and scientific skills, (2) appropriate spirituality guided by cultural values and beliefs in making critical decision involving conflicting choices and (3) strategic capability to integrate multi stakeholders across multiple disciplines to reach holistic action-motivated consensus. Through partnerships, universities train highly qualified graduates equipped with SLO-based SCC suitable for emerging "green" jobs. It is important to integrate STEM and principles of sustainability towards the development of policies for mitigating and adapting to climate hazards. Integrating STEM and UN SDGs into the government decision-making framework, in conjunction with active community engagement, would cultivate sustainability-led approaches for overcoming climate hazards via problem-based, solution-oriented and action-motivated community projects. Through these sustainability-focused community projects, knowledge and skills including communication and interpersonal skills, essential to problem solving and conflict resolution will be co-developed. Sustainability is a long arduous process facing a steep learning curve, requiring much patience and perseverance, and demanding creativity and innovation. Creative and innovative community-university partnership and collaboration would pave the way for transforming society toward sustainability.

7 Contribution of STEM

7.1 STEM in Climate Change Mitigation and Adaptation

The 2015 Paris climate change agreement and other sustainability commitments towards low carbon economies, have created new opportunities in the cross-disciplinary field of "green jobs". The simplest definition of a green job is one that reduces the negative impact made on the environment, relative to the status quo. However, a major problem in filling these new green vacancies is the lack of job-specific skills in STEM and related careers (Bird and Lawton 2009). STEM has immense application in sustainability-related research and applications. For example, STEM was instrumental in developing cutting-edge simulation model MANTRA-O18 for detecting early warning signals regarding regime shift induced by climate change from glycophytic to halophytic vegetation in coastal wetlands including the Florida Everglades (Teh et al. 2019). Such regime shifts can have dire consequences on coastal vegetation and ENR. Early detection of vegetation regime shifts can provide valuable lead time to mitigate or adapt to the impact of climate change. This early detection involves university-community engagement and interaction at the local and regional levels, by way of data collection, analysis, synthesis and outreach. This problem-based university-community research collaboration will lead to solution-oriented actions to protect local coastal resources against the impact of climate change. Encouraged by the success in the Florida Everglades, similar university community engagement is currently ongoing at a research site in P. Kukup, Johor, Malaysia, funded by the L'Oréal-UNESCO Fellowship awarded to the second author. Undoubtedly, mathematics is an integral and essential component for advancing STEM and related research, which is crucial to environmental protection, economic growth and social justice. This expanding contribution of mathematics towards STEM, medical sciences, security in water and food could be a beacon to attract more students in mathematics and STEM to meet the new opportunities in green jobs of the future. The knowledge, network and communication developed in this university-community engagement in Florida and Johor would help bridge the gap among STEM, community and government to foster STEM-based community-oriented policy on all national and regional matters, particularly those pertaining to climate change.

7.2 STEM Community Partnership

The authors have been actively engaged in several research projects centred on development of STEM tools and innovations (e.g. software) to address real-world problems. The mathematical software named TUNA (Tsunami-tracking Utilities aNd Application), developed by the authors, was successfully commercialised, assisting clients such as Universiti Teknologi Petronas in assessing tsunami waves impact on

offshore oil and gas platforms and mitigating potential impact of sea level rise (SLR) as well as Universiti Tenaga Nasional in assessing and mitigating tsunami waves' impact on coastal power plants as part of the SLR research. These projects constantly involve scientists and students from various STEM disciplines, in line with the spirit of integrating STEM in teaching and research. In a current project sponsored by L'Oréal-UNESCO for Women in Science Malaysia, the second author is leading a team of scientists in the field of Science (Mathematics, Biology), Technology (Computer Science), Engineering (Coastal and Ocean Engineering) to investigate climate change impacts, including unusual weather patterns and SLR, on coastal resources. The goal is to enhance the sustainability of coastal groundwater and vegetation in Penang by means of model simulations and university-community partnership. The key to managing diversity and complexity in STEM engagement with community is the establishment of confidence and mutual trust through respect and communication facilitated by SLO and SCC. University-community partnership in an inclusive environment is crucial to achieving common goals in SHE.

7.3 STEM Collaboration in USM

Another successful example of SLO and SCC is demonstrated in a university project in USM on evaluating the potential health hazards of fume emissions from the Chemistry School to the nearby Science Complex (Koh et al. 2006). The modelling analysis indicated that the air pollution levels in the fume emissions were well within the international safety guidelines and hence were unlikely to pose health hazards for occupants in the surrounding buildings and in the campus. However, some occupants residing in the Science Complex expressed concern regarding the model's true representation of the real condition. After inclusive and extended discussions, all parties were convinced that field and lab measurements should be conducted to complement and validate the modelling results. Therefore, in collaboration with the scientists in STEM disciplines, concomitant eight-hour field-lab surveys were conducted over several days on personals working in the affected buildings. This collaborative effort between STEM disciplines involving mathematical simulations and field-lab measurements succeeded in reassuring the campus community that the fume emissions from the chimneys were unlikely to post health hazard (Teh and Koh 2020).

8 Conclusion

Education is a critical activity that one goes through to acquire the skills, knowledge and attitude to face the unknown future. Hence, it is the best period during which the issues related to sustainable development (SD) should be explored to prepare the students for application of SD knowledge at future workplace or for further training in specialized SD contexts. Programs for ESD should focus on positive solutions by

critically reflecting on successful case studies with out-of-classroom experiences to widen the students' perspectives and to enable a deeper analysis of their own life experiences. For this purpose, it is crucial that university educators be prepared with the right communication and pedagogical skills for this reorientation of education towards sustainability. HEIs should no longer be limited to producing talents in the subject matter. Rather HEIs should inculcate informed and motivated citizens having the creative problem-solving skills, scientific and social literacy, and commitment to responsible actions that will help ensure an environmentally sound, socially just and economically prosperous future (Leal Filho and Pace 2016). This paper has presented an overview on university-community partnership essential for empowering SLOs at the local, national and international levels. Case studies and examples were presented to illustrate how SLO and SCC have been an important instrument for establishing sustainability networks and for empowering transformative experiences among students and educators through mutual learning and knowledge generation. Much more needs to be achieved in the future. HEIs should integrate their SLO-based research and teaching with community aspirations and government policy through deep engagement. Deep understandings of the government policy process and community dynamics are essential for the transformation of society towards sustainability-led lifestyle. Disciplines within STEM should be integrated holistically with other disciplines in social sciences and humanity to unleash the combined strength for driving sustainability-based policies and programs.

It is crucial to go beyond the national border to engage with ASEAN nations in the process of conserving natural resources and protecting the environment by developing coherent cross border sustainability policy. The contiguous terrestrial and marine resources within ASEAN are interlinked and therefore, a decision, or lack of one, that an ASEAN member makes could affect the other ASEAN members. Working within and through ASEAN would provide an opportunity to know and understand each other ASEAN member policy processes and build consensus. Deep understanding of the diversity of policy processes in ASEAN is critical in reaching long lasting consensus. Integrating SLO-based university research and teaching with government sustainability policy and sustainability-focused community outreach across ASEAN nations will enrich students and educators' learning experiences beyond the traditional classroom learning framework. The networks and collaborative partnerships established across ASEAN will provide a framework for effective transborder transformation to sustainability. It is hoped that the Jeffrey Sachs Center on Sustainable Development in the Sunway University and the Center for Global Sustainability Studies in USM could provide effective leadership towards the attainment of this goals, working in collaboration with ESSSR and AASHE.

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Higher Education Institutions as Drivers of Sustainable Communities: A Case Study of the University of Southern Santa Catarina Empowering the Community

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Abstract Higher Education Institutions (HEIs) play a key role in creating change in communities and societies as a whole. As a result of the emergence of new challenges, mainly related to the management of resources (food, water and energy), the promotion of well-being, security, equality and education, universities are pressured to become responsible for promoting sustainable development in communities. In this sense, this study presents the case of a Brazilian Community University, the University of Southern Santa Catarina (Unisul), which implements numerous practices aimed at the community, carrying out training, education, research, outreach, academic events, consulting on business, legal assistance and medical clinics, as well as promoting sustainability within campuses' infrastructure, inspiring local communities to incorporate the University's sustainable values. In addition to the many benefits obtained through actions taken by HEIs and living labs, it is hoped that such actions will cooperate with sustainable development goals (SDGs) to achieve

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a better and more sustainable future for all. With this study, it was concluded that Unisul, besides promoting innovations for sustainable development in each level and sector of the university, operates the learning environments to the students and the communities surrounding its campuses, bringing solutions to the existing local and global challenges.

Keywords Higher education institutions · Universities · Sustainable communities · Sustainable development goals · Sustainability · Living labs

1 Introduction

The international community has shown a growing concern for sustainability and the SDGs, that can be exemplified by the 2030 Agenda of the United Nations (2015c). As opinion makers and great research contributors, HEIs are key actors in raising awareness for sustainability once they have within their reach a number of fundamental tools to promote change in communities through education and cooperative projects to improve infrastructures (Cortese 2003).

This article aims to demonstrate how HEIs can be drivers of sustainable communities and collaborate to the accomplishment of the SDGs through a case study of a project developed by Unisul in collaboration with the community and government as well as a literature review regarding sustainable HEIs. HEIs are responsible for knowledge transmission and in many countries are the major producers of scientific research (Zago 2011). Such roles are extremely important for the promotion of sustainable development. HEIs also have a great interaction potential, since students are part of communities, as well as the case of community colleges which provide essential services to many groups while transmitting knowledge to students, which is the case of Unisul (Garcia et al. 2015).

The SDGs were formulated by the United Nations in 2015. The 17 goals aim to reach a better future with equality, peace and security (United Nations 2015c). It is expected that these goals are taken into consideration in the formulation of public policies by governments (Griggs et al. 2013). However, it is a common responsibility to incorporate the SDGs in order to reach sustainability, and that includes HEIs. SDG number 11, "Sustainable Cities and Communities" is one of the goals to which HEIs can contribute the most through its interactions with communities and sustainable initiatives (United Nations 2018b). Campuses sometimes have the infrastructure of cities, making them ideal environments to demonstrate sustainability initiatives, such as the Living Labs approach and proper resource management (Keyson et al. 2017).

The case study of Unisul regards its collaboration in the development of a government report which aims to promote a participative management of the Itapocu River Basin alongside communities and private sector. The Itapocu River Basin is located in Santa Catarina, Brazil and covers 3,273,789 km^2. The basin is part of most of the economic activities of the communities of the region, as well as the main provider of resources for the population. The region goes through a number of extreme cli-

matic events which will be approached further. Accounting all these factors, Unisul, alongside the government of the state of Santa Catarina, has elaborated a plan to aid communities prosper and sustainably manage the critical resources provided by the basin. Through the case study and literature review it is possible to acknowledge the importance of HEIs in the strengthening communities to accomplish SDGs.

2 Methods

The methodological process used in this article consists of two parts: the fist one is a bibliometric review as presented by Arksey and O'Malley (2005) and confirmed by Levac et al. (2010). This spectrum was used to identify state-of-the-art literature on Sustainable Higher Education Institutions, Living Labs, Green Campus and the role of Universities, and how can these things help implementing Sustainable Development. The first step in the bibliometric research was to identify the research question: how can HEIs promote Sustainable Development in communities?

The second step was to identify relevant studies to that goal. Firstly, the following databases were selected: Science Direct, Scopus and Web of Science. In these databases, a search was conducted for the following keywords: Higher Education Institutions; Sustainable Communities; Sustainable Development Goals; Sustainability and Living Labs. As in systematic literature reviews, inclusion and exclusion criteria were adopted, favoring breadth rather than depth in the selection. The third step was selecting material for the study; since there is a great number of publications presented for each search, the 20 most relevant and the 20 most cited articles were selected for a deeper analysis based on their relevance for the research question. To present a summary regarding the number of studies selected for this research, Table 1 was constructed.

The fourth step was charting the data to organize articles in order to compile concepts and definitions. The fifth step was collating, summarizing and reporting the results, so selected articles were the foundation for the literature review. The second part of the methodological process was made in order to support the qualitative

Table 1 Selection of scientific articles

Keywords	Science direct	Web of science	Scopus
Higher education institutions	10.068	8.113	13.442
Sustainable communities	3.705	567	1.904
Sustainable development goals	7.377	3.495	4.783
Sustainability	1.430.474	127.707	183.786
Living labs	833	338	1.273
Number of articles selected due the revision of articles' abstracts	87	92	75
Final portfolio selection	15	17	19

Table 2 Reports used in the study case

Report	Year of publication	Study step
Activity report: product 02—Step A	2016	Strategy for involving society in plan elaboration
Activity report: product 03—Step B	2017	Basin's socioeconomic and environmental diagnosis
Activity report: product 04—Step C	2017	Basin's hydric resources diagnosis
Activity report: product 05—Step D	2017	Basin's hydric demands forecast
Activity report: product 06—Step E	2017	Elaboration of the hydric resources plan in the Itapocu River basin
Hydric resources plan on the Itapocu River Basin	2018	Synthesis report

character of this research: a mapping of documentation related to the analysis. To validate the study case presented, the Project of Itapocu River Basin, the mapping was made in reports published by Unisul, the reports used for the case study can be found in Table 2.

This study case was chosen to inspire and facilitate learning using real examples, in a specific socioeconomic context. The results found in this research methodological process are exposed in the next sections: Sect. 3 presents a literature review and Sect. 4 presents Unisul's participation with the Water Resources Project of Itapocu River Basin.

3 Literature Review: Sustainability in Higher Education Institutions

HEIs have an important place in the generation and transmission of knowledge, which allows them to integrate and encourage different types of acts that can lead to social changes (Beringer and Adomßent 2008; Aleixo et al. 2018). Sustainable HEIs can create models of sustainable practices for society through actions in their own campuses and from it connect how this model fits into the behavior of people in their daily lives and how to educate them on sustainable actions (Cortese 2003; Freidenfelds et al. 2018). They have the ability to promote union between individuals and institutions inside and outside their spaces and intervene in other areas of society, due to their independence from other institutions, as well as their nature of free research and great promotion of knowledge exchange (Stephens et al. 2008; Vargas et al. 2019).

Different definitions are used to explain sustainable HEIs. For Shriberg (2002, p. 53) "Sustainable colleges or universities explicitly set the goal of long-term institutional integration with healthy human and biotic communities", seek to do no

harm to the environment and integrate sustainability-related issues into their main functions like research, teaching and service operations. Velazquez et al. (2006) brings a general definition by authors that define a higher education institution as one that manages and promotes, at regional and global scales, the reduction of negative effects on the environmental; economical; social and health spheres, due to the use of resources to perform their basic functions, thus helping society to adopt more sustainable lifestyles.

Clugston and Calder (2000) indicate that HEIs should implement practices that include their commitment to sustainability through written statements in their mission and purpose, as well incorporate sustainability concepts into their courses and academic research and encourage students to critically analyze environmental issues. These can have positive effects overall, in culture, employment and adding value to the regions' products; but also might have negative impacts, when resources as water and energy are not managed properly (Madeira et al. 2011).

In this article, the concept of Community Higher Education Institution is used, represented by the study case in the Brazilian HEI Unisul. According to Brazilian law nº 12.881 (Brazil 2013), passed in 12 November 2013, Community Higher Education Institutions are organizations of Brazilian civil society constituted as associations or foundations, with the legal personality of a private firm, which invest all their resources in Brazil to achieve institutional goals. They must act with transparency and responsibility and bring benefits for communities, promoting activities of public interest, offering free services to the population and institutionalizing permanent outreach programs and community action to help the formation and development of students and society.

3.1 Living Labs, Green Campus and the Role of Universities

The application of sustainability within HEIs should frame and establish a sustainable agenda by adapting its internal processes, so that there is energy and water efficiency, waste management, green operations and sustainable buildings (Berchin et al. 2017; Ramísio et al. 2019). The creation of a sustainability committee within universities contributes to the establishment of sustainable policies and objectives within the campus. It supports the people responsible for sustainable initiatives by disseminating information and coordinating all projects, such as fundraising and policy implementation (Velazquez et al. 2006; Leal Filho et al. 2019).

The role of Universities is fundamental to sustainable development, due to their character as centers of knowledge and similarities to cities spaces. Their operations have direct and indirect impacts on the environment, such as administrative tasks, commuting of students and great consumption of water, food and energy (Disterheft et al. 2012; Leal Filho et al. 2018). At the same time, universities provide research and promote knowledge in the area of sustainability, integrating their staff, students and external community into more sustainable practices and resource use awareness (Alshuwaikhat and Abubakar 2008; Berchin et al. 2018).

Living labs are increasingly being used in universities as a method of experiment where researchers, students and external stakeholders apply new sustainable technologies and test them on their campus to address the challenges of climate change (Evans et al. 2015; Masseck 2017). Since universities offer real world locations, living labs allow the conduction of interactive projects, involving action of all actors and the exchange of knowledge that contribute to long-term results (Voytenko et al. 2016). The Living Lab approach allows universities to reduce their carbon footprints and to use their resources efficiently by implementing learning experiences directly with students, linking academic activities to the implementation of sustainable practices (Cohen and Lovell 2013; Evans and Karvonen 2014).

The University of Malta in Mediterranean, for instance, used a Living Lab methodology to implement The Center for Environmental Education Research (CEER) to educate and disseminate sustainable practices to local people through the provision of educational programs (University of Malta 2019). The centre lead to the creation of the Masters in Education for Sustainable Development (MESD) was covering studies on sustainability, waste management, sustainable means of transport and students carrying out projects in real life and engaging local people to learn about sustainable practices. Through the analysis and suggestions based on the projects carried out, improvements were implemented in the course, encouraging a greater exchange of knowledge within the university and the local community, as well as encouraging contact with other communities at national and international level (Leal Filho et al. 2017).

Another form of implementation of sustainability within HEIs is the building of green campus, based on establishing a core team with extensive knowledge about sustainability, defining what kind of initiatives will be taken, identifying the challenges of universities and setting goals to achieve a sustainable campus (Dahle and Neumayer 2001; Humblet et al. 2010). It includes the creation of sustainable buildings and facilities; use of efficient energy systems and resources management; promotion of research to the university and external community, and the availability of courses that teach students about sustainability (Alshuwaikhat and Abubakar 2008; Tan et al. 2014).

Ball State University, a HEI in the United States, implemented in its campus an action plan that allowed the creation of sustainable structures in vehicle and pedestrian areas, as well as spaces defined for use of the external community. The green buildings of the university were built preserving trees of the region and landscapes and adapted sustainable practices through the use of recycled materials and high-efficiency lighting (Koester et al. 2006). In China, more than 200 universities have focused on implementing a campus energy management system (CEMS), combining eco-technologies and green education for energy and efficient campus; CEMS monitors real-time energy used by campus buildings in an intelligent manner and delivers energy statistics, energy auditing and energy efficient retrofit, and through these data it measures and performs analyzes to use energy more efficiently (Tan et al. 2014).

3.2 Higher Education Institutions as Drivers of the Sustainable Development Goals

The United Nations' SDGs were adopted September 2015, starting the most ambitious development project in world history (Herrera 2019). SDGs were first discussed by countries in 2012 as a project to build on successes and address shortcomings of the Millenium Development Goals (MDGs), a project with a people-based approach, widely seen as a roadmap to progress for low-income countries (Plum and Kaljee 2016). SDGs offer a wider approach, considering planetary problems and they seek to address what literature calls the triple bottom line for human welfare: economic development, social inclusion and environmental preservation (Sachs 2012). For that end, the United Nations have highlighted their focus on people, planet and prosperity, as well as peace and partnerships (United Nations 2015a).

SDGs are considered to be indivisible and universal (Plum and Kaljee 2016) with synergies to be found among them (Timko et al. 2018). SDGs are integrated by design and using them together is the key to harness them to their full potential (International Council for Science 2017). SDGs have global relevance, since all continents deal with problems related to sustainable development: air quality in Asia, food security in Africa, clean energy generation in Europe and worldwide climate change and poverty. However, SDGs must be addressed locally (Salvia et al. 2019).

In this context, the links between sustainability and HEIs are well-documented in literature (Leal Filho et al. 2015). HEIs have been seen as important actors for implementing and enhancing sustainable development since the concept was created (Friman et al. 2018), since they are centres of knowledge and innovation and have the potential to be key drivers in changing society. As Sustainable Development is becoming increasingly important (Yáñez et al. 2019), it would deeply benefit from involving students and young population in the discussions about the leaders in a time when SDGs will shape political decision-making (Gusmão Caiado et al. 2018), as well as helping to prioritize needs and allocate resources in communities (Plum and Kaljee 2016).

It is believed that HEIs are the best places to start environmental-friendly activities, since they can teach principles of understanding and management and are places where the best environmental practices can be demonstrated (Freidenfelds et al. 2018). Sustainable development can be adapted to all areas within HEIs: in education, research and outreach, but also in their own administrative management, since they can be seen as mini-cities (Parvez and Agrawal 2019). Some frameworks for sustainable development within HEIs have emerged and the first of them was the Talloires Declaration, in 1990 (Ramísio et al. 2019). The Talloires Declaration's 10-point plan focus on public awareness (points 1, 3, 4 and 6); institutional awareness (points 2, 5 and 7); and cooperation with other institutions (points 8 and 10) (ULSF 1990). As of March 2019, 507 HEIs around the world had signed the Talloires Declaration, including Unisul (ULSF 2019).

3.3 The Role of Universities in the Development of Sustainable Communities

Human settlements are becoming increasingly urbanized, following a long-time trend: in 1930, 30% of the population lived in cities (Roseland and Spiliotopoulou 2017); in 2014, more than half of the world lived in these areas and this number is expected to grow to 75% by 2050 (Clark and Cooke 2015). While cities are catalysts of innovation, productivity, technology and infrastructure development (UN-Habitat 2016), such urbanization brings new problems and might reinforce existing ones, such as pollution, vulnerability to natural disasters, incapacity of providing basic services (United Nations 2017).

Since cities are increasingly the centre of human habitation and production, they are the places where solutions to these problems must be found. SDG 11 in the UN's 2030 Agenda is "Sustainable Cities and Communities" (United Nations 2015b). While there is a not a clear model of what a sustainable community looks like (Roseland and Spiliotopoulou 2017), cities and communities need to address problems in housing, transport, economy and environment in order to be considered sustainable (United Nations 2016). Other areas, such as waste collection (United Nations 2017) and air quality (United Nations 2018a) still need to be addressed.

HEIs are believed to be the best place to start environmental-friendly activities, since they can teach principles of education and management (Freidenfelds et al. 2018) and are key drivers in changing society, be it participating in community sustainable actions or managing their own structure sustainably (Yáñez et al. 2019). HEIs and civil society would both greatly benefit from more connection in their practical and theoretical work; however, community engagement is currently not incentivized, since cooperation outcomes are not recognized as legitimate results by the current structure of scientific production (Čada and Ptáčková 2013). If HEIs could empower their students to act on sustainability issues with holistic thinking, a bottom-up approach to sustainability in communities would be possible (Szitar 2014).

4 The Water Resources Plan of the Itapocu River Basin: The Case of Unisul

Unisul is a community university in southern Brazil, established in 1964 in the state of Santa Catarina. The institution has 3 campuses, around 25.000 students and more than 100 distance education hubs. In order to improve knowledge production, development and dissemination, Unisul invests in education, research and outreach and commits to pluralism and a free flow of ideas (Unisul 2019a, b). Since it is a community university, Unisul is a non-profit institution with social responsibility, committed to education, social welfare and student development and devoted to public use (Unisul 2019a; Teixeira 1994).

Sustainable development is incorporated to the DNA of institutions and is one of their main goals. In establishing a policy for environmental education, Unisul has stimulated social actions in the environmental sphere, creating examples of good practices for internal and external community and raising awareness about the environment and sustainability (Unisul 2019c).

Considering HEIs' role and importance to promote community development, a solid and continuous relation is needed between universities and their surroundings. In this sense, Unisul serves as a model, working and cooperating with its community, promoting development and safety in the economic, social, environmental and political spheres. In this research, a study case in the Water Resources Plan of the Itapocu River Basin was selected. This research project was executed by Unisul, the Government of the Santa Catarina State and Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina (FAPESC).

4.1 Overview of the Water Resources Plan of the Itapocu River Basin

The Water Resources Plan of the Itapocu River Basin was a project developed in the state of Santa Catarina, a partnership between government, university and community, with the objective of reaching a participative management of the Itapocu basin and its water resources in an efficient and sustainable way. The project was funded by the Sustainable Economic Development Secretary of the State of Santa Catarina and executed by Unisul, with support from the Management Committee of the Hydrographic Basin of the Itapocu River and the Association of Municipalities of the Itapocu Valley, two community organizations. This project illustrates how universities can contribute to increase sustainability and environmental awareness in communities and governments.

The project was divided in 5 steps and 1 synthesis report. Step A, named Strategy for the Involvement of Society in the Plan's Elaboration, focused on identifying social actors, diagnose institutions and acting roles related to water resources management. Step B, Social Economical and Environmental Diagnose of the Basin, studied the characteristics of the basin, superficial and underground water storages, and social-economical aspects. Step C, called Itapocu River Basin Water Resource Diagnose, aimed to account the quantity and quality of water as well as its uses. Step D, Prognosis of Water Demands, focused on hydric balances and a proposition for the alignment of water courses.

The final step, E, named Elaboration of the Integrated Plan of the Hydrographic Basin of the Itapocu River, has set goals and actions. Finally, the synthesis report brought a more dynamic and summarized version. The main goal of this project is to implement a participative management system, that brings together the government, the private sector, education institutions such as Unisul and the population, in order to preserve and use it in the most efficient way natural resources, in this case

the hydrographic basin of the Itapocu river. In this section, some of the goals and measures intended by the project will be exposed.

4.1.1 Natural Characteristics of the Itapocu River Basin

This section was written based on reports B and C of the Water Resources Plan of the Itapocu River Basin, as well as the synthesis report (de Albuquerque Junior et al. 2017a, b, 2018). In the first part of this section the main natural characteristics will be exposed. The study conducted by government and university has developed 5 reports, being report B and C about the natural characteristics of the hydrographic basin of the Itapocu river. Figure 1 presents the planning units in the Itapocu river basin.

As seen in Fig. 1, the Itapocu river basin is composed of 8 planning units, which justifies the need for a sophisticated action plan for this region. The basin occupies 3,273,789 km^2 and is located in the northeast area of the state of Santa Catarina, covering 12 cities with a joint population of 6.403 inhabitants. Table 3 shows more physical characteristics in the Itapocu river basin and adjacent areas.

The Itapocu basin has a temperate rainy and humid climate, its flora is inserted in the Atlantic Forest biome and its geographical matrix is varied, due to frequent rain and high temperatures. The economic activities of the region directly influence in the basin. Trade is centered around foodstuffs, mainly rice crops, chickens and fishing;

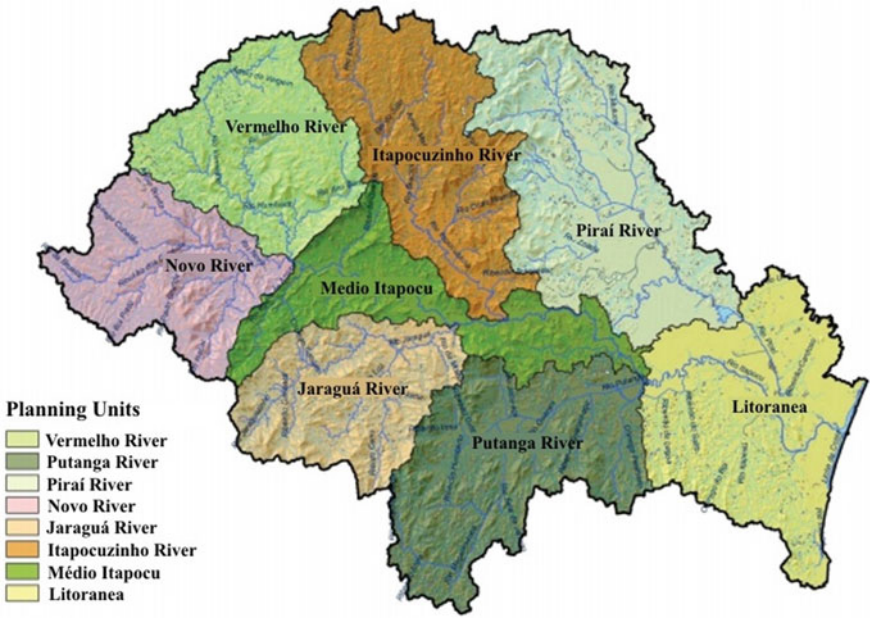

Fig. 1 Planning Units of the Itapocu river basin. *Source* de Albuquerque Junior et al. (2018, p. 14)

Table 3 Physical characteristics of the Itapocu River Basin

Characteristics	Results
Itapocu river drainage area	2888.838 km^2
Itajuba river incremental area	30.958 km^2
Basin perimeter	524.22 km
Compactness coefficient	2.76
Shape factor	0.14
Itapocu river length	86.80 km
Drainage density	1.76
Average declivity	10.77°

Source de Albuquerque Junior et al. (2018)

mining, especially sand and clay extraction; the textile and steel industries, and small businesses. Due to the region's complexity and the community's high dependency on the river's basin, it is fundamental that climate issues are taken into account. An important part of the reports regards extreme climatic events and anthropogenic actions, which might have hazardous consequences for the basin, and finally conservation measures which already existed before the management actions proposed by the reports. These topics will be discussed below.

The most common extreme climatic events that occur in the basin are floods and landslides. The main cause of floods was considered to be the occupation of areas that once were water storages, therefore being caused by human action. As for the landslides, the accounted reason was the varied lithology from which the substrate is formed, therefore being a natural reason, not caused by human action. However, these natural erosive processes that result in sediments when associated with human actions, such as the presence of pesticides, can deeply affect both fauna and flora as well as human activities.

Unmanaged human action, such as urbanization, have made the basin more fragile to extreme natural events as well as the consequences of anthropogenic action itself. The reports highlight the exposure of soil masses, due to the extraction of clay and sand, making the basin more prone to landslides. Another factor is that 40% of the basin is occupied with human structures and activities. Besides urbanization and mining, agriculture, pasture and reforestation also contributed to erosion and soil degradation. Before the implementation of this management project, the Itapocu basin had 11 conservation units.

4.1.2 Project Development and Objectives of the Water Resources Plan of the Itapocu River Basin

The following section was written having as reference reports D, E and the synthesis report of the Water Resources Plan of the Itapocu River Basin (de Albuquerque Junior et al. 2017c, d, 2018). The selected goals and measures were chosen by the authors

taking into consideration how they involve government, HEIs and population, as well as how they improve sustainability in the community. The process of establishment of the goals and actions was developed in reports D and E. The first actions regarded uniting dealerships that are responsible for managing sanitation systems; agents of the government, such as the mayor and councilmen; private sector institutions, such as local industries and business; and environmental organizations. When brought together, these agents settled their objectives and needs related to the basin, as well as organized a schedule and budget.

Each agent agreed to provide a report on the results of the meetings and their interactions with the basin (water quality, water waste, extreme events and pollutants). Environmental education was an important and effective tool used in the project. Through environmental education it was possible to engage the population not only in the present, but also for the future. This practice enables people to learn what is sustainability and how, besides preserving the environment, it improves economic development of communities. The project linked environmental education with the main economic activities. The environmental education goal, besides being present in community schools, is form educators, researchers and stakeholders, which is where the partnership with the university is most important.

Public policies are another important element to ensure practices are being conducted properly. The project in Itapocu developed policies focused on surveying and water treatment. To aid public policies, the project created support actions which had the contribution of the community and helped define the priority of each policy.

4.1.3 Interactions Between Actors of the Water Resources Plan of the Itapocu River Basin

Section 4.1.3 was written based on report A and the synthesis report of the Water Resources Plan of the Itapocu River Basin (Oliveira et al. 2016, de Albuquerque Junior et al. 2018). The main actors identified were the government, the university and the community. This project had the participation of several government members, as the State Governor and his staff, the Secretary of State of Economic and Sustainable Development, the Director of Hydric Resources and the Manager of Hydric Resources Planning.

The government supported the development of the project and their participation is important in the local context through city halls and legislation; the university gathered and treated the data and is an important link regarding environmental education; and the community is constantly in touch with the basin and are the main responsible for maintaining sustainability through technology and knowledge received from other sectors. The goal of involving the community in all of the elaboration process in the hydric resources plan helps complementing the diagnosis' technical survey and is essential to ensure integration between management and planning actions. Society also collaborates providing information not present in regular data sources. They can also promote the project to more people in more successful ways,

provide opportunities for debate within communities and become the most aware stakeholders.

5 Results and Discussion: The Case of Unisul

This final section was based on all reports of the Water Resources Plan of the Itapocu River Basin (de Albuquerque Junior et al. 2017a, b, c, d, 2018) and seeks to presents results and discussion in the study case analysis. Reports have shown that in the last 50 years, most of the extreme events in the Itapocu river basin had hydrological origins, such as floods. Hydric resources stored in aquifers in the Itapocu river basin might work as a source of supplies to ensure water security in its region.

In around 40% of the basin's area, the main activities are agriculture, mining, urban areas, pastures, natural fields and reforestation areas, including 11 conservation units. Regarding basic sanitation, the situation is not different from Brazilian average and few families have access to sewage systems. The goals of Itapocu basin plan had as a parameter for accomplishment the number of users registered for each measure. However, meetings between stakeholders had great results, allowing the opening dialogue path that was previously nonexistent, connecting decision-makers, the scientific community and population, resulting in agility in political decision-making and saving time and resources. The project has constructed models based on current, moderate and optimistic scenarios regarding the Itapocu river basin.

If the current case scenario proceeds, there will be hydric stress in several points in the basin, while some regions, as sub-basins in the Putanga River, Jaraguá River and Piraí River are already under the effect of water scarcity. The moderate scenario presents changes in water saving and considers as a target a 30% reduction in water losses compared to initial volumes. However, even if losses were reduced, some sub-basins as Putanga River, Jaraguá River and Piraí river would continue to suffer with water scarcity.

In an optimistic scenario, a 25% reduction in water losses was set as a target. To that goal, decision-makers must be involved, since such a reduction in water losses might be enough to meet population demands, given that in all planning units there is enough water to meet the demands of the region. A deeper analysis in hydric resources management might contribute to mitigate the problem of scarcity, especially in urban centers; one alternative is to develop mitigating measures for some economic sectors, basic sanitation and solid waste management. The mitigating actions will be enlisted as follows in Table 4.

It is expected that with meetings, registrations and environmental education efforts, water resources can be used more efficiently and sustainably, and government, community and university partnerships might increase. Creating these reports allows governments to take specific actions to solve populations' problems, as improving water quality in critical places, create a scenario to avoid a hydric crisis, create an indicator plan for environmental sanitation, create programs directed towards hydric

Table 4 Proposals for mitigating actions in relevant areas for the project

Mitigating actions	
Agriculture	• Pre-germinated system (which consumes less water) • Superficial densification (avoids water loss through infiltration) • Frame cultivation system (efficient irrigation) • Proper use of fertilizers and soil correctives • Less use of pesticides and correctly management of their packs • Environmental license • Integrated production
Aquaculture	• Decantation ponds (these ponds reduce up to 60% of the pollutants through sedimentation of solids and nutrients suspended in water) • Water recycling • Use of the wetlands practice
Industry	• Treatment of the industrial effluents • Adequacy to current legislation • Zoning guidelines • Environmental education • Water reuse • Use of alternative water sources
Sanitation	• Sewage collection and treatment systems in every municipality of the basin • Monitoring of the treatment systems • Environmental education programs
Solid waste management	• Landfills • Recycling and selective collection networks • State policy of solid waste management • Environmental education programs

resources, establishing an organizational structure to support structural management, and prospection of financial funding sources.

6 Conclusions

The main goal of this study is to understand how HEIs can promote advances and acceleration of sustainable development and SDGs in surrounding communities through the case of a Brazilian Community University, Unisul. As a result of this study, we conclude that Unisul, using the Water Resources Plan of the Itapocu River Basin in a partnership with the State of Santa Catarina and the community, has obtained a satisfactory result, creating participative administration in the Itapocu basin, empowering and educating the local community. It is worth highlighting that the project has allowed a deeper environmental awareness of the community, developing environmental education and preservation activities that have shown the population how important ecosystemic services are to the local economy. In this sense,

local communities became more aware about the environmental challenges regarding the basin, as well as more resilient and prepared to face future challenges in the region.

Not only community security has improved, but the plan has allowed a larger involvement of the community in creating public policies, putting decision-makers, university and population in the same dialogue table. This has also allowed State Government to invest in accurate and specific actions, saving time and public resources. Since this is a complex and integrator project, it is understood that its relevance must be highlighted once it has allowed a significative increase in the sustainability of the region, connecting several different stakeholders and allowing an increase in resilience and environmental awareness by all players involved. In this sense, it is understood that HEIs such as Unisul have great capacity of changing and promoting development through research, the "possession" of knowledge and human resources.

In this study, it is understood that the university is a central actor in promoting sustainable development in communities. It is hoped that projects such as the Itapocu River Basin can be replicated worldwide, respecting differences in geography, politics, society, economy and environment; and allowing communities to grow stronger through HEIs.

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Collaborative Learning Through an Extension Program: Building Sustainable Knowledge and Challenges for Undergraduate Students

T. Corredato Periotto and J. Gonçalves Vicente

Abstract From the point of view of a collaborative methodology that opens possibility, for problem solving, proposing solutions and stimulating critical thinking, the Program of Excellence in Basic Education, extension activity, since 2014 at the Center for Higher Education in Maringa—Brazil. In line with the Sustainable Development Goal (SDGs), in defense of quality Education. Focused on the academic performance of 4th and 5th grade students, the Program currently serves 32 cities in the Northwestern Paraná. There are 103 schools that investigate the level of learning of 7674 students in the management of school education in the pedagogical dimension. Involved in the work execution are 380 students from different undergraduate courses. The objective of this work is to report the experience of students from other areas beyond teaching and knowledge through collaborative practice in an extension program. The involvement of students in this activity favored the development of their cognitive and social skills, the search for knowledge, teaching and learning that placed them in the position of in charged for their learning in a sustainable society.

Keywords Extension program · Collaborative learning · Quality education · Sustainable development

1 The Teaching-Learning Progress in Extension Activities

When planning the process of teaching-learning, the teacher needs to consider that the education is conceived inside and outside the boundaries of the school. When the student arrives in the school he/she carries along a cultural and knowledge baggage. In turn, Pedrosa (2007) emphasizes that the teaching-learning process happens when

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the student acts as the protagonist of his/her formation, a critical subject, an active improver of social reality.

When one has the opportunity to reflect the theory from practical actions, this approximation of the subject with the reality favors the restructuring of his/her thought and understanding of the complexity of what is being studied. The teacher's way of acting and the strategies are of utmost importance for learning, both for the student and the teacher. The teacher as articulator can use many possibilities linking teaching, research and extension, understanding that the educational process is centered on social interaction and mediation.

In this respect Periotto and Jacovazzo (2005) emphasize that the university environment, when proposing extension activities, enables the interdisciplinary of the studies. In the academic field, where the professional training of the student happens, the opportunities for the experience of the tripod teaching, research and extension are more evident having each one its importance. However, it is in the extension activity that the contact with the real and the interaction with the social are achieved.

It is through extension activities that teaching and research complete each other in the search and construction of knowledge favoring teachers and students involved, say Periotto and Jacovazzo (2005). This possibility of approaching the community outside the academic space is a great opportunity to exchange experience and prove the theory. Teachers, students and the attended community interact in an efficient way of teaching-learning from the real practice.

2 Collaborative Learning and Sustainability

Collaborative learning aims at the involvement and active participation of students, favoring the exchange of experience and is a possible methodology to adopt in different contexts, as pointed by Tapscoot (2010, p. 160). "[…] *the teacher was the wise man and should pass on knowledge to the students, who, grateful, had to write down the words of the wise man and reproduce them in exams*".

In the context of the collaborative activity, there is no subdivision into independent parts to carry it out. All participants contribute and engage themselves in tasks with one goal. This combined involvement ensures that the information shared during the questioning and discussion is available to all involved being possible to observe the relevance of its contribution and its meaning to the one who offered it and its representation to the group.

Regarding collaborative learning, it is evident that in this methodology the construction of knowledge has as its source the interaction and autonomy of those involved, both teacher and student and the community that is benefited from.

According to Demajorovic and Silva (2012), new opinions are formed when a group of students discusses, reflects, constructs hypotheses, resorts to the teacher and dialogues with each other. This requires engaging everyone in the building and sharing of knowledge. This collaborative way allows the experience experiences that puts to the test all existing knowledge and concepts (Silva and Soares 2011).

Collaborative practices are defended by Torres and Irala (2014) as a methodology for the shared understanding that is built from the commitment to teach and learn that each one of the involved aims at a solution.

According to Jacobi et al. (2009), collaborative learning becomes sustainable when there is a re-signification and re-interaction of shared information and concepts based on the experience of each student. Elkjaer (2004) emphasizes that learning must be understood as a social process that is established through collective or individual relationships.

To educate for sustainability, for Springett and Kearins (2001) is to meet the needs of the students when they seeks knowledge, respecting their limitations and giving room so that their potentialities are improved in a way that shared and built knowledge is not limited to a specific moment but, which serves as a basis or complements for future practice.

Working for sustainability in the educational context for Springett (2005), is not a simple task to the point of awakening in the student the reflection of the challenges that he/she can find in society. It is believed that extension projects in the field of education can be a challenging exercise in concrete experiences involving students from different areas of knowledge and levels of training.

Jacobi et al. (2011) complement that the possibilities such as scientific meetings, communications, discussion groups and other dynamics that favor the exchange of experience, research in the collaborative format contribute to the development of values and attitudes that consolidate sustainability considering nowadays aspects and prospecting for the future. Corcoran and Wals (2004, p. 3) add that "*higher education can play a central role in transforming society towards sustainability*".

In the university context, when undergraduates are in the process of professional training and personal identification, Klavins and Pelnena (2010) highlight that there is a universe favorable to involvement and reflection on sustainability. Thus, the organization of extension projects that open space for collaborative practices can be recognized as a methodological strategy that involves sustainable development. When contemplating real situations, provoking the students in the development of their abilities to solve transdisciplinary problems, this is realized, it is not only a matter of finding a solution or path. It is the breaking of paradigms that often prevent the necessary changes from happening.

3 Methodology

The universe surveyed contemplates 103 schools of the public network of basic education in 32 municipalities belonging to the Northwest region of Paraná. Those involved are 7674 students in kindergarten, 4th and 5th grade, the director, pedagogue, teacher and other school staff, families and organized civil society. This is an exploratory research, since there will be the direct involvement of the researcher. As for the procedures, it is characterized as a field research, as it uses different resources such as action-research for data collection (Marconi and Lakatos 2011). Regarding

the approach, this is a qualitative research considering the proposed objective and the public served.

As for the procedures, different actions were carried out involving 380 students from the following courses: Master on Knowledge Management, Specialization in School Management, Logistics Management, Internet Systems, Psychology, Civil Engineering, Nursing, Public Management, Law, Physiotherapy, Accounting, Biomedicine, Human Resources, Administration and Pedagogy of UNICESUMAR.

The actions performed by the students under the supervision of their teachers were: field research to identify the problems and deficiencies found in the assisted schools; application of a structured questionnaire; preparation and application of an assessment of Portuguese and Mathematics; training workshops for the director, pedagogues, teachers, other school staff; families and organized civil society.

The activities involved data collection, diagnosis, organization of thematic workshops and training lectures, preparation of reports, interpretation and discussion of information. This contact with the investigated individuals, schools, families and representatives of organized civil society has promoted a rich laboratory of experiences for students.

4 Results and Implications

Created in 2014 by the UNICESUMAR Program of Excellence in Basic Education (PEEB) extension activity that has the proposal of investigating how the management of school, teacher, family and organized civil society can impact the development of quality education of the city public network has been showing itself as a suitable space for collaborative learning.

For the university elementary school is not unfamiliar because, they have already been through it when they were beginning to study. In the training stage in which they are, they can see themselves by another perspective to identify situations that can negatively and positively impact students' performance.

From its foundation until this moment (PEEB) in the execution of its actions, relies on the involvement of teachers from different areas of knowledge and their students. In this respect, Periotto-Corredato and Vicente (2017, p. 426) agree that "[…] *quality education is a common right and cannot be understood as a neutral and isolated element. It is built, considering public policy in all spheres, the actors involved and their personal and social interests*".

The study universe attended by (PEEB) is of 32 municipalities in 103 school units of the city public education network, specifically the 4th and 5th grade and all professionals who work in the school, the director, pedagogue, teacher, support staff, as well as the family and organized civil society, which play a key role in the success of basic education.

Since 2015, searching for answers that could contribute to quality education for all as listed in the (SDGs), the (PEEB) gave opportunities for reflection and shared learning among 380 students from UNICESUMAR in the following courses: Master

on Knowledge Management, Specialization in School Management, Logistics Management, Internet Systems, Psychology, Civil Engineering, Nursing, Public Management, Law, Physiotherapy, Accounting, Biomedicine, Human Resources, Administration and Pedagogy and their teachers.

The participation of these students took place from the beginning of the (PEEB) activities and continues nowadays, alternating groups, courses and actions. The activities already carried out and that enabled collaborative learning, occurred with the application of the evaluation books to find out the level of knowledge in Mathematics and Portuguese, in addition to a socioeconomic questionnaire for 7674 students in kindergarten and, 4th and 5th grade, with the participation of students from the Management in Logistics course. Psychology students took responsibility for raising the readiness level of the kindergarten including their reading and writing skills. The teachers, directors and other professionals of the school were involved in the Physiotherapy course that worked with the health of the education professional. They collected data on posture, weight, habits that could have repercussions on some discomfort during the execution of the work.

The contribution of the group was very promising, because facing such responsibility, after arguing among their peers, they resorted to a course teacher to validate their decisions. This teacher rescued the theory and challenged them to find an optimized solution for the distribution of materials and typing the data.

It is worth noting here interesting moments in which some of them, when presenting their proposals, recognized that they would only succeed if there was the complement of the suggestion of another group member. At the end, this group presented two proposals named as belonging to the group and it was the responsibility of the PEBE coordinators to decide to save time or energy.

When executing the accepted proposals, it was clear the readiness, self-reliance and maturity with the activity. They were clear that if any step failed the whole would be compromised. Students of the Management course in Human Resources and Administration organized the teams to collect the material and counted the expenses and the procedures to be used to present them. Some students, on their own initiative, have volunteered to take on some of the functions in advance.

Timely following the same proposed script for the evaluation notebooks, the directors, pedagogues and teachers of each school also responded to a socioeconomic questionnaire that was under the responsibility of another group.

After the application of the instruments for data collection, at the end of that stage, the coordinators of the (PEEB) promoted a meeting. They were able to listen to the individual manifestations and considerations of the teams that were formed. There was a sense of unit, different from that of when they began. They felt part of the (PEEB) and even rehearsed some interpretations regarding the experienced context.

During data typing phase, a new formatting of teams was presented and it was reformulated from the performance and commitment to the work that required a set of conditions needed for that activity. At the end of this stage, the (PEEB) coordinators presented the new actions that were: return and diagnostic, organization of thematic workshops and training lectures, preparation of reports, interpretation and discussion of information. All of them had the participation of the students guided by the teachers of the respective courses.

5 Conclusion

The collective construction of knowledge occurs from the moment the student is in the stage of maturity to contribute and receive through an active process of intellectual development. Participating in extension activities is to provide opportunities for cognitive autonomy and social interaction, characteristics of collaborative learning.

The (PEEB) by opening opportunity for the collective construction of knowledge in its execution, provoked the participants to seek theoretical and informational apparatus, to fill their own learning gaps and to respond to the group's need. They have been challenged to self-evaluation as citizens, students and future professionals with the capacity to create and enjoy a responsible and sustainable future.

Contact with the outside community, schools, families and representatives of organized civil society, and involvement with extension activities as a whole, promoted a rich laboratory of experiences Although there is a diversity of areas of knowledge, the integration of knowledge according to the collaborative methodology, considering the panorama of basic education of the municipal network, participants got involved with the project and with the group. They sought theoretical and informational instrumentalization to fill their own learning gap and to respond to the group's need. They were provoked to self-evaluate as citizens, students and professionals with the capacity to create and enjoy a responsible and sustainable future.

There is still a long way to go but it is believed that enabling the exchange and construction of knowledge through collaborative practices in higher education in order to look at basic education with the perspective that the quality of Education is not only the commitment of the of society as a whole, in a manner that it can be proceeded in a sustainable way.

There is no more space for retrogressive methodologies or only limited to classrooms, Information is accessible to all social layers and in real time. Extending the learning space of higher education students in a collaborative way looking at basic education, is thinking about the sustainable future of education.

The university environment, when proposing extension activities, makes possible the interdisciplinary studies. In the academic space where the professional training of the student happens as an opportunity for the experience of the tripod: teaching, research and extension are more evident in each of its importance. However, it is in extension activity that the contact with the real and the interaction with the social is materialized.

The opportunity to go to the field following the planned strategies in search of the satisfaction of the objective outlined by the (PEEB), and the experience in the investigated context, generates critical manifestations and, from them, discussions and reflections on their own performance as an undergraduate student, future professional and political citizen. Following the collaborative methodology, participating students can offer support to others in different areas, which leads to an additional improvement of the knowledge they possess.

In this scenario, the proposal of extension programs such as the PEEB, which opens space for interdisciplinary collaborative practices in the area of basic education, can contribute to the implementation of the 4th Sustainable Development Goals, which is Quality Education.

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Universities, Regional Development and Sustainability

Walter Leal Filho

Abstract This final paper summarises some of the lessons learned from the book and outlines some areas where further action is needed, and via which universities may maximize their contributions in fostering sustainable development at the local level.

Keywords Universities · Sustainability · Higher education · Regions · Science

1 Introduction

Universities are widely acknowledged as institutions where the combination of good quality teaching, well founded research and an extensive programme of extension (i.e. courses, seminars and events targeted to further and continuing education) provides a significant contribution to a country's scientific and economic development. Universities are institutions constantly in transition and always developing themselves (Göransson and Brundenius 2011). They are also proven to help to develop the human capacity in their regions (Abel and Deitz 2011).

No matter where they are located, it is a matter of fact that Universities are intimately associated with the city they are based. This is particularly so in cities of small (up to 90,000 inhabitants) and medium sizes (e.g. up to 200,000 inhabitants) where local universities are important employers (sometime being the top or number two after the city administrations). In these contexts, universities can very much influence a city's cultural diversity and the existence of amenities. In all cities hosting universities—be them large or small—there are theaters, cinemas and a lively programme of cultural activities. In addition, in those cities which host many universities this trend is even clearer: not only the high number of university students means that the substantial infra-structure needed to host them is available (from public transport to housing), but also because their purchase power is very important to the economies

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of the hosting cities. Indeed, in cities which host 5 or more universities (e.g. London, Hamburg, Paris, Madrid, but also Tokyo, New York, San Francisco or Toronto) the sheer students numbers mean the provision of direct and indirect employment to tens of thousands of people, from university services to restaurants and entertainment.

In many contexts, the very title (official name) of the University reflects the city or region they are based at, in a clear demonstration of their local affinity. Examples such as the University of Bradford (UK), University of Aalborg (DK), University of Hamburg (DE), University of Gröningen (NL), University of Padova (I), Oporto University (P), Uppsala University (SE), to name all but a few, attest this. But it is not only a matter of location. The study programme of many universities is often directly linked to their geographical position. This explains why the small University of Freiberg—a mining area in eastern Germany- offer an extensive study programme in mining, whereas the University of Bergen in Norway (surround by oil fields) has an extensive off-shore engineering programme.

2 Universities and Regional Development

The links between sustainability and universities in a regional development context offers however a different picture: comparatively few universities (and, *inter alia*, cities) have a strong sustainability profile which can be promptly associated with their regions. Indeed, it is fair to say that across the world many regions are lagging behind and are missing the various opportunities teaching and research on matters related to sustainable development offer, because the links with universities in this area are not so strong as they could be. This is not to say that these universities are not aware about what sustainability is and what they can do for their regions. This is not the problem. It is a noticeable, sheer lack of local and regional emphasis, that disturbs: sustainable development is, along with climate change, one of the most important challenges of modern times. Yet, it is central to the activities of only a handful—albeit growing—number of universities. Figure 1 describes some of the elements which illustrate the links between sustainability and regional development.

In an earlier work, Leal Filho (2010) has outlined the fact that proportionally little emphasis seems to given to sustainability by large universities. Indeed, many universities perform activities in the area of environmental protection (e.g. energy savings programmes, waste management, etc.) and regard this as their contribution to sustainability, neglecting the fact that operations at the regional level are also very important.

In order to claim excellence in the field of sustainable development and to be relevant to their regions, universities need to have fulfill six main criteria:

1. the existence of a core number of staff who have formal qualifications in the field by means of doctoral degrees on matters related to sustainable development and who are interested to work regionally;

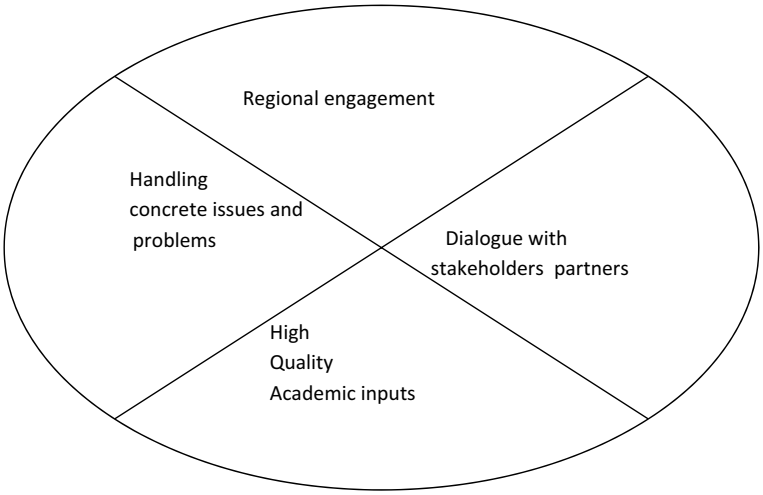

Fig. 1 Sustainability and regional development

2. the existence of a strong publications profile on sustainable development issues published in international journals, which address regional issues;
3. the existence of a robust research programme with externally-funded projects handling sustainable development matters which are relevant to their regions;
4. the implementation of principles of sustainable development with a regional perspective, as an intrinsic part of university teaching programmes;
5. the integration of sustainable development in the context of university activities and operations (e.g. campus greening) with local links;
6. the existence of a programme of extension (outreach) on sustainable development topics, for the non-students public at the local and regional levels.

It is admittedly not easy to fulfill all these criteria. Most universities will fulfill a couple of them, but there are only few examples of universities which provide an emphasis to all six criteria, which would be an ideal scenario.

This state of affairs suggests that action is needed in order to allow universities to integrate sustainable development in regional development. Some of the measures that can be undertaken without a great deal of extra resources are:

(a) **Fostering the links between the theory and the practice of sustainability**: by means of case studies, pilot projects and regional initiatives on-the-ground, it can be illustrated how close to reality sustainability is and how cities and regions may benefit from it. There are various good examples of initiatives which provide an excellent basis against which the real value of regional sustainability efforts can be seen. One of them is the initiative RCE (Regional Centres of Expertise on Education for Sustainable Development), created in response to the United Nations Decade of Education for Sustainable Development (DESD, 2005–2014). The RCE networks address local sustainable development chal-

lenges through research and capacity development, hence contributing towards fostering closer links between universities and their regions.

(b) **Going into the specifics**: although the broader, theoretical discussion on sustainability is helpful, there ought to be more attempts to get into specific issues and themes of regional relevance. For example, energy use, sustainable water consumption or sustainable production are some of the contexts where there are relevant approaches can regionally be used, and in the context of which clear outcomes can be expected.

(c) **Disseminating the value of sustainability**: a major problem seen in both industrialised and developing nations alike, is that the value of approaches towards sustainability is not widely acknowledged. A further problem is that not all good experiences are duly documented, a problem publications going as far as 1999 (book "Sustainability and University Life", Leal Filho 1999), "Teaching Sustainability at Universities" (Leal Filho 2002) or the "Handbook of Sustainability Research" (Leal Filho 2005) have tried to address. Here there is a clear need for more demonstration and information, so as to raise its profile, which may lead to increased acceptance and hopefully, further use.

There are at present signs that the subject matter of sustainability is progressively being disseminated as both an aspect of teaching programmes and as a context for research. As demonstrated by Leal Filho et al. (2018) the ground for the introduction of concepts of environmental education and sustainability at the regional level is very fertile. However, prior to being able to fully take advantage of the degree of acceptance sustainability has, it would be important to cater for the training needs of university staff, so that they feel confident to introduce concepts of regional sustainability as part of their works. The same applies to students (Shephard et al. 2015) who need to be more actively engage on sustainability affairs.

As seen in the data and examples described in this book, which are symptomatic of the reality in many institutions of higher education, a certain degree of preparedness to pursue sustainability needs to be felt at the regional level. This state of affairs is also seen in some developing countries, where innovation at university level takes place at a relatively lower pace than in industrialised nations and where the lack of resources sometimes prevent active engagement on the debate on regional themes. But a number of features need to be put into place so as to enable all universities to fully engage on the debate on sustainability and take advantage of the opportunities it provides. Some of these are:

i. a greater understanding of the role may play in implementing regional sustainable development;
ii. more reliable in-service training provisions on matters related to sustainability to academic staff;
iii. set-up of research centres or working groups to debate how best to pursue regional sustainability via specific initiatives;
iv. development of partnerships and networks (intra-institutional and inter-institutional) to exchange ideas and experiences;
v. the setting-up and execution of specific projects.

Last but not least, attempts to implement regional initiatives related to sustainability at universities should be followed according to a proper structure (e.g. Regional Sustainability Programmes, Regional Sustainability Action Plans, etc.). Although this is not always possible or easy, it helps to provide a sense of direction as to where efforts are going into. They also help to measure results against aims within a number of months or years. Such results are, without any doubt, the most persuading arguments in dismissing, once and for all, misconceptions about sustainability.

3 Conclusions

One of the first documents outlining the need for further engagement of universities into environmental affairs, the "Magna Charta of European Universities" promulgated in Bologna in September 1998, states that:

> …universities must give future generations education and training that will teach them, and through them, others to respect the great harmonies of their natural environment and of life itself.

Among the most effective ways of achieving this, mention can be made to the need to afford sufficient emphasis to sustainability, since it deals not only with "ecological" matters, but also with the pool of factors that influence the environmental balance and quality of life.

Although the value of regional sustainability initiatives is broadly acknowledged within the university community, there are still various barriers that need to be addressed so as to clear the way for action. Prior to being able to undertake long-term works in this area, it is important that current misconceptions are also duly addressed. One of the ways to do that is via concrete initiatives at the regional level, in the framework of which the practicality and efficiency of sustainable approaches are shown. This need, which has been largely overlooked in the past, should be duly addressed, since it is not only responsible for the lack of action in the past, but future, long-term progress depends on it.

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