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Exploring the Local Sustainability Approach Using Indicators

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Abstract

The purpose of this research was to analyze the application of the Barometer of Sustainability (BS) as a tool for monitoring the sustainability process, using the case of the municipality of Ribeirão Preto, Brazil. The method adopted was based on the important seven stages for the BS application. The methods used were exploratory, descriptive, analytical and field research approaches, combining primary and secondary data. BS as an evaluation tool has proved useful in contributing to the understanding of social and natural phenomena, providing the monitoring of sustainability on a local scale. The findings indicated that the municipality had a greater concern with socioeconomic issues in relation to environmental issues. Based on BS, Ribeirão Preto was classified as intermediate level in relation to Sustainable Development, presenting better performance in the Human Subsystem. To solve the main methodological difficulties related with sustainability indicators to measure the sustainability dimensions on local level, and transpose these challenges is a continuous and emergency process. The integration of information from institutional bodies and sharing of data are paramount for public management at the municipal level to help develop and consolidate national databases. In this paper the authors demonstrated that is necessary to develop efficient methods of sustainability evaluation for local practice to develop policies and actions and add value in the decision-making process of local governments.

Keywords: sustainability indicators, barometer of sustainability, local sustainability

1. Introduction

For some time we face challenges in the efforts to turn our attitude and behaviour towards nature and society in a more realistic and responsible direction. The interaction among three pillars that are economic, ecological and social systems should be based on a holistic worldview. In this perspective, the concept of sustainability and wellbeing depend on interplay between the three pillars (Ingulfsvann, Jakobsen, & Nystad, 2015).

Sustainable development is a concept that comes from a long historical process and suffering various interpretations (Imaz & Sheinbaum, 2017), which brings together various themes as it reaches and meet several different questions, like an approaches, goals, content types, aspirations and desires. Sustainability must be dimensioned and measured, analysed by own criterious, based on decision-making process. Many ways to measure sustainable development are disponible to propose this way of measuring, each of which provides potentially useful, though particular and different, insights from multi-stakeholders, including government, policy makers, academics and the general members of society (Ramos & Caeiro, 2010). According to Hanley, Moffatt, Faichney and Wilson (1999) and Ginson (2006) as a multifaceted concept, sustainability concept claims aggregate measures, based on different sustainability domains and their integration, that in due assessment course define whether a system is sustainable or not.

Based on Sustainable Development concept, Meadows (1998) defines the concept of wellbeing human as encompasses individuals' capacity to achieve happiness, self-respect, self-realization, community, transcendence, and enlightenment, involving health, social relations, freedom of choice and material needs. Daly (1991) argued that is crucial managing a stock with wellbeing components to provide the continued satisfaction of our wants and needs inherently involves protecting the throughputs that replenish that same stock. Also is necessary to consider the ecosystem in this perspective, because it is integrated on human life of inseparable way (Prescott-Allen, 2001).

Evaluation sustainability methods have proliferated during the last few years, and the abundance of these initiatives were considered the “indicator industry” (King, Gunton, Freebairn, Coutts & Webb, 2000; Hezri and Hasan, 2004). Many indicator sets have been assembled, but none has been widely implemented, and their integration to support self-regulating sustainability is still a major challenge (Moldan & Dahl, 2007). Despite the high number of Sustainability Indicators initiatives undertaken on a national scale, there has been little work done on interaction at the national, regional and local levels (Ramos, 2009). It demonstrated the need of efforts to articulate and developing sustainability assessment systems at municipal level as a starting point to provide primary databases for the construction of information at the regional and national levels. Developing of Information platforms which will set the stage for policies with action plans is important in determining which environmental projects should be prepared (Bostanci & Albayrak, 2017). However, these methods are expensive and often time-consuming to conduct, but are an important part of the assessment process, considered an unappealing and difficult task. On the other hand, making the results comprehensible and meaningful to the general public is also challenging but essential if evaluations are to be translated and inserted into policy and action (Becker, 2004).

We are living at a time when modern information technologies increase the flow of information but not our ability to absorb it in the same speed, we need information tools that synthesize and digest information for rapid assimilation while making it possible to explore issues further as our need. This is one of the goals of indicators that are symbolic representations designed to communicate a property or trend in a complex system (Moldan & Dahl, 2007). According to Chapter 40 in Agenda 21 from United Nations Conference on Environmental and Development, Indicators to sustainability should be used to collect, process, and use information with the goal of making better decisions, directing smarter policy choices, measuring progress, and monitoring feedback mechanisms (Ramos & Caeiro, 2010).

Sustainability Indicators should measure characteristics or processes of the human-environmental system that ensure its continuity and functionality far into the future. Specifying the characteristics of the system to be maintained can be very subjective and specific, and political, philosophical, and cultural differences may prevent any wide consensus (Moldan & Dahl, 2007). To guide the sustainability approach we must follow on its principles. According to Hardi and Zdan (1997) these principles, called the “Bellagio Principles”, serve as a guide for the application of a sustainability assessment system. The idea behind of these principles was that harmonization is not simply a matter of selecting common frameworks and indicators, but of following a common approach of developing and using measurement systems as an integral part of how institutions and society working (Pintér, Hardi, Martinuzzi, & Hall, 2012).

The consolidation of a “standard” methodology that generates information that offers consolidated sustainability results and meets all needs at all scales is still much discussed and criticized by scientists. Among the tools of evaluation of Sustainable Development that allow to evaluate the levels of sustainability, those that are considered more associated to the theme are: Barometer of Sustainability (Prescott-Allen, 2001); Dashboard of Sustainability (Hardi, 2000); Ecological-footprint (Wackernagel & Rees, 1996); Sustainability Environmental Index (World Economic Forum, 2001); Pressure, State, Response (United Nations [UN], 1996); Global Reporting Initiative (World Business Council for Sustainable Development [WBCSD], 1992, 2001); Compass of Sustainability (Atkinson et al., 1997); Driving, Pressure, State, Impact, Response (European Environment Agency [EEA], 1999); Human Environment Index (Singh, Murty, Gupta, & Dikshit., 2009; United Nations Environment Programme [UNEP], 2000), among others. Both synthesize quantitative information, reflecting qualitative analytical aspects.

The evaluation tool chosen for the present research was the Barometer of Sustainability (BS) that allows to understand, evaluate and communicate the society on the interactions between man and biosphere, in an objective and scientifically proven way. BS is a methodology for assessing sustainability developed by Prescott-Allen, as evidenced by The Wellbeing of Nations in 2001, supported by the International Union for Conservation of Nature and Natural Resources (IUCN) and the International Development Research Center. The methodology for building BS is flexible, not composed of fixed indicators, and allows the construction of Performance Scales, which contains the intervals of degrees of sustainability and have comparative attributions. This methodology combines indicators of human wellbeing (social, economic and institutional) and ecological (ecosystem) wellbeing, which can be applied from the local to the global scale.

BS has been used in some researches in Brazil, in different space cuts (local, regional, state, national). Among municipalities in Piracicaba Basin (São Paulo State) and Minas Gerais State, most cities were considered unsustainable (Braga, Freitas, Duarte, & Carepa-Souza, 2004). The municipality of Teresópolis, in Rio de Janeiro State, was classified as an intermediary (Silva, 2006). The metropolitan areas of São Paulo and Belo Horizonte were classified as unsustainable (Braga, 2006). The municipality of Campina Grande, in Paraíba State, was classified as almost sustainable (Barros, Amorim, & Cândido, 2009), and in the same State, the municipality of João Pessoa was considered at the intermediate level in relation to sustainability (Lucena, Cavalcante, & Cândido, 2011). More recently, BS was also applied in two municipalities of São Paulo State (Machado, Duft, Picoli, & Walter, 2014) from the perspective of sugarcane production. As an example of the statewide approach, experience in the Rondônia State can be cited, which pointed to the level of almost unsustainable (Siena, 2008). On the national scale, we can cite the study carried out for Brazil (intermediate level classification) developed by Kronemberger, Junior, Nascimento, Collares and Silva (2008).

The aim of this research was to analyze the application of the Barometer of Sustainability as a tool for monitoring the sustainability process, taking as a case the municipality of Ribeirão Preto, Brazil, using available data in timeline 2009-2012. The main issue for the use of this timeline is that the research was developed with data base and information reports available in 2013. For this, we used the most updated data at that moment of data collection. The data used were used to test the application of the sustainability assessment tool, and to identify its weaknesses and potentialities in use at the municipal level.

1.1 Barometer of Sustainability

BS was designed and developed by a team of interdisciplinary researchers, and with the support of researcher Robert Prescott-Allen, from the institutions International Union for Conservation of Nature (IUCN) and International Development Research Center (IDRC) (Prescott-Allen, 2001). This tool is part of the System Assessment Method (SAM) (Prescott-Allen, 1999; Singh et al., 2009), and works to monitor human and ecological conditions related to the progress of sustainable development. It was created to increase the perception of the whole and to understand the interaction between society and the environment, in a coherent way, and to have a broad vision of these two subsystems. It brings in essence the need to integrate and organize data in order to effectively assist the representation of the environmental and human diagnosis (Prescott-Allen, 1999).

Human and Ecosystem Wellbeing Assessment had its first phase in the years 1994 to 1996, where evaluation approaches were tested by teams along with IUCN offices, supported by IDRC, in Colombia, Zimbabwe, India, America Central, South Africa and Pakistan (Prescott-Allen, 1997). In a second moment, from 1997 to 1999, Robert Prescott-Allen begins to develop substantively his work with the IUCN and his own model of evaluation, publishing The Wellbeing of Nations in 2001, evaluating 180 nations. This book assumes that Sustainable Development comes from combining human wellbeing with the ecological wellbeing. This hypothesis is evidenced in the Egg of Wellbeing Egg metaphor. This metaphor demonstrates that just as an egg is only good if the egg white and the yolk are good, then its simbolize that society is sustainable only if this society and ecosystems are well (Guijt, Moiseev and Prescott-Allen, 2001).

The stress flow of people in the ecosystem is from pollution, high level of resource consumption (energy, water, etc.), poor conservation of natural resources (eg aquifer contamination), technological deficiencies (eg, oil spill), etc., as well as the benefits are the conservation and preservation of natural resources, reuse and treatment of waste, etc. The stress flow of the ecosystem in people is the effects of natural disasters (eg tsunamis, storms, hurricanes), severe climate change, soil erosion, etc. (Prescott-Allen, 1999, 2001; Bossel, 1999).

The selection of indicators to compose the BS is based on hierarchical method, composed of seven stages, called the Seven-stage Cycle for assessment, which helps to justify the importance and relevance of the chosen indicators in relation to the concept of Sustainable Development, making perceptible deficiencies and needs of the physical space considered in the study.

The Sustainability Assessment method described above is developed by combining a reflective process and measurement through data gathering and handling. Reflection on individual perspectives about sustainability or specific groups to think about their contexts in a structured model, prompting them to consider difficult issues, look for patterns and make judgements. Furthermore, is necessary that the process of identifying performance indicators, collecting data and combining findings and results to obtain an overall situation of specific themes or sustainable development in general perspective be understood as a key issue in all steps to this assessment cycle (Guijt, Moiseev, & Prescott-Allen, 2001). The method can be adapted for use at many levels, from global to local, but cannot be applied on organizational and individual level. The agents involved in assessment process define what the system is on which they wish to extract as information of the assessment, but according to

Prescott-Allen (2001) this method is less appropriate on geographical scales less than 100km². Each stage of sustainability assessment by BS is described below:

Stage 1. Determine the purpose of the assessment: this stage highlights key questions that are crucial for the evolution to the next stages, questioning: Why is evaluation necessary? Who is it for - who will use the results? What will be the scope of the evaluation? With whom will it be held and how will they participate? How will the necessary tasks be performed and what will be the sequence?

Stage 2. Define the system and goals: stakeholders involved in assessment should decide which are main human and ecosystem aspects to be taken into account, creating goals that will be sought from the desired objectives in the observation of needs and in identification of relevant elements. These elements are key issues or concerns that must be considered in order to obtain an adequate sense of the state of each dimension. The objectives give support to the elements, providing a logical bridge between the general objectives of the research and the system and subsystem, being an important part in the elaboration of the performance scales and the evaluation criteria of these scales.

Stage 3. Clarify dimensions, identify elements and objectives: the dimensions are five, according to the common system of dimensions for the construction of the Barometer of Sustainability. The framework of dimensions ensures the inclusion of key components for any sustainability assessment system. In this stage, it is necessary to identify the elements, sub-elements and objectives. The elements are grouped in dimension and reflect fundamental aspects or issues that characterize the conditions of the human and ecosystem subsystems. Sub-elements are a more specific category: if the element is very broad, it can be divided into two or more sub-elements.

Stage 4. Choose indicators and performance criteria: The choice of indicators must meet four characteristics (be measurable, representative, reliable and feasible), so that, from the combination of these selected indicators, it is possible to generate indices that do not distort the results.

Stage 5. Gather data and map indicators: within the evaluation, the result of the indicators should contemplate their choice and tabulation of the recorded data, always organized according to performance scale criteria adopted. The evaluation needs to compose its own database, make agreements with existing data sources, receive them regularly and organize surveys and monitoring systems for all indicators.

Stage 6. Combine indicators and map indices: using the score obtained in the previous stage, must have performed the requirements of the previous stages to feed their system. After processing the data in the dimensions, it is necessary to generate indexes that will result in a visual representation in the Barometer of Sustainability. The combination of the data treated is reflected in indexes that provide a measurement of Sustainable Development, assessing the interaction between society and the environment.

Stage 7. Review results and assess implications: the review of results enables users to examine the links between indicators, standards used for assessing performance scales, opportunities sighted, strengths and weaknesses, and obstacles to overcome, considering the elimination of many implications for next scenario.

2. Method

2.1 Ribeirão Preto, Brazil as an Analysis Subject

Several instruments to promote the sustainability of development in the face of climate change, environmental, and society-related phenomena have been discussed and need to be put into practice. According to Fernandes, Malheiros, Philippi Jr and Sampaio (2012) in these cases social participation in the decision-making process, respect for the precautionary principle, transparency of the management system, investments in science and technology, adequate proportionality between the dimensions of sustainability are some of the changes that the paradigm of sustainability proposes. The municipal management in Brazil contemplates a wide set of variables that make complex the processes of decision making in public management. Among these variables we must consider the importance of the relationship between natural resources and anthropogenic activities, due to the high population concentration and high levels of pollution. This can be proven in large municipalities in Brazil, as was proposed in this paper presented here.

The choice of the municipality of Ribeirão Preto as a subject of research happened with the emerging need to communicate the society about the levels of local sustainability, motivating the public power to make feasible studies in the ecological, economic, social and institutional spheres. The information resulting from these studies can guide management at the municipal level in relation to sustainability. This could broaden the vision of all the actors involved in municipal management, triggering new discussions about factors that may enable a way to promote development in the municipality, not forgetting the social and environmental demands.

Ribeirão Preto has been demonstrating significant economic growth in recent years, and the consequences of this progress can not be disregarded. The idea of evaluating the human and ecosystem wellbeing in this municipality was due to doubts as to whether the two dimensions progressed concomitantly. Urban and social equipment, derived from local development has an impact on the physical environment, modifying the interactions between human and ecosystem, recreating social and environmental conditions. There is a need to understand the environmental consequences within the economic evolution of the municipality, and if there is any apparent mismatch between human and ecosystem wellbeing.

2.2 Characterization of the Study Space

The study area of this research is the municipality of Ribeirão Preto, located northeast of the State of São Paulo, Brazil, 313 km from the capital São Paulo city. The total area (urban and rural) of the municipality is 650.92 km², with a degree of urbanization of 99.72 per cent, and a population of 669,180 inhabitants (State Data analysis System Foundation [SEADE], 2018). The municipality of Ribeirão Preto is part of the Water Resources Management Unit 4 (named UGRHI 4 - Pardo), which is composed of 23 municipalities, being supplied by the Guarani Aquifer, which according to Environmental Company of the State of São Paulo [CETESB] (2018) is the largest water source trans-boundary underground in the world.

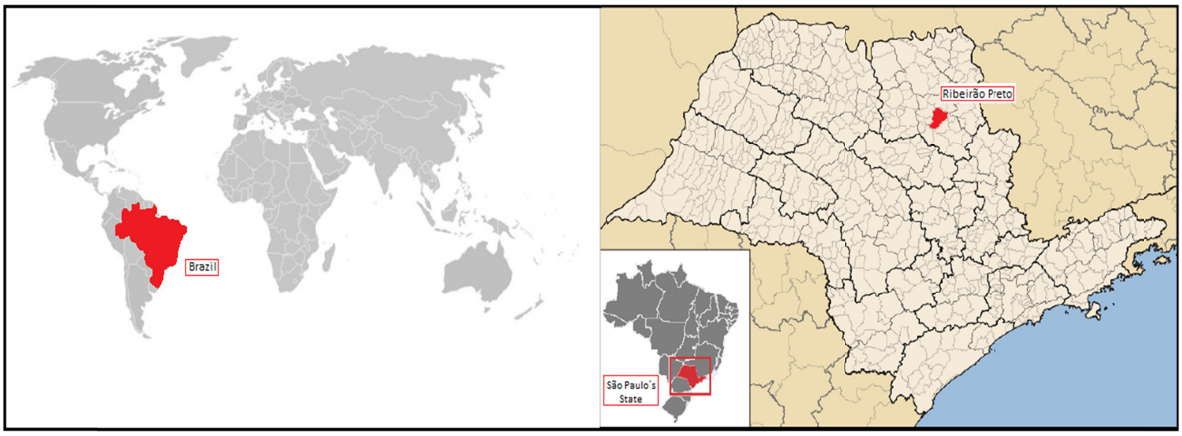

Figure 1. Identification of the subject of study - Ribeirão Preto, Brazil

2.3 Research Steps

The method used in this research was based on Seven-stage Cycle for application of the Barometer of Sustainability (Guijt, Moiseev & Prescott-Allen, 2001), with exploratory, descriptive, analytical approaches and field research (Bhattacherjee, 2012), with application study case in Ribeirão Preto, Brazil. Also were made tabulation of data, composed of interpretative elements combined with the findings, allowing comparison, contrast, measurement, classification, interpretation and evaluation of the results. It was based on calculations from scientifically tested instrument that generates a graphical result with quantitative and qualitative characteristics. The calculations were developed from official data, considered as reliable and with scientific validity. The results of the calculations and the final results were aggregated by themes and analyzed. The Seven-stage Cycle for the application of the Barometer of Sustainability, already mentioned in the theoretical framework, was the main methodological resource used and crucial both in the aspect of the research process and in the execution of the research planning. Interactively complemented the study and helped bring elements from the institutions and stakeholders consulted to systematically organize the results.

As recommended by Sauders, Lewis and Thornhill (2009), in this study the field research had a complementary function, not only for collecting primary data to support conclusions, but also for obtaining restricted information from data source departments. This helped to understand the limitations and the relationship between the various institutional bodies of the municipality. According to Bhattacherjee (2012), facts and phenomena occurred and observed in the field research contributed to the recording of variables that, perhaps, could not be scored in the application of an indirect method. The discussion with institutions about the themes of this research facilitated complementary observations for the development of methodological rout.

2.4 Selection of Indicators to Compose the Barometer of Sustainability

The selection of indicators for the composition of BS tool was made based on secondary data available, adding other primary data collected in the field that helped to understand the dynamics of sustainability dimensions in the municipality. According to Sauders, Lewis and Thornhill (2009), secondary data consist both raw data and published summaries, and most types of organisations collect, gathring it and incorpore this variety of data to support their operations, transforming them into information. Also include both quantitative and qualitative data, and they are used principally in both descriptive and explanatory research. Moldan and Dahl (2007) defines primary data primary data as the findings collected by yourself, without using intermediate sources. Most research questions are answered using some combination of secondary and primary data (Sauders, Lewis & Thornhill, 2009). From the data collected, the performance scales were elaborated, which are divided into five sectors, defined by values that represent conditions ranging from unsustainable to sustainable. Such values are goals to be achieved or standards set globally, nationally or locally (Prescott-Allen, 2001).

Each component dimension of BS was supplied with a significant number of indicators, to better support the analysis of the results, but in each dimension and theme, the number of indicators is conditioned by the diversity of aspects present and the availability of data. One of the main directions for the research was to gather the highest number of indicators for each theme, to reduce the individual effect of each indicator, avoiding some kind of trend. The higher the number of indicators the more representative it is, and its result is more robust and robust.

2.5 Transposition of the Indicators into the BS Assessment Scale

An important step of the research was the transposition of the numerical value of the indicator to the Barometer of Sustainability scale. It was done using a simple linear interpolation formula that indicated the quality interval at which a given indicator was allocated. The mathematical formula below shows the transposition of scales and the relation between MD_x (Municipal Development) and BS_x (Barometer of Sustainability scale), whether the scale of Municipal Development increasing or decreasing. This is done in the operation of calculating the degree of the local indicator in the Barometer of Sustainability scale:

$$BS_x = \left\{\left[\frac{(MD_A - MD_X)(BS_A - BS_P}{(MD_A - MD_P}\right](-1)\right\} + BS_A \quad (1)$$

A = previous boundary of the range containing X. P = posterior boundary of the range containing X. After the transposition to the BS scale, we can visualize in which sector of sustainability the indicator is punctuated.

Subsequently, indicators are aggregated into themes; with the calculation of the arithmetic mean of the values of the themes and aggregates in thematic indexes and consequently in a subsystem index. Prescott-Allen (2001) explains that, in all cases, the values 0.5 can be rounded down to facilitate evaluation.

2.6 Elaboration of the Performance Scales

The performance scales of Ribeirão Preto indicators were developed according to national and international references identified in specialized literature, including indicators used in other regions of the world, at different levels of development, considering targets and standards of national and international institutions, based on sustainability concept (ecosystem and human resources).

2.7 Methodological Limitations

Some indicators were vetoed by the difficulty of elaborating performance scales for these indicators and the lack of data for some sustainability issues. Another important limitation was the difficulty of finding data in the same periodicity, which indicated temporary interruptions in the development of indicators in all the organs consulted for this research. However, these limitations did not compromise the results of the research because the main purpose of the study was to apply and test the BS method at the municipal scale.

3. Results and Discussion

After calculating the values of the indicators within the limits of each interval, the individual levels were obtained for transposition of the value for the BS scale. After this stage, the thematic level (thematic indexes) was calculated using the arithmetic mean that demonstrates the state of the theme in relation to Sustainable Development, as described in Tables 1 and 2.

3.1 Ecosystem Subsystem

The Ecosystem Subsystem was composed of a smaller number of indicators than the other subsystem. This shows that there is less availability of environmental data in relation to social, economic and institutional data for municipalities. According to Beke-Trivunac, Jovanovic, Radosavljevic and Radosavljevic (2014), in the field of environmental protection, the most significant direct responsibility lies with local governments, which increases the responsibility of local government and the attention of society.

Table 1. Level of the sustainable development indicators and the themes of the ecosystem subsystem in BS scale of Ribeirão Preto, Brazil

Theme	Indicators	Value in the unit of measure of origin	Source	Data year	Indicators level in BS scale	Thematic Index in BS scale
Atmosphere	Inalable particles PM_{10} (μg/m³)	119.50	CETESB 2012a	2011	66	71
	Sulfur Dioxide SO_2 (μg/m³)	3	CETESB 2012a	2009	99	
	Nitrogen dioxide NO_2 (μg/m³)	95.50	CETESB 2012a	2011	80.5	
	Ozone O_3 (μg/m³)	119.50	CETESB 2012a	2011	70	
	Number of vehicles per capita (per 1000 inhabitant)	429.52	CETESB 2012b SEADE, 2012	2011	57	
	Tree cover (per cent)	23.58	Filho, 2012	2012	57.5	
Water	Water Quality Index	39	CETESB 2012c	2011	44	71.5
	Index of Quality of Protection of Aquatic Life	2.80	CETESB 2012c	2011	74	
	Groundwater Potability Indicator	95.80	CETESB 2012c	2010	97	
Biodiversity	Natural vegetation (per cent)	6.22	Forestry Institute of São Paulo State, 2009	2009	12	12
Land	Total anthropized area (per cent)	93.78	Forestry Institute of São Paulo State, 2009	2009	3.5	9.5
	Land in use Agrosilvopastoral (per cent)	68	Ribeirão Preto, 2012a	2012	16	

The indicator with worse performance of the Ecosystem Subsystem was the Total anthropized Areas. This indicator revealed a level of anthropization in the total area of the municipality of 93.78 per cent, considered unsustainable. According to Kronemberger et al. (2008), Brazil has a total anthropic area of 36.6 per cent, classified by the author in intermediary level. The anthropogenic change causes a decrease in the coverage of primary vegetation of the soil, loss of regeneration areas, increased degradation of green areas and the entire ecosystem, among other damages. The process of occupation and land use must be based not only on the exploitation of monoculture (sugarcane, in case of Ribeirão Preto), much less on the property speculation that accompanies the municipality, but by a management that can sustainable use and reflected use of natural resources in this area. Biodiversity losses reflect the critical value of this indicator, resulting from a historical negative impact of use and occupation of the municipality's territory.

The reuse of previously anthropogenic areas, efficient and continuous management of biotic resources and elimination of misuse and land use presuppose an evolution of the municipal sustainability process, establishing harmony between ecosystem and human wellbeing.

3.2 Human Subsystem

The Human Subsystem was composed of indicators that interact within each theme, considering its current state and trend, to observe possible consequences and trends, according to the performance of the total of indicators that make up this subsystem.

Table 2. Level of the sustainable development indicators and the themes of the human subsystem in BS scale of Ribeirão Preto, Brazil

Theme	Indicators	Value in the unit of measure of origin	Source	Data year	Indicators level in BS scale	Thematic Index in BS scale
Health and Population	Population growth rate	1.42	SEADE, 2013	2012	85.5	77
	Child mortality rate	9.70	Ribeirão Preto, 2011a	2011	81	
	Rate of children under 1 year with vaccination	95.70	DATASUS, 2012	2011	82.5	
	Immunization against infectious childhood diseases (per cent)	95	Ribeirão Preto, 2011a	2011	88.5	
	Percentage of underweight children under 5 years of age	3.70	Ribeirão Preto, 2011a	2011	85	
	Percentage of families with health profile beneficiaries of the *Bolsa Família* program	56.94	Brazil, 2013	2011	56.5	
	Mothers who had seven or more prenatal visits	82.52	SEADE, 2012	2010	63	
	Maternal mortality rate (per 100,000 live births)	24.6	DATASUS, 2012	2010	42	
	Psychosocial Attention Center coverage rate per 100 thousand inhabitants	0.74	Brazil, 2012a	2011	82.5	
	Hospitalization beds (coefficient per 1,000 inhabitants)	3.14	SEADE, 2012	2011	92	
	Density of dwellers per dormitory in adequate situation (per cent)	88.11	IBGE, 2010	2010	90	
Wealth	Unemployment rate	4.91	IBGE, 2010	2010	83.5	60
	Average monthly payment (USD)	660	IBGE, 2010	2010	55	
	GDP per capita	11.983	SEADE, 2010	2010	66	
	Municipal GDP (in USD billion)	7.235	SEADE, 2012	2010	49	
	Gini Index	0.45	IBGE, 2010	2010	50	
Community	Mortality coefficient for homicides (deaths/100,000 inhabitants)	10.43	SEADE, 2012	2010	41.5	49
	Coefficient of mortality from transport accidents (deaths/100,000 inhabitants)	23.19	SEADE, 2012	2010	18	
	Families served by social programs (per cent)	5.90	IBGE, 2010	2010	88	

The indicator with the lowest value found in the Human Subsystem was the Maternal Mortality Rate (per 100,000 live births), also known as Maternal Mortality Ratio (RMM) and with the highest value the indicator Hospitalization beds (coefficient per 1,000 inhabitants).

The maternal mortality ratio (MMR) estimates the risk of death of women occurring during pregnancy, abortion, childbirth or up to 42 days after delivery attributed to related causes or aggravated by pregnancy, abortion, delivery, puerperium or by measures taken in relation to them (Brazil, 2012b). From this definition, we can identify maternal deaths based on their causes, such as direct or indirect. Direct maternal deaths are those resulting from obstetric complications of maternity (pregnancy, childbirth and postpartum), interventions, omissions, incorrect treatment, or a chain of events resulting from any of the above. Deaths due to obstetric hemorrhage or hypertensive disorders in pregnancy, or those due to complications of anesthesia or caesarean section, are classified as direct maternal deaths. Indirect deaths are those that result from preexisting diseases, or diseases that developed during pregnancy and were not related to direct obstetric causes, but aggravated by the physiological effects of pregnancy (World Health Organization [WHO], United Nations Children´s Fund [UNICEF], United Nations Population Fund [UNFPA] & World Bank, 2012).

Since the late 1980s, Brazil has developed initiatives to improve the coverage and quality of information on maternal deaths. The main one is the establishment and structuring of maternal mortality committees and the institutionalization of maternal death surveillance, which were dealt with in MS / GM No. 1,119 / 2008. This ordinance, based on some articles that compose it, lists the determinants so that the data is generated correctly, not compromising the trustworthiness of the indicator to be generated. According to the Municipal Health Department, in order to reduce maternal mortality, the municipality maintains 100 per cent of deaths in women of childbearing age (Ribeirão Preto, 2011).

Ribeirão Preto presented an indicator of maternal mortality of 24.6 deaths per 100,000 live births, categorized in this research as an intermediary. This indicator, even though it is the one with the worst performance in the subject that belongs to it, is much higher than that found for Brazil, which was 56 deaths per 100,000 live births in 2010, reaching that same year the peak of 85 deaths for each 100 thousand live births and 36 deaths per 100,000 live births (WHO et al., 2012).

The nations of Brunei, known as the State of Brunei Darussalam, located in Southeast Asia, Saudi Arabia, the Middle East and Grenada, a component of the Caribbean, have a Maternal Mortality Indicator similar to that found for the city of Ribeirão Preto, with a value of 24 deaths for every 100,000 live births (WHO et al., 2012). With approximate figures are the countries of Fiji (26 deaths per 100,000 live births), Oceania, Chile (25 deaths per 100,000 live births), and Lebanon (25 deaths per 100,000 live births) in the Mediterranean (WHO et al., 2012). Globally, maternal mortality fell by 47 per cent between 1990 and 2010, but is still far from ideal (WHO et al., 2012).

3.3 Performance of Human and Ecosystem dimensions

Figures 2 and 3 demonstrate the performance of the themes within the BS scale, in the Ecosystem and Human Subsystem, allowing the perception and communication of the findings in a clear way.

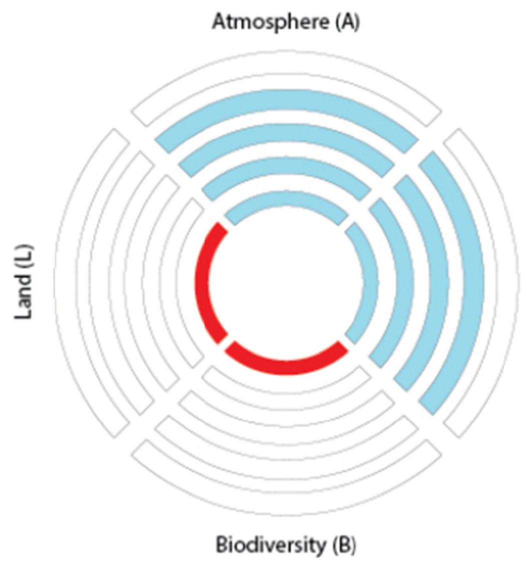

Figure 2. Ecosystem dimension performance

Figure 3. Human dimension performance

The aggregation of indicators into themes for the Ecosystem and Human Subsystem resulted in four and six thematic indexes, respectively, as shown in figures x and y. The combination of these indices resulted in the Wellbeing Index of Ribeirão Preto (52.5), considered as an intermediary. Table 3 shows the values of the Ecosystem and Human Subsystems and the Ribeirão Preto System, Brazil.

Table 3. Wellbeing Index (WI) of Ribeirão Preto, Brazil, based on Ecosystem Wellbeing Index (EWI) and Human Wellbeing Index (HWI)

Ecosystem Wellbeing Index (EWI)	Wellbeing Index (WI)	Sustainability Level
41		
Human Wellbeing Index (HWI)	52.5	Medium
64		

Figures 4 and 5 demonstrate the position of Ribeirão Preto in BS, pointing to the value of WI, and EWI and HWI value distribution in graphical model.

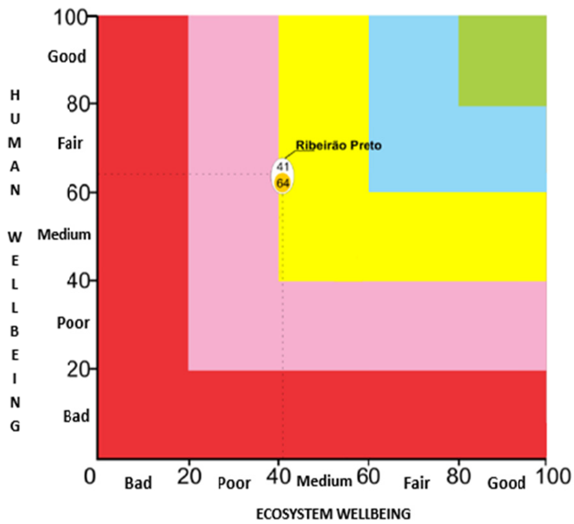

Figure 4. Wellbeing Index (WI) of Ribeirão Preto, Brazil

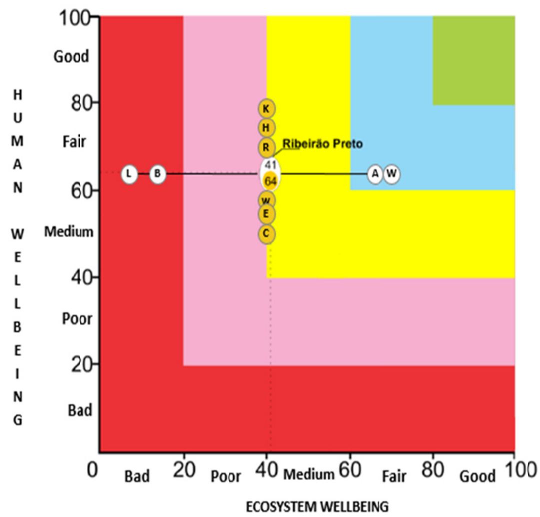

Figure 5. Dimensions of Ecosystem Wellbeing and Human Wellbeing in thematic index (disaggregated form)

BS demonstrated that Ribeirão Preto is at an intermediate level in relation to DS, presenting better performance in the Human Subsystem. This revealed that the municipality is more concerned with socioeconomic than with environmental issues, not fully complying with the DS principles. Environmental issues should be better addressed in the locality in order to initiate an awareness of the stakeholders so that there is an interaction with the problems encountered in the municipality and that solutions for possible problems are resolved in a decentralized manner. This dynamism can promote cooperation among stakeholders, with shared information to provide knowledge of vulnerabilities and potentialities of the municipality, with the objective of making DS possible at a municipal level.

At the municipal level, two studies involving BS in Brazil obtained the same level of sustainability of Ribeirão Preto. First one elaborated for Teresópolis, Rio de Janeiro State (Silva, 2006) and another one in João Pessoa, Paraíba State (Lucena, Cavalcante & Cândido, 2011). Considering the values for the three municipalities, Ribeirão Preto has the best index in the Human Subsystem (HWI) and the worst in the Ecosystem Subsystem. In Teresópolis studie, the Ecosystem Subsystem (EWI) obtained the value of 55 (Silva, 2006). Among the component indicators of the Ecosystem Subsystem, the indicator included in the theme Land use and Vegetation cover, denominated Area with vegetation cover (per cent), presented performance in the BS Scale of 63, the best of the Subsystem. The Human Subsystem (HWI) presented the result of 42 (Silva, 2006). The indicator with the best performance in this subsystem, inserted in the Housing theme, was the Percentage of households with electric lighting, which pointed to the value of 99.4 in the BS scale.

For municipality of João Pessoa, the worst performing indicator considered in the Ecosystem Subsystem (EWI) was a component of the Resource use theme and was called the Recyclable Waste Recovery Rate. It presented unsustainable level in BS scale. In Human Subsystem (HWI), the indicator Disease of the respiratory system presented the most critical result, also indicating the unsustainable level (Lucena, Cavalcante & Cândido, 2011).

4. Conclusions

The Barometer of Sustainability evaluation tool proved to be effective at the local scale, as it helped to understand the complexity of a system, facilitating the understanding of social and natural phenomena within the spatial clipping, demonstrating its potential to assist in decision making. BS can assist the municipal government in the planning and management process for different dimensions of analysis, since it can gather relevant information regarding municipal sustainability. BS can be considered as a component part of the process of environmental management and municipal sustainability. It should be noted that the use of BS can contribute to the sustainability of municipalities, promoting the continuity and maintenance of environmental quality and municipal sustainability, making public policies compatible at the municipal level. In practice, an approximate consensus on the key elements associated with the concept of sustainable development can be aligned with the UN Sustainable Development Goals (SDG).

The elaboration of the Performance Scales was an extremely important stage in BS, since it was at that moment that the limits for each degree of sustainability were established, divided into five bands. At this stage, there were difficulties in reconciling values and limits tolerable by the spheres involved in the Sustainable Development process, which was considered a methodological challenge.

The indicators considered in the BS were selected with the objective of meeting the particularities of the analyzed system, with data collection from reliable and available sources. The results synthesized by the evaluation demonstrated some of the needs of the municipality and may be the subject of future research in the field of municipal sustainability.

The use of BS methodology at the municipal level presented in all stages of this research many strengths and weaknesses.

Potentialities:

- Evaluates progress towards Sustainable Development;
- Generates information that is a component of the decision-making process;
- Provides ease of perception in graphic display;
- Has flexibility in the composition of the indicator group;
- Enables the collection of environmental, social, economic and institutional indicators;
- It makes it possible to collect indicators and reflect indices in the human and environmental spheres; and
- Facilitates user interpretation through graphic presentation.

Fragilities:

- Limited number of indicators to feed the research;
- Low level or lack of data in functional organs;
- Variables expressed in different units of measurements or presented in different time series and with reference to different spatial units;
- Difficulty in choosing sources for elaborating performance scales;
- Subjectivity when constructing performance scales; and
- Data with low level of reliability.

This perception highlighted the main methodological difficulties of BS, and that the transposition of these challenges is a continuous and emergency process. The integration of information from functional bodies and sharing of data are paramount for public management at the municipal level to help develop and consolidate national databases.

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