A conceptual model for sustainable development assessments

Juvancir da Silva

Programa de Pós-Graduação em Gestão Ambiental, Universidade Positivo, Curitiba/PR, Dept. de Administração, Universidade Estadual de Ponta Grossa, Ponta Grossa/PR
juvancirsilva@hotmail.com

William Bonino Rauen

Programa de Pós-Graduação em Gestão Ambiental, Universidade Positivo, Curitiba/PR, Dept. de Hidráulica e Saneamento, Universidade Federal do Paraná, Curitiba/PR
wbrauen@gmail.com

ABSTRACT: With most of the population living in cities while relying heavily upon resources provided from rural areas, the urban footprint and environmental pressure do not cease to grow, which presents great challenges for achieving sustainable communities and the Sustainable Development goals of the United Nations. Unsustainable urban growth can be seen as both a cause and a consequence of natural resource degradation, social, economic, cultural and educational shortcomings and poor and/or insufficient infrastructure. The complex interrelations amongst such matters contribute to form one of the wicked problems facing socioenvironmental systems around the globe. Any sustainability analysis must encompass such dimensions and capture such interrelations, if it is to achieve realistic results. Sound decision and policy making also depends upon robust data and information, which are usually compiled for indicators, indexes and systems of indicators. In this sense, this paper presents a new conceptual model developed for sustainable development assessments encompassing the natural, social and built capitals, as defined in the well-known Meadows report: 'Indicators and Information Systems for Sustainable Development'**.** Content analysis supported by a review of related international literature led to the subdivision of each capital into categories and subcategories, for which 52 sustainable development attributes were derived. Individual indicators that represent such attributes and their interlinkages can then be compiled to suit data availability and specificities of a given scenario of interest, as part of future integrated sustainable development assessments.

Keywords Sustainable development; indicators; conceptual model; capitals

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1. INTRODUCTION

The ongoing social and environmental degradation as a result of economic growth was highlighted in the report 'The Limits to Growth', which was a milestone in the theory of sustainable development. The report highlighted the interdependence between economic growth and natural resources emphasizing the limits of natural order and social development for economic growth (Meadows et al. 1972).

Three main goals were then established for the conservation of natural resources: maintain ecological processes and life support systems, preserve the genetic diversity and ensure the sustainable use of species and ecosystems (IUCN, 1980). This was followed by the establishment of the sustainable development paradigm, as the development that meets the needs of present generations without compromising the ability to meet the needs of future generations (WCED, 1987). Hence, sustainable development implies achieving inter- and intra- generational equity, in a dynamic environment inseparable from society (Waas et al. 2014). Intergenerational equity requires that future generations have at least the welfare of present generations (Komiyama & Takeuchi, 2006). This view implies the recognition that limitations are imposed on current technology and social organization by limited environmental resources and ability of the biosphere to absorb the effects of human activities. The constraint of sustainability is thus imposed upon anthropogenic development, in the sense of using natural resources without reducing stocks beyond their ability to recover (IUCN, 1980).

Working in favour of sustainable development requires great effort from managers and policy makers to obtain appropriate information and reduce uncertainties, at various scales. However, sustainable development is intrinsically multidimensional and uncertain, which makes its assessment and measurement both challenging and complex. A sound understanding of the inter-relationships between different aspects of the environmental, economic and social dimensions is required to assist in structuring such a complexity for the sake of information communication and decision making (Komiyama & Takeuchi, 2006; Kajikawa, 2008; Sachs, 2009; Jerneck et al. 2011; Waas et al. 2014). Meadows (1998) is a key classical text in this respect, for its description of sustainable development aimed at providing a structured framework for building indicator and information systems.

In this context, the objective of this study was to construct a conceptual model for sustainable development analyses based upon Meadows (1998) framework of social, built and natural capitals.

2. METHODS

The object of this study was the structured analysis and characterisation of sustainable development in socioenvironmental systems. A qualitative research approach based on content analysis (Bardin, 2008) was taken. Following Gil (1999), the steps of content analysis were pre-analysis, analysis and interpretation of the document. In the pre-analysis stage, a literature review of key sustainable development publications led to the selection of Meadows (1998) as the reference text for the conceptual model development.

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This report was thus scrutinised with the purpose of structuring a conceptual model. Meadows (1998) proposed assessment of sustainable development in dimensions represented by social, human, natural and built capitals. Considering the issues raised in this report and supported and complemented by a review of the literature, it was possible to identify key levels for the analytical subdivision of sustainable development aspects. Such a hierarchical subdivision was made in the order of capitals > categories > subcategories > attributes, where the latter were the key measurable sustainable development issues to be associated with indicators.

3. CONCEPTUAL MODEL DEVELOPMENT

The model is illustrated in Figure 1, in terms of the analytical subdivision into natural, social and built capitals, each with the corresponding categories, subcategories and attributes. The following sections outline the hierarchical conceptual model developed herein as a result of the content analysis and literature review.

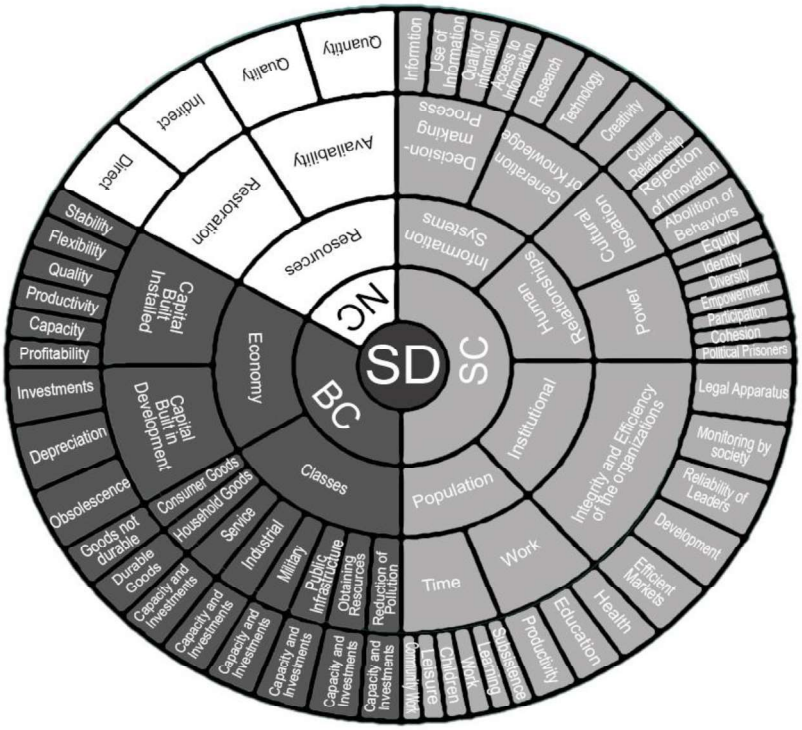

Figure 1. Conceptual framework for sustainable development (SD) assessments, in terms of the social capital (SC), natural capital (NC) and built capital (BC), with seven categories, 19 subcategories and 52 attributes of analysis

3.1 Social Capital

An instrumental perspective is defined for the social capital as relations of rational actors who, in an economically oriented way, use their social connections and social networks to gain access to resources for survival (Espinoza, 2001; Arriagada, 2003; Sehnem & Macke, 2015). In this perspective, Bourdieu (2001) refers to the social capital as the bindings and

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social approaches perceived and joined by permanent and useful connections. Such connections are based on material and symbolic trading established and perpetuated by the recognition of approximations and bindings.

The social capital in Meadows (1998) is defined as the stock of attributes that do not belong to a single individual, but to society as a whole. Such attributes depict how prepared a society is to face their problems and seek solutions for sustainability. In this sense, for Meadows (1998) the human identity is a result of the social capital. The first category of analysis was thus defined as *population*. The pillars of such human capital are its characteristics, such as age, gender structure and the work force. These are factors in the production system for economic gain, through interactions with the built and natural capitals. Health, education and productivity of the human capital are attributes that allow this capital to increase or lose productivity. Another key aspect is the way in which time is allocated and spent by the population, considering subsistence activities, learning, working, raising children, leisure and community work.

In addition to this, the social capital in Meadows (1998) is further described by the following categories: *information systems, human relationships* and *institutionalism*. The flow of information allows for social relations to occur. The social capital is enveloped in the flow of information, so that society should be able to organize the various data that represent events in information. Quality information systems are thus a key component of the social capital, which can be used in decision-making and knowledge generation processes. The decision-making process encompasses transformation of data into information, access to information, use and quality of information. The generation of knowledge can be evaluated in terms of scientific research, technology and the capacity for technological development, and the creativity of the population (Meadows, 1998).

Human relationships was identified as another category of analysis of the social capital. It includes the set of social interactions that form society. Human relations can be evaluated by the level of cultural isolation and power relations. Culture is closely linked with collective well-being. Power is associated with the ability to direct people's efforts to achieve something that they would not necessarily achieve independently; it may, thus, be seen as the opposite of freedom (Meadows, 1998). The existence of conflict due to an uneven appropriation of social capital, and its use to maintain positions of power is taken into consideration when studying the social capital within the framework of the political conflict (Arriagada, 2003). Social participation and communication can be evaluated for identifying any unequal power distribution between groups (Lehtonen, 2004). In Meadows (1998) it is possible to identify the attributes of social cohesion, social participation, social empowerment, cultural identity, human diversity, social equity and social mobility as aspects that represent power relations in society. Human relations may also be linked with the vision of the social capital of a group, which, according to Arriagada (2003), represents its mobilisation ability by means of relations of trust, reciprocity and cooperation. Trust is the result of repeated interactions among people. Reciprocity involves favour-based exchanges, while cooperation is seen as goal-oriented action.

Based on Meadows (1998), existence of political prisoners, degree of income distribution, number of police and their distribution in the population, concentration of ownership of media in the public and private sectors and percentage of gross domestic product

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concentrated in the largest companies can also be used to describe power relationships. These attributes represent democracy, for their ability to demonstrate the level of social freedom and the distribution of power. In this sense, the attributes of income distribution and political prisoners can best represent power relations, for their association with the levels of social equity and social participation.

Institutionalism figures as another category of analysis. This term is taken to represent the integrity and efficiency of the institutions, which can be analysed in terms of the legal apparatus that regulates social relations and trade, society's monitoring capacity, reliability of leaders, efficient and regulated markets, and institutional development. If such aspects are neglected, institutions are usually unable to meet social needs (Meadows, 1998). Institutionalism is also in line with the concept of social capital as networks of social relations (Bourdieu, 2001; Espinoza, 2001), through which individuals are able to guarantee access to resources and meet their needs by means of formal organizations (Meadows, 1998). Furthermore, for Sehnem & Macke (2015) elements of social organizations such as networks, norms and trust enable cooperative action and the achievement of mutual benefit within the sociocultural perspective.

3.2 Natural Capital

The natural capital represents the natural resources, both renewable and non-renewable, and ecosystem services (Daly & Farley, 2004; Dietz & Neumayer, 2007). It is essential for environmental sustainability, as its functions ensure the survival of humanity and of the biosphere as a whole. Its functions are to provide resources for the production of goods and services to humanity, to absorb wastes from production and consumption, as a life support system through climate and water, and human well-being by amenities such as the landscape (Ekins et al. 2003).

The natural capital has been described in an economic and in an ecological perspective. In the economic perspective, the natural capital is linked to the maintenance of stocks and flows of nature to provide income, being a restriction for economic growth. In ecological terms, it represents the physical volume of energy flows and stocks from the environment (Jacobi & Sinisgall, 2012).

Meadows (1998) considers the natural services for the economy as invaluable, but which should, nonetheless, undergo valuation to enable its proper use. In the economic perspective, this capital is represented by inputs of resources and energy flows from the terrestrial ecosystem, which are transformed into economically valuable goods and services, thus generating revenue for their producers. However, from the output value of natural capital processing systems one should deduct the cost of waste, as well as the costs of treating pollution or damage caused to the built, human and natural capitals. One of the biggest challenges for achieving sustainable development arises from an inadequate consideration of the costs of waste from the processing and consumption stages.

Waste resulting from the production of goods and services, if reused or recycled, can be considered as investments in natural capital, because this process reduces the depletion of natural capital for reintroduction of waste into the production process. However, if such waste causes degradation of socioenvironmental systems, it should be associated to

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depreciation or consumption of natural capital (Ekins et al. 2003). For Meadows (1998), if a production system is not recycled or rendered harmless, this system cannot be maintained and sustained without serious repercussions. In this sense, it is necessary to assess the natural capital resilience, in terms of its ability to assimilate waste. The main challenges for developing sustainability indicators are the gradual natural capital degradation, interactions among its different forms and the timeframes for its exhaustion and for reaching critical limits. Such limits may be dictated by resource or waste flows. All this indicates that dynamic integrated assessment models are needed.

The natural capital is used unsustainably when its stocks are declining and/or waste is increasing. According to Ekins et al. (2003), the reduction in the stock of natural capital is a sign of environmental unsustainability. For Meadows (1998), it is necessary to determine the amount of natural capital that should be kept untouched, as insurance, admitting our ignorance about the forms and the real value of natural capital. In this case, it is necessary to identify the critical assimilation rate, as well as the timeframe for reaching an acceptable level of waste and resource depletion. In this sense, a sustainable natural capital use should be assessed through its decline and recovery, representing the relationship between the rate of use and the rate of restoration. These rates can be assessed through the *resource* category, in terms of its availability for multiple uses, in quantity and in quality terms. It is understood that if natural capital is qualitatively and quantitatively available above the levels required by the multiple uses, then there is a situation of sustainability. Otherwise, there is a situation of unsustainability. This category also encompasses the restoration subcategory, which is represented through direct and indirect conservation actions for the assimilation of waste arising from resource usage.

3.3 Built Capital

Pérez-Maqueo et al. (2013) regard the built capital as manufactured goods and the infrastructure resulting from human inventive ability and technological improvements. Bossel (1999) considers the built capital as a support system for production activities, being constituted by the economic system and infrastructure. The identified categories of analysis are, thus, *economy* and *classes*.

For Meadows (1998), operating the built capital requires natural resources (natural capital) and labour and management (human capital) to produce goods and services to meet needs of the social capital. Waste and pollution are generated in this process, which must be absorbed by the natural capital and/or by built capital systems. In this sense, the built capital is the stock of production capacity of the economy. One subcategory of analysis thus identified was the installed built capital, which can be assessed by means of its capacity, stability, flexibility, quality, productivity and profitability.

For Meadows (1998), economic productivity is determined by the built capital availability and quality. Part of the built capital income is invested back into the built capital, which influences the economy growth rate. The built capital sustainability and growth are defined by the difference between investments in production capacity and the rates of depreciation and obsolescence. In this sense, built capital under development was identified as another subcategory of analysis, which can be represented by attributes for investment, depreciation and obsolescence. This is in agreement with other built capital

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literature. For instance, Bossel (1999) recommends that the built capital be assessed through the ratio between maintenance investment and the rate of depreciation, and through the built capital net growth evaluated by the infrastructure and economic system; Sachs (2009) states that adequately maintaining the infrastructure stock, equipment and buildings allows extending its life cycle and reducing depreciation, which in turn reduces the demand for replacement capital and releases resources for investment; and Pérez-Maqueo et al. (2013) recommend the analysis of built capital through public investment in infrastructure and public revenue.

Besides the economic perspective, the built capital can be analysed by the classes of capital. The industrial class represents the production capacity, industrial machines and equipment, and is an indicator of economic growth. The domestic goods class encompasses durable goods used in homes, and is an indicator of well being. The service class includes hospitals, schools, banks and government buildings that assist the social capital. The consumer goods class encompasses the consumption of paper, clothing and food, and is also an indicator of social well being. The military class represents the effort to maintain the security of natural capital, the economy and society. The class of public infrastructure involves roads, bridges, ports, water distribution systems and other systems that serve the economy, such as electricity and communications supply systems. The resource acquisition class encompasses the extraction of natural capital. The pollution reduction class includes the wastewater treatment systems, waste incinerators and repair systems, all of which are required to reduce waste emission (Meadows, 1998). These last three classes are not directly productive, but are required to cover the supply or maintenance costs of other classes.

The consumer goods and domestic goods classes can be analysed through their consumption ability of non-durable and durable goods. The remaining subcategories can be analysed by their installed capacity and investment.

4. CONCLUSION

Population growth and the concentration of human activities in urban areas have led to a scenario of natural resource depletion, uncontrolled environmental degradation and socioeconomic problems. Socioenvironmental sustainability is thus threatened, and a desire to make urban development more sustainable requires that human well being is reconciled with the preservation of environmental quality. The complex interrelations between social and environmental systems make for a challenging problem, so that any efforts undertaken to identify solution pathways require a comprehensive and structured approach. In this study a conceptual model was developed based on Meadows (1998) and other key international literature. A hierarchical structure is proposed in which the natural, social and built capitals are subdivided into categories, subcategories and attributes of analysis. A novel conceptual framework is thus proposed, aimed at supporting decision and policy making processes involving indicator-based analyses of sustainable development.

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