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ENVIRONMENTAL DEVELOPMENT INDEX (IDA): CALCULATION FOR MUNICIPALITIES IN THE METROPOLITAN REGION OF CAMPINAS - SP

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Abstract: The construction of indexes in subnational units is extremely important to provide detailed information for assessing the situation and monitoring public policies considering aspects of environmental sustainability. Indexes and indicators are essential as they serve as a guide for decision-making at various levels, allowing measurement of progress and achievement of environmental development objectives established in government actions. This research aims to find evidence on the environmental development of the municipalities in the Metropolitan Region of Campinas/SP (RMC) through the construction and evaluation of the Environmental Development Index (IDA). This index will serve as a subsidy, in future research, for the construction of the Sustainable Development Index (IDS) for the MRC. In the result, a satisfactory environmental performance was detected in the Metropolitan Region of Campinas, while most municipalities are in an "acceptable" situation in terms of environmental sustainability for a set of 56 indicators. With this unprecedented application for the RMC, it hopes to point out situations (diagnoses) to guide the manager to put into practice clear and direct corrective measures (direct to the target), which will serve as a reference for the formulation and application of public policies for municipal development/ more effective at regional level, in addition to enabling the creation of a strategic bank of information (system of indexes and indicators) for monitoring and evaluating the sustainability of development.
Keywords: Environmental Development Index, Environmental Sustainability; Indicator; Agenda 21, Public Policies.

INTRODUCTION

Sustainable development is characterized by a vision of seeking carrying capacity, the optimal scale, the balance of the evaluated dimensions (economic, social, environmental and institutional), treating the variables with the same weight, with the same importance.

What is the impact, how much is gained and how much is lost in a given operation? The challenge is to portray the real level of sustainability; therefore, measurements are essential. It is considered as a strategic tool, the use of indicators and, more than that, the construction of composite indexes due to the integrative approach (multidimensionality) of the concept of sustainable development as exposed in the "Principles of Bellagio Stamp" (PINTÉRD et al., 2012).

As of 1992, with the holding of ECO-92, the term Sustainable Development was strengthened and disseminated, mainly through the document called Agenda 21. The effects of this report were very positive and it was characterized as a participatory planning instrument for the sustainable development, while one of the main advances was the systematization of construction and monitoring of a set of indices and indicators that can help countries and their subnational units (states and municipalities) with information on the results of the decisions taken on production and consumption that impact on the environment (UN, 2001).

The creation of the Sustainable Development Commission (CDS) was another important contribution of Agenda 21, whose purpose would be to monitor world progress on the issue of sustainability. One of the needs, expressed in Agenda 21, would be the formulation of sustainable development indicators and, therefore, the creation of appropriate instruments for decision-making (UN, 2001).

The CDS was responsible for creating a

common basis for assessing the degree of sustainability, as most indicators were not adequate to achieve this objective. A major challenge for the CDS was to initiate a project of sustainability indicators at the national level, which would be carried out based on the promotion of comparability, accessibility and quality of current indicators (UN, 2001).

Another historical milestone concerns the holding in Ghent (Belgium), in 1995, of the Workshop "Indicators for Sustainable Development for Decision Making", whose objectives were to disseminate and generate greater acceptance by the scientific community and politicians, the use of sustainable development indicators. The results were positive and highlighted the need to formulate sustainability indicators (BELLEN, 2006).

Sustainability indices and indicators are crucial as they serve as guides for decision-making at various levels. They provide information on the social, economic, environmental and institutional situation of a region compared to regions with higher standards, allowing the measurement of progress and the achievement of sustainable development goals established in government actions (FRAINER et al., 2017).

Sustainability indices and indicators are highly relevant, as they serve as guides for decision-making at various levels. They can identify information about the social, economic, environmental and institutional situation of a region compared to regions with higher standards, allowing the measurement of progress and the achievement of sustainable development goals established in government actions (SOUZA et al., 2019).

In a superficial analysis, index and indicator have the same meaning. The difference is that an index is the final added value of an entire calculation procedure in which indicators are even used as the variables that compose it (KHANNA, 2000).

A multidimensional indicator unites the different areas of development and provides a synthetic measure of well-being with the potential to support the formulation of public policies to improve the living conditions of the population (FGV, 2012).

The Environmental Development Index (IDA), instrument of this research, is considered a synthetic indicator (or index) that aggregates a series of information to assess the sustainability of environmental development.

The IDA aims to systematize the aspects related to the environmental development of the municipalities. It includes variables related to major themes: biodiversity, soil, availability of water resources, air, sewage, drainage, access to urban and rural garbage collection, among other variables.

The processes of data collection and construction of comparative analyzes, at regional levels, significantly minimize the incidence of sampling errors and make the results more accurate to represent reality (SANTANA E BARRETO, 2016).

The choice of a municipal index is related to the objectives of regional development policies, becoming a more effective instrument for monitoring regional policies (SOUZA et al., 2019).

In this context, the need to carry out research and studies to assess the level of sustainability of subnational units emerges. The proposal in this research considers the municipalities of the RMC as an object of study.

The Metropolitan Region of Campinas (RMC), also known as Greater Campinas, was created by State Complementary Law n. 870, of June 19, 2000, comprising 20 municipalities: Americana, Artur Nogueira, Campinas, Cosmópolis, Engenheiro Coelho, Holambra, Hortolândia, Indaiatuba, Itatiba, Jaguariúna, Monte Mor, Morungaba, Nova

Odessa, Paulínia, Pedreira, Santa Bárbara d'Oeste, Santo Antônio de Posse, Sumaré, Valinhos and Vinhedo.

The MRC occupies an area of 3,791 km², which corresponds to 0.04% of the Brazilian surface and 1.47% of the territory of São Paulo. It is the second largest metropolitan region in the State of São Paulo in terms of population, with more than 3.2 million inhabitants, according to the estimate by the Brazilian Institute of Geography and Statistics (IBGE) for 2018, and participates with 8.75% of the State GDP in 2016 (Fundação SEADE), adding the municipality of Paulínia, with the highest GDP per capita in the country, and the municipality of Campinas, which occupies the 3rd position in the GDP of São Paulo and the 11th place in the national ranking. The region still has a modern industrial park, diversified and composed of complementary sectoral segments. Also noteworthy is the presence of innovative centers in scientific and technological research, as well as an important university complex installed.

It is assumed that the municipalities of the RMC would have a high level of sustainability due to the local and regional dynamism. However, in searches carried out by virtual means (internet) and through a bibliometric research, no type of systematized measurement was observed, there are no actions for the construction of development indexes, whether in the public or private sphere. From these considerations, the following question arises: what would be the level of environmental sustainability of the cities in the MRC? What is the importance of creating the IDA?

The general objective of this study is to find evidence on the environmental sustainability of the municipalities in the RMC through the construction and evaluation of the IDA. Specifically, the objective is: to select variables to compose the environmental dimension; to structure a system of indicators for the composition of the IDA; calculate the EDI and assess the degree of environmental sustainability; create a ranking and establish comparisons between municipalities.

With this unprecedented application for RMC, he expects a change in organizational culture in organizations, since indices and indicators are considered management instruments. You only know what you measure. Measuring is essential.

Most of the indicators used are related to programs and projects – they point out effort and quality. It subsidizes the decision-making process of an organization, especially in the achievement of sectorial goals and strategic objectives.

The public benefited by the research results is the academy itself, public agencies, companies and society in general. Accordingly, we can cite as main contributions: technical notes (diagnoses) to guide the manager to put into practice clear and direct preventive and corrective measures in his municipality (direct to the target); reference for public agents in the formulation and application of public policies for municipal/regional development; creation of an information bank (panel of indices and indicators/observatory) for monitoring and evaluation; basis for other studies related to the theme of sustainability, allowing micro-regional clippings or by group of other municipalities; possibilities to replicate the methodology according to sectoral needs, especially in Metropolitan Development Agencies, and even be used by the private sector for marketing actions

This is a series of scientific articles involving the four dimensions of sustainable development and their respective indices: i) in the economic dimension, the Economic Development Index – IDE was constructed; ii) in the social dimension, the Social Development Index – ISD was prepared; iii) in the environmental dimension, we have the then Environmental Development Index – IDA; iv) finally, in the institutional dimension, the composition of the Institutional Development Index. These indices, in aggregate form, will make up the Sustainable Development Index - IDS.

As this is a series of "ID" development indices, it is worth noting that the theoretical and methodological basis is unique, including being presented in other scientific articles: the ISD, published in January 2020, by the ``Revista Ibero-Americana de Ciências Ambientais`` -RICA (v.11 - n.1); the IDE, accepted in early 2020, with publication scheduled for September 2020, in the Brazilian Journal of Management and Regional Development-G&DR; the IDI, submitted to the ``Revista de Administração Pública``-RAP, of the Getúlio Vargas Foundation (FGV); finally, the IDA, the result of a presentation in this journal.

Therefore, the IDA is one more of the "ID" series, and the entire theoretical/ methodological foundation is contained in the article already published by RICA 11(1) 2020. And that such base is now used to deal with the development of another index. If before the indices were the ISD and the IDE, now it is the IDA. If before, the research parameters focused on the social and economic dimensions respectively, now, the research turns to another parameter, that is, the environmental dimension.

Therefore, this article presents, in addition to this introduction, a second topic that brings a discussion about the theme's sustainable development and sustainability, indices and indicators and their differences, and another that presents the concepts of EDI and environmental sustainability in terms of the its speech, nature and acting characteristics. The third topic presents the methodological bases and attributions that guide the construction and evaluation of the IDA. The fourth and fifth topics expose the result and discussion of the data respectively, and in the sixth, the conclusions of the article are presented.

THEORETICAL REVIEW

SUSTAINABLE DEVELOPMENT X SUSTAINABILITY

The concept of sustainable development specifies a new way for society to relate to its environment, in order to guarantee its own continuity and that of the external environment (BELLEN, 2006).

Sustainable development is established with progressive and balanced economic development, with more social equity and increased environmental sustainability (LUXEN and BRYLD, 1997).

Carrying capacity assumes a key role in delimiting the scope of sustainable development - determining the "optimal scale". (CAVALCANTI, 2010).

It is in recognizing the limits of ecosystems that the greatest possibilities for the development process are found. In addition, not least, is innovation. It is in this sense that the need for sustainability-oriented innovation systems is spoken of today (ABRAMOVAY, 2012).

Measurements are essential for the concept of sustainable development to become operational (HARDI and BARG, 1997). The challenge is to portray the real situation of sustainability (DAHL, 1997).

The evaluation tools are characterized, in the planning function, useful for the development of public policies (MOLDAN and BILHARZ, 1997).

Sustainability is a way of aligning human practices with the limited potential of each biome and the needs of present and future generations (BOFF, 2016).

In assessing sustainability, holistic indicators and dimensions compatible with reality are needed for a deep analysis and final tabulation (BELLEN, 2006).

The indicator system suggested by the UN/CSD uses four dimensions of sustainability: economic, social, environmental and institutional (UN, 2007).

Sustainable development is achieved in the face of an ideal level of sustainability, in other words the so-called "Ideal Point for Sustainable Development".

The foundations of sustainable development (SD) are:

- Economic Sustainability (SE);
- Social Sustainability (SS);
- Environmental Sustainability (SA);
- Institutional Sustainability (IS).

INDICATORS X INDEXES

Indicator measures the variation of the variable in relation to a specific basis, has a certain level of aggregation, indicates something relevant, evaluates the performance and trend (GALLOPIN, 1996).

An index is the final added value of an entire calculation procedure in which indicators are even used as the variables that compose it (KHANNA, 2000).

Indexes are indicators that condense information obtained by aggregating values (BELLEN, 2006).

A simple indicator is not capable of showing the reality of a situation (BOSSEL, 1999).

To reach sustainable development, the indicators must be linked or aggregated (GALLOPIN, 1996).

For sustainability monitoring purposes, it is essential to have indicators with a certain degree of aggregation, which can clearly and concisely capture problems (BELLEN, 2006).

Bibliometric research through the CAPES Periodicals Portal resulted in the identification of 12 scientific papers under the title "Sustainable Development Index or Indicator" (SOUZA et al., 2019).

The theme has few scientific works produced in the country, despite its relevance. Those that are produced are occasional, with no continuity/update policy (SOUZA et al., 2019).

IDA AND ENVIRONMENTAL SUSTAINABILITY

Environmental sustainability relates to the objectives of preserving and conserving the environment, which, in turn, are fundamental to maintaining the environmental quality of current and future generations (MARTINS and CÂNDIDO, 2008).

Environmental indicators represent selected statistics that summarize some aspects of the state of the environment, natural resources and related human activities (MMA, 2019).

The ecosystem's ability to regenerate is slow and sharp. It is evident that, in the current conditions of the environment, it is erroneous to rely on the orientation that nature can provide everything that is expected and wanted. This time, to ensure favorable conditions for life, it is necessary to assess the impact left on the Planet and think that the limits of nature are being exceeded (TOIGO and MATTOS, 2016).

In this context, it is necessary to generate knowledge of the impacts generated by human beings in different ecosystems in order to be able to act towards sustainable development (SOUZA et al., 2009).

With the purpose of increasing knowledge about ways to measure sustainable environmental development, a synthesis will be made about the correlated and existing indices and indicators (PEREIRA et al., 2016).

Souza et al., (2009) reports that there is a wide range of variables that build environmental indicators, thus allowing an unlimited number of experiments. However, it is necessary to ensure that the indicators can provide, induce and promote well-structured and reasoned policies and decisions.

With the purpose of evaluating the environmental sustainability of the municipalities and the researched region, the Environmental Development Index (IDA) was formulated, which aims to synthesize the aspects related to the environmental performance of the municipalities. The IDA makes it possible to compare the performance of municipalities among themselves and their performance over time. Indicates that the higher the index, the better the level of environmental sustainability of the researched object.

The concept of environmental sustainability is equally important to the economic, social and institutional dimensions of sustainable development.

METHODOLOGY

RESEARCH SUBJECT/UNIVERSE

The methodology proposed in this research considers the municipalities of the Metropolitan Region of Campinas/SP, as an object of study, focusing on the research of secondary data, which will be collected with the purpose of constructing the IDA.

VARIABLES

The IBGE publication "Sustainable development indicators: Brazil 2017" is a guide for the elaboration of the set of variables that allows a more complete assessment of sustainability, considering the peculiarities and characteristics of the MRC.

Martins and Cândido (2008) point out the need to measure and evaluate the situation in which a municipality finds itself in relation to sustainability.

In this research, the last available database of each variable was used, collected for statistical treatment and subsequent calculation of the ADI that are contained in the system of indicators of the environmental dimension, according to Chart I.

Table I. System of selected indicators – environmental dimension.

Indicator system (IDA)

1 - Indicator - Degree of urbanization

2 - Indicator - Afforestation of public roads

3 - Indicator - Urbanization of public roads

4- Indicator - Lightning strike density per km2/year

5 - Indicator – Urban demand (water)

6 - Indicator - Ratio urban human consumption / total consumption

7 - Indicator - Ratio rural human consumption / total consumption

8 - Indicator - Outflow of consumption in the manufacturing industry

9 - Indicator - Mining consumption / total consumption ratio

10 - Indicator - Thermoelectric generation/total consumption consumption ratio

11 - Indicator - Animal water consumption / total consumption ratio

12 - Indicator - Consumption ratio of irrigated agriculture / total consumption

13 - Indicator - Consumption / water withdrawal / total

14 - Indicator - return / withdrawal of water / total

15 - Indicator - no service, no collection and no treatment

16 - Indicator - service by individual solution

17 - Indicator - service with collection and without treatment

18 – Indicator – Service with collection and treatment

19 - Indicator - Total generated load

20 - Indicator - Total launched load

21 – Indicator – Per capita collection and treatment expense

22 – Indicator – Average water tariff

23 – Indicator – Average sewage tariff

24 - Indicator - Index of total water service

25 - Indicator - Urban water service index

26 – Indicator – Density of water savings per connection

27 – Indicator – Participation of household water savings in total water savings

28 - Indicator - Hydrometering index

29 - Indicator - Water fluoridation index

30 – Indicator – Average per capita water consumption

31 – Indicator – Rate of losses per call

32 – Indicator – Total sewage service index referred to municipalities served with water

33 – Indicator – Urban sewage service index referred to municipalities served with water

34 - Indicator - Sewage collection index

35 – Indicator – Sewage treatment index

36 – Indicator – Treated sewage index referred to consumed water

37 – Indicator – Sewage overflows by network extension

38 - Indicator - Incidence of non-standard residual chlorine analyzes

39 – Indicator – – Incidence of non-standard turbidity analyzes

40 – Indicator – – Incidence of non-standard total coliform analyzes

41 – Indicator – Per capita expenditure on urban stormwater drainage and management services

42 – Indicator – per capita investment in drainage and management of urban rainwater

43 – Indicator – Paving and curb coverage rate in the urban area in the municipality

44 – Indicator – Coverage rate of public roads with networks or underground rainwater channels in the urban area

45 – Indicator – Portions of perennial natural watercourses with open channels

46 – Indicator – Plots of perennial natural watercourses with closed canalization

47 – Indicator – Density of rainwater collection in the urban area

48 – Indicator – Share of households at risk of flooding

49 – Indicator – Per capita expenditure with RSU

50 – Indicator – RDO collection coverage rate in relation to the total population

51 – Indicator – Direct RDO coverage rate in relation to the urban population

52 - Indicator - Unit cost of collection

53 – Indicator – Coverage rate of selective collection, door to door in relation to the urban population

54 – Indicator – Recovery rate of recyclables in relation to the amount of RDO and RPU

55 – Indicator – Rate of sweepers per urban inhabitant

56 – Indicator – Weeding rate per urban inhabitant

Source: Adapted by the Author of Bellen (2006) and by Martins and Cândido (2008).

TYPE OF RESEARCH

Applied research with a quantitative approach due to the type of data to be collected and the use of statistical procedures. Applied research aims to acquire knowledge in order to solve identified problems (Gil, 2010).

Marconi and Lakatos (2015) characterize applied research for its practical interest so that the results are immediately applied in the solution of problems that occur in reality.

As for the objectives, the research is characterized as exploratory because it makes the problem more explicit because it considers the most varied aspects related to the fact or phenomenon studied.

DATA COLLECTION INSTRUMENT

As for the data collection instruments, it is classified as documentary research, due to the survey of materials that did not receive an analytical treatment or that could be re-elaborated according to the objectives of this research.

There are documentary studies that mainly use quantitative data in the form of records, tables, graphs or databases, while in these cases the analytical process involves statistical procedures.

The survey takes place through research with city halls, the IBGE, the State System of Data Analysis Foundation of São Paulo (SEADE), the Campinas Metropolitan Region Agency (AGEMCAMP), research institutes, NGOs, etc.

According to Roldan and Valdés (2002), the proposed methodology for selecting the set of local indicators to compare and generate a ranking of municipalities in a region, uses the following requirements as criteria for selection:

- The availability and reliability of data sources;
- The most up-to-date statistical data possible;
- The representation in the analysis of three systems: natural, social and economic, with their regional importance;
- A holistic approach that includes both quantitative and qualitative terms.

DATA ANALYSIS METHOD

The data analysis procedure fits as descriptive statistics to summarize and represent a set of data by simple measures. Its purpose is to present forms for a data survey, to highlight data presentation techniques through tables and graphs and to offer the proper statistical measures for numerical analysis. The need for data on a national basis was closely intertwined with the development of descriptive statistics, methods centered on the collection, presentation and characterization of a data set, in order to properly describe the various characteristics of that set (LEVINE et al., 2005).

For data processing, electronic spreadsheets were used to format information in the IDA elaboration process. It is proposed to conduct an analysis by size and general level of environmental sustainability.

The proposed methodology for preparing the IDA evaluates the levels of environmental sustainability, considering the criteria used worldwide for choosing indicators and the specificities of focusing on local development. For Martins and Cândido (2008), when considering each of the selected indicators, attention must be paid to the following characteristics: a) to be significant for the reality investigated and for the focus of the study; b) be relevant to the decisions that guide public policies; c) reflect temporal changes; d) allow for an integrated and systemic approach; e) use measurable variables; f) be easy to interpret and communicate and; g) have a well-defined, transparent and objective methodology for the purposes of the investigation.

Adapted from Souza et al. (2020), the steps for determining and evaluating the IDA correspond to: (i) building a database (indicator system) for sustainable development issues, selecting topics within the environmental dimension; (ii) the normalization of the variables to make them comparable and amenable to aggregation; (iii) calculating the arithmetic mean for determining the environmental development index; (iv) the results obtained by municipality, and classified to create an IDA ranking for evaluation and analysis of the level of environmental sustainability.

The first stage of selection of topics to generate a metropolitan database follows national methodologies, considering the relevant variables, within each dimension, that have municipal information. In addition, the criterion of representativeness combined with the availability of information at the municipal level was adopted. For this, UN international indicators and indices were adopted as a reference, combined with the selection made by the IBGE for the national Sustainable Development Index.

Once the first stage of selection of indicators was carried out, the selected variables were normalized using the method suggested by Sepúlveda (2005), transforming the indicators into indices, which allowed the comparability of variables from different units, in addition to normalizing the data in a number that varies from 0 to 1, so that the closer to 1, the better the municipality is in terms of environmental sustainability.

From this perspective, it was also necessary to take into account that there are indicators that are positively correlated, and others, negatively. To perform an aggregation, all indices must point to a positive relationship to be able to be aggregated and thus generate a synthetic indicator. Therefore, the relationship (positive or negative) that these variables present was identified by the following relationship: positive (the higher, the better; and the smaller, the worse) and negative (the smaller, the better; and the larger, the worse), according to the context of their relationships.

As proposed by Sepúlveda (2005), the ADI can be calculated by the weighted average of the variables considered (already transformed into indices to allow aggregation). In the present study, the same weight was applied to all variables in the calculation of the ADI, so that different weights were not attributed with the purpose of generating bias or bias in the final calculation (WAQUIL et al., 2010). Thus, the EDI was calculated by the arithmetic mean of the indices of the variables that make up the environmental dimension. Therefore, the weighted mean is identical to the arithmetic mean.

The normalization procedure foresees that, if the indicator has a positive or negative influence on the environmental dimension, it must be analyzed separately according to equations (1) and (2), respectively. Theoretically, for a positive indicator, in (1), the maximum observed value will have a score of 1, that is, the higher the indicator, the better the index; and the smaller the indicator, the worse the index. As for the negative indicator, in (2), the higher the indicator; worse will be the index, and the smaller the indicator; the better the index.

Using equation (2), the behavior of the index after normalization will be like that of the positive indicator (1), that is, the higher, the better (maximum value 1), and the lower, the worse (minimum value zero), according to formulas Next:

$$I_{(+)} = \frac{x - \text{mín}}{\text{máx} - \text{mín}} \qquad (1)$$

$$I_{(-)} = \frac{\text{máx} - x}{\text{máx} - \text{mín}} \qquad (2)$$

In which:

$I_{(.)}$ = normalized index, calculated for each municipality; x = value observed in each municipality; min = minimum value of the indicator for all municipalities; max = maximum value of the indicator for all municipalities.

The minimum and maximum values of each indicator under study were assigned according to each selected variable, regardless of its measurement unit. Thus, it was possible to normalize the data to a comparable basis.

The generated index can be classified according to the level of development sustainability. To this end, the evaluation model is presented with five intervals of 0.2 tenths each, in which the levels of sustainability could be distributed in a disbelieving way, starting with the best level, the "ideal", going through the "acceptable" situation, of "alert" or "attention", "bad" and, finally, the lowest grade, called "critical" (SOUZA et al., 2020). The levels are represented in Table I.

RESULTS

For the calculation of the Environmental Development Index (IDA), a system of 56 indicators of the theme in question was used, with a high degree of relevance, for each municipality that is part of the Metropolitan Region of Campinas (RMC), thus totaling 1,120 municipalized data.

Initially, the indicators were normalized taking into consideration, their polarity (greater/better or smaller/better). With the normalized values, the ADI was determined by the arithmetic mean, whose results are in Table II, which were classified and ranked for evaluation and analysis regarding environmental sustainability.

DISCUSSION

Note that the average of the environmental dimension reached the index of 0.6367, which determines an "acceptable" level of environmental sustainability for the RMC. The value of the minimum and maximum ADI obtained a small interval of around 27%, which demonstrates a reduced range of environmental realities.

The municipalities, for the most part, are well evaluated and have "acceptable" levels of environmental sustainability. As shown in Table 2, we have the best ranked municipalities: Hortolândia (0.7320), Paulínia (0.6905), Pedreira (0.6826) and Morungaba (0.6817). At the level considered "alert" is the minority of municipalities, as in the case of Monte Mor (0.5851), Santo Antônio de Posse (0.5776), Sumaré (0.5766) and Artur Nogueira (0.5751).

It is worth noting that the municipality of Campinas, despite presenting an "acceptable" level, occupies an intermediate position in the ranking (13th), despite having the highest GDP in the MRC and one of the largest university-technological complexes in the country.

CONCLUSIONS

In a punctual analysis of the IDA, the satisfactory performance of the Metropolitan Region of Campinas is noticed, while the majority of the municipalities are in an "acceptable" situation in terms of environmental sustainability. It is observed that no municipality reached a level considered "ideal", the closest is Hortolândia (0.7320), for a set of 56 indicators selected in the environmental dimension.

It follows then, from the point of view of the environmental dimension, that 80% of the municipalities of the MRC are in an "acceptable" situation and 20% have a level considered "alert", in turn, in a situation far from the "bad" or "bad" level. "critical" in environmental sustainability.

Most likely, compliance with environmental legislation, rational use of resources, attention to discharges/waste, concern for the well-being of the population and all control and risk management justify the acceptable rates and all the concerns of the municipalities regarding this reality. Likewise, the understanding of this reality through the IDA allows the elaboration of policies that promote sustainable development and, consequently, the elimination of any environmental aspect that interferes in the development of future generations. In other words, evaluate the efficiency, effectiveness and effectiveness of all environmental management as correctly as

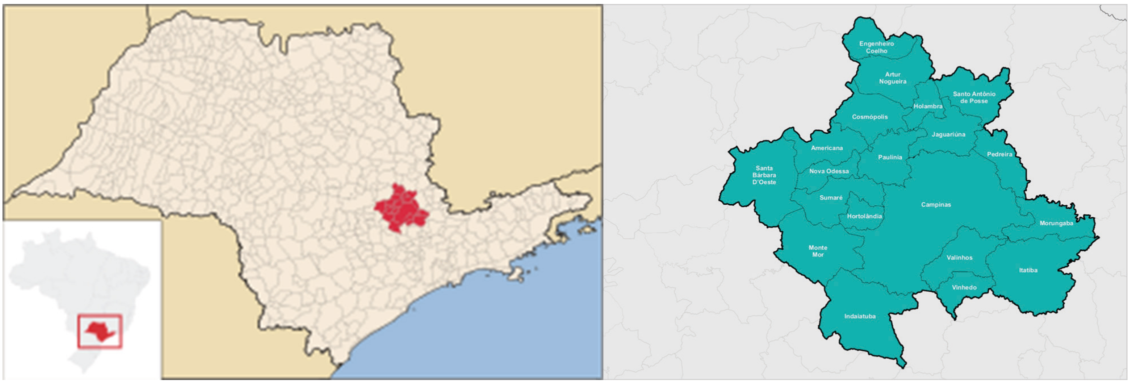

Figure I. Metropolitan Region of Campinas.

Source: SinBiota (2019); Emplasa (2019).

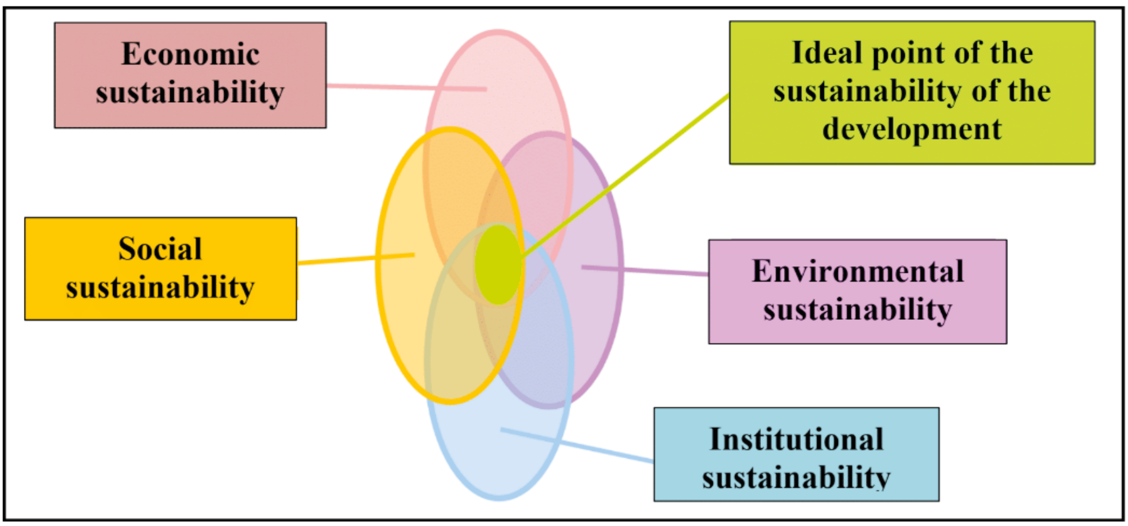

Figure II. Sweet Point of Development Sustainability.

Source: Prepared by the Author.

Index (0 – 1)	Level
1,0000 – 0,8001	Ideal
0,8000 – 0,6001	Acceptable
0,6000 – 0,4001	Alert
0,4000 – 0,2001	Bad
0,2000 – 0,0000	Critical

Table I. Classification of the level of development sustainability.

Source: SOUZA *et al.* (2020)

RMC – Metropolitan Region of Campinas	Environmental Development Index (IDA)	Ranking
HORTOLÂNDIA	0,7320	1º
PAULÍNIA	0,6905	2º
PEDREIRA	0,6826	3º
MORUNGABA	0,6817	4º
ITATIBA	0,6624	5º
ENGENHEIRO COELHO	0,6602	6º
VALINHOS	0,6565	7º
INDAIATUBA	0,6457	8º
NOVA ODESSA	0,6346	9º
VINHEDO	0,6345	10º
AMERICANA	0,6253	11º
SANTA BARBARA D´OESTE	0,6103	12º
CAMPINAS	0,6071	13º
JAGUARIÚNA	0,6059	14º
HOLAMBRA	0,6058	15º
COSMÓPOLIS	0,6053	16º
MONTE MOR	0,5851	17º
SANTO ANTÔNIO DE POSSE	0,5776	18º
SUMARÉ	0,5766	19º
ARTUR NOGUEIRA	0,5751	20º
Average of dimension	**0,6327**	-

Table II. Ranking of the Environmental Development Index - IDA.

Source: Prepared by the Author

possible.

Finally, the proposal for an Environmental Development Index (IDA) aims to allow additional conditions for public managers to propose and promote preventive and corrective actions, in the short, medium and long term, to leverage municipal (and metropolitan) performance in order to achieve optimal levels of environmental sustainability.

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REFERENCES

ABRAMOVAY, R. **Muito além da economia verde**. São Paulo: Ed. Abril, 2012, 248 p.

BELLEN, H. M. van. **Indicadores de sustentabilidade: uma análise comparativa**, 2 ed., São Paulo-SP: Editora FGV, 2006, p. 41-62.

BOFF, L. **Sustentabilidade: o que é – o que não é.** 5 ed. Revista e ampliada, Petrópolis, RJ: Vozes, 2016, p. 17.

BOSSEL, H. **Earth at a crossroads: paths to a sustainable future**. Cambridge: Cambridge University Press, 1998.

CAVALCANTI, C. **Concepções da economia ecológica: suas relações com a economia dominante e a economia ambiental.** Estud. av. vol.24 no.68 São Paulo, 2010.

DAHL, A. L. **The big picture: comprehensive approaches**. In: MOLDAN, B.; BILHARDZ, S. (Eds.). Sustainability indicators: report of the project on indicators of sustainable development. Chichester: John Wiley & Sons Ltd., 1997.

EMPLASA-Empresa Paulista de Planejamento Metropolitano S/A. **Pesquisa 2019**. Disponível em: <https://emplasa.sp.gov.br/RMC>. Acesso em: agosto, 2019.

FRAINER, D. M.; SOUZA, C. C.; REIS NETO, J. F.; CASTELÃO, R. A. **Uma aplicação do Índice de Desenvolvimento Sustentável aos municípios do estado de Mato Grosso do Sul**. Interações [online]. 2017, vol.18, n.2, p.145-156. Campo Grande-MS. ISSN 1518-7012.

FGV-Fundação Getúlio Vargas. **Indicador Social de Desenvolvimento dos Municípios – IDAM**. Escola de Economia de São Paulo: Novembro de 2012.

GALLOPIN, G. C. **Environmental and sustainability indicators and the concept of situacional indicators**. A system aprroach. Environmental Modelling & Assessment, n. 1, p. 101-117, 1996.

GIL, A. C. **Como elaborar projetos de pesquisa**. 5 ed., São Paulo-SP: Atlas, 2010, p. 27-67.

HARDI, P.; BARG, S. **Measuring sustainable development: review of current practice**. Winnipeg: IIDA, 1997.

IBGE. **Indicadores de Desenvolvimento Sustentável: Brasil 2017**. Rio de Janeiro: IBGE, 2017.

KHANNA, N. **Measuring environmental quality: an index of pollution.** *Ecological Economics*, v. 35, n. 2, nov. 2000, p. 191-202.

LEVINE, M. D. et. al. **Estatística Teoria e Aplicação usando o Microsoft Excel em Português**. 7 ed., Tradução CURTOLO, E. B., SOUZA, T. C. P., LTC Editora, Livros técnicos científicos Editora S.A., 2005.

LUXEM, M; BRYLD, B. **The CSD work programme on indicators of sustainable development**. In: MOLDAN, B.; BILHARDZ, S. (Eds.). Sustainability indicators: report of the project on indicators of sustainable development. Chichester: John Wiley & Sons Ltd., 1997.

MARCONI, M. A.; LAKATOS, E. M. **Técnicas de pesquisa**, 7 ed., São Paulo-SP: Atlas, 2015, p. 07-71.

MARTINS, M.F.; CÂNDIDO, G.A. **Índice de Desenvolvimento Sustentável para Municípios (IDSM): metodologia para análise e cálculo do IDSM e classificação dos níveis de sustentabilidade – uma aplicação no Estado da Paraíba**. João Pessoa-PB: SEBRAE, 2008.

MMA-MINISTÉRIO DO MEIO AMBIENTE. **Indicadores Ambientais Nacionais**. Site<https://www.mma.gov.br/informacoes-ambientais/indicadores-ambientais>. Acesso em: Dezembro, 2019.

MOLDAN, B.; BILHARDZ, S. (Eds.). **Sustainability indicators: report of the project on indicators of sustainable development**. Chichester: John Wiley & Sons Ltd., 1997.

ONU. **Indicators of Sustainable Development: Framework and Methodologies**. New York: NU, 2001.

ONU. **Indicators of Sustainable Development: Guidelines and Methodologies**. New York: NU, 2007.

PEREIRA, M. S.; SAUER, L.; FAGUNDES, M. B. B. **Mensurando a sustentabilidade ambiental: uma proposta de índice para o Mato Grosso do Sul**. Interações, Campo Grande, MS, v. 17, n. 2, p. 327-338, 2016.

PINTÉRD, L; HARDIB, P.; MARTINUZZIC, A.; BELLAGIO, J. H. STAMP: **Principles for sustainability assessment and measurement**. Ecological Indicators, n. 17, 2012, p. 20-28.

ROLDÁN, A. B.; SALDÍVAR-VALDÉS, A. **Proposal and application of a Sustainable Development Index**. Ecological Indicators, v.2, n.3, 2002, p.251-256.

SANTANA, A. S.; BARRETO, R. C. S. **Qualidade institucional e desempenho econômico: análise empírica dos municípios brasileiros, 2010**. Revista Brasileira de Estudos Regionais e Urbanos, v. 10, n. 2, p. 253-271, 2016.

SEPÚLVEDA, S. **Desenvolvimento Microrregional Sustentável: métodos para planejamento local**. Tradução de Dalton Guimarães. Brasília: IICA. 2005, 296 p.

SINBIOTA - Sistema de Informação Ambiental do Programa Biota/Fapesp. **Pesquisa 2019**. Disponível em: <http://sinbiota.biota.org.br/>. Acesso em: agosto, 2019.

SOUZA, C. F. C.; MASTRODI, J; LONGO, R. M. **Estudo Bibliométrico sobre Índice de Desenvolvimento Sustentável Municipal (IDSM), disponibilizados no Portal de Periódicos CAPES**. Meio Ambiente e Desenvolvimento Sustentável [recurso eletrônico] / Organizadoras Juliana Thaisa Rodrigues Pacheco, Juliana Yuri Kawanishi, Rafaelly do Nascimento. – Ponta Grossa, PR: Atena Editora, 2019, v.1.

SOUZA, C. F. C.; MASTRODI, J; SOUZA, C. C., FRAINER, D. M. **Índice de Desenvolvimento Econômico (IDE): cálculo para municípios da região Metropolitana de Campinas/SP**. I Sustentare – Encontro de Sustentabilidade (código SUST-SOC005 – categoria Artigo Completo): PUC-Campinas, setembro de 2019, Campinas-SP.

SOUZA, C. F. C.; MASTRODI NETO, J; SOUZA, C. C., FRAINER, D. M. **Índice Social de Desenvolvimento (ISD): cálculo para municípios da região Metropolitana de Campinas/SP**. Revista Ibero Americana de Ciências Ambientais, v.11, n.1, p.445-459, 2020. DOI: http://doi.org/10.6008/CBPC2179-6858.2020.001.0039

SOUZA, J. H.; PAULELLA, E. D.; TACHIZAWA, T.; POZO, H. **Desenvolvimento de Indicadores Síntese para o Desempenho Ambiental**. Revista Saúde e Sociedade-USP. São Paulo, v.18, n.3, p.500-514, 2009.

TOIGO, C. H.; MATTOS, E. J. **Desenvolvimento e meio ambiente: o que os principais índices têm a revelar?** Revista Ensaios FEE, Porto Alegre, v. 37, n. 2, p. 553-580, 2016.

WAQUIL, P.; SCHNEIDER, S.; FILIPPI, E.; RÜCKERT, A.; RAMBO, A.; RADOMSKY, G; CONTERATO, M.; SPECHT, S. Avaliação de desenvolvimento territorial em quatro territórios rurais no Brasil. Redes, v.15, n.1, 2010, p.104-127.

Acessos em sites:

Site:<https://nacoesunidas.org/pos2015/agenda2030/>. Acesso em agosto, 2019.

Site:<https://sidra.ibge.gov.br/pesquisa/ids/tabelas>. Acesso em agosto, 2019.

Site:<https://cidades.ibge.gov.br/brasil/panorama>. Acesso em: agosto, 2019.

Site:<https://www.ibge.gov.br/estatisticas/economicas/contas-nacionais/>. Acesso em: agosto, 2019.

Site:<http://www.seade.gov.br/>. Acesso em agosto, 2019.

Site:<https://meumunicipio.org.br/>. Acesso em: agosto, 2019.

Site:<http://www.agemcamp.sp.gov.br/investimento/>. Acesso em: agosto, 2019.

Site:<https://emplasa.sp.gov.br/RMC>. Acesso em: agosto, 2019.

Site:< https://www.significadosbr.com.br/>. Acesso em: Janeiro, 2020.

Site:< https://www.dicio.com.br/>. Acesso em: Janeiro, 2020.

Site:<https://www.senado.leg.br/atividade/const/con1988/con1988_26.06.2019/art_174_.asp>. Acesso em: Janeiro, 2020.

Site:<http://www.tesouro.fazenda.gov.br/-/infracoes-da-lei-de-responsabilidade-fiscal-e-suas-penalidades>. Acesso em: Janeiro, 2020.

Site:< https://www12.senado.leg.br/noticias/entenda-o-assunto/lrf>. Acesso em: Janeiro, 2020.