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A Comparative Study between the Cidade Nova and Marabá Pioneira Urban Centers Marabá-PA

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Abstract: Environmental impacts in urban areas are frequently associated with an expansion in the urban area, through which population growth is one of the indicators of changes to the environment by soil use and habitation, which triggers negative effects and contributes to the non-establishment of sustainable development. Accordingly, the lack of urban planning permits unbridled growth that does not consider the supporting capacity of the environment. Thus, the objective of this study was to compare environmental impacts in two centers of the municipality of Marabá with the aim of determining the most significant environmental indicators for the estimation of environmental impacts and their influence on the population's quality of life. The methodology adopted was a survey of documentary evidence. Six environmental indicators defined for the municipality. Then, interaction matrices created to attribute values and weights to each variable to obtain an index of urban environmental quality for each indicator. The results indicated that the Marabá Pioneira urban center affected by the negative effects of human activities. Thus, the development of environmental studies is essential to strengthen the adoption of measures aimed at ensuring a balanced environment and quality of life for the population.

Key words: environmental indicators, human action, urban environmental

1. Introduction

Environmental impacts in urban areas are common because of excessive demographic expansion associated with the growth of cities. Accordingly, soil use and habitation are seen as the main agents of change, given the environmental issues that make sustainable development and containment of the negative effects urbanization a challenge [1].

Thus, the absence of urban planning contributes to the modification of the environment without considering its supporting capacity. This capacity is related to the way in which the use of resources occurs as well as the frequency and intensity with which this ensues. In addition, this term denotes the maximum limit supported by an environment under a given production system [2].

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In turn, urban planning encompasses a set of actions that provide a harmonious relationship between the urban activities performed and the establishment of conditions for land occupation that are based on the adoption of municipal development policies with the purpose of improving the quality of life of inhabitants [3]. However, what is observed in practice is that this occupation of the area occurs in a disorderly manner without obeying urbanity criteria, which overburdens urban resources equipment.

Furthermore, it can be observed that these actions depart from social nature, because the urban environment is a reflection of the society in which it is a part. That is, actions are materialized in spatial forms within the human disturbances that constrain the formation of the urban environment. In other words, there is a set of variables that shape an urban ecosystem [4].

An urban ecosystem mirrors a series of interlinked factors so that cities can ensure necessary for cities to

ensure its maintenance with the import of a series of features, as they have no autonomy for this production. In this context, the search for basic survival inputs, which include raw materials, capital, and water, is vital. However, because it integrates a productive chain, the result is the conversion of these inputs into waste, which generates an environmental imbalance [5].

The current dynamics of the municipality of Marabá, located in the southeaster region of Pará, is influenced by historical events, which denote a change in the local productive structure that is strongly marked by livestock and mineral extraction. Faced with these changes, a transformation has occurred in the socio-spatial organization of the municipality, which has generated a discontinuous amplification of demographic expansion in the urban centers of Marabá Pioneira and Cidade Nova [6].

As a result, a study of environmental impacts in the urban environment is of utmost importance to understand the situation of a given locality and to evaluate the environmental consequences of implementing a project or a specific action, with the aim of guaranteeing protection to the environment and maintaining the quality of life of the population. The mathematical models used for this evaluation integrated tools in the search for more sustainable alternatives [7].

Thus, the objective of this study was to compare recurrent environmental impacts in the Marabá Pioneira and Cidade Nova urban centers to identify the most relevant environmental aspects as well as the negative effects of these actions, with the aim of obtaining environmental quality indexes for the variables established.

2. Materials and Methods

2.1 Location of the Study Area

The municipality of Marabá, located in the southeast of Paraná, has a demographic profile because of the confluence of two large rivers in the region, namely Tocantins and Itacaiúnas. The economic relationships that were established contributed to the dynamism of the area, with consequent demographic growth and expansion of the urban centers of the city (Fig. 1).

2.2 Methodological Procedures

The methodological procedures adopted in this study were based on a survey of documentary data, to carry out a literature review to explore the topic in greater detail. According to Treinta et al. (2014) [8], this type of data survey helps to organize a set of steps to obtain a given result, that is, it was configured as a precept for the performance of studies.

Hence, the SciELO and ISSUU databases researched for articles indexed in the subject of environment from 2011 to 2017. Key words, such as environmental quality, urban planning, and environmental indicators, were used for this purpose. These publications allowed the adequacy of their indexes to be adapted to the reality of the municipality of Marabá.

The thesis entitled “Local Sustainability Index: An evaluation of the sustainability of the municipalities around the Rio Doce - MG State Park” [9] served as the basis for the construction of interaction matrices; the objective of which was to evaluate the pressures exerted on the environment to minimize the impacts resulting from human actions.

In summary, the steps adopted were as follows:

(1) Choice of Environmental Indicators

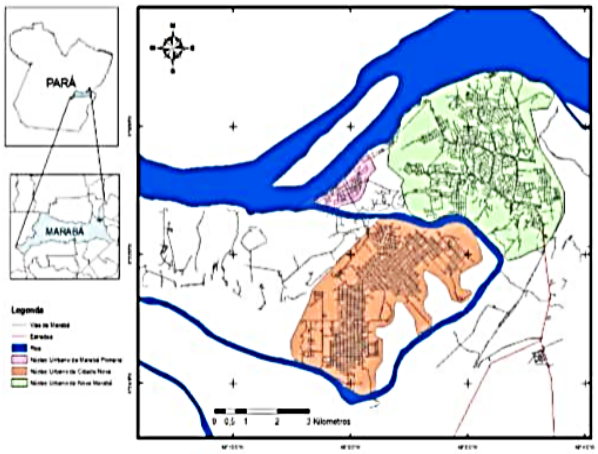

Fig. 1 Map of the urban centers of the municipality of Marabá-PA [6].

Environmental indicators are of fundamental importance because they transform a condition or problem that is not palpable into a perceptible one, i.e., they are the result of direct observation. However, using statistics, the terms gain a clearer meaning, as values are adopted to perform a quantitative analysis. According to Tostes (2010) [10], a quantitative descriptive analysis (QDA) allows for the survey, description, and quantification of attributes to use statistics.

(2) Determination of Environmental Variables

Environmental variables reflect numerous issues to be considered for the analysis of environmental indicators. They determine that for each environmental indicator, a set of variables should be used that will assist in a more detailed, and less subjective, evaluation.

(3) Definition of a Comparative Scale of Parameters

The third step consisted of defining a comparative scale of parameters, that is, the pre-definition of values that would be allocated according to a qualitative and quantitative assessment that reflects the level of importance of each variable, i.e., the values assigned later, which were conditioned by this scale. These values ranged from 1 to 10.

(4) Allocation of Values on a Scale of 1 to 10

The values from 1 to 10 represented a finite scale for adoption in matrices, since these were used to calculate the other values and the statistical analysis with the purpose of obtaining a relationship that indicates the pressures exerted on the environment by human actions (Table 1).

(5) Definition of Differentiated Weights for Each Variable

The definitions of differentiated weights for each variable were since even if they were encompassed by the same environmental indicator, both had divergent significance since some were more expressive, while others did not have direct effects, and were thus less expressive (Table 2).

(6) Elaboration of Matrices for Quantitative Analysis

Table 1 Quality level adopted for each value.

Value	Quality Level
1-3	Low importance
4-7	Medium importance
8-10	High importance

Table 2 Allocation of weights according to importance.

Weight	Quality level
1-2	Low importance
3-4	Moderate importance
5	High importance

Then, the assigned data were entered a matrix of interaction to define the urban environmental quality index (UEQI) by means of a checklist that incorporated the most important points for the composition of this index, that is, it did not occur at random.

(7) Calculation of Environmental Quality Indexes for Each Variable

The calculation of the indexes of environmental quality for each variable is shown in Eq. (1):

$$UEQI = IaPa + IbPc + LnPn \quad (1)$$

Where:

UEQI: Urban environmental quality index

I: Partial index obtained by the value of each variable

P: Weight assigned to each variable

For analysis, a comparative table was elaborated to evaluate the UEQI. As observed, it is a comparative scale that relates a range of values to their respective level of quality to evaluate and contrast the obtained indexes for each urban center under study. However, these values reflected an inversely proportional relationship, since the lower the UEQI value, the higher the level of urban environmental quality (Table 3).

(8) Comparison of the Indicators Obtained for the Urban Centers Cidade Nova and Marabá Pioneira

Table 3 Scale of the urban environmental quality index.

Ueqi value	Urban environmental quality
1-40	Excellent
40-60	Fair
60-100	Poor

After the elaboration of interaction matrices for both urban centers, a comparative study between both centers was conducted. This study assessed the pressures exerted on the environment by interpreting the obtained UEQI values to determine the environmental aspects that differentiated the centers and how human action has changed the quality of life of the population (Tables 4 and 5).

The indicators listed in column 1 were defined according to their degree of importance as well as their relevance, as from them the conditions of environmental quality were assessed via indexes, i.e., they can be used to express a given situation with high significance.

Column 2 contains the variables considered for each indicator, i.e., they were used as an evaluation reference. Thus, a detailed view of the scenarios that determined the magnitude and importance of what was analyzed is provided.

Column 3 displays the weight assigned for each variable and indicates the different relevance attributed to each variable in order to streamline the evaluation and reduce the subjectivity of the conclusions, that is, to ensure that even when integrating a single matrix, the values obtained are reliable.

Likewise, column 4 assigned the values for each variable according to a predefined scale that integrated a directly proportional relationship to the importance given (low, medium, or high). It should be noted that these scores were defined on a scale of 1 to 10.

Table 4 Interaction matrix for the Marabá Pioneira urban center.

Environmental indicator	Environmental variable	Weight	Value	Ueqi
Population growth	Birth rate	2	5	70
	Mortality rate	1	3	
	Job creation	3	6	
	Urban structures	3	7	
	Migration	3	8	
Basic sanitation	Water supply	3	8	82
	Sewage system	3	8	
	Population health	4	7	
	Pest control	2	3	
Use of water resources	Bathing	4	7	82
	Potability	4	4	
	Surface contamination	3	3	
	Flooding	3	7	
	Drainage	2	4	
Waste production	Waste collection	3	8	60
	Final disposal	2	9	
	Urban sanitation	2	9	
Environmental education	Schooling	2	4	40
	Environmental awareness	3	6	
	Quality of life	2	7	
Vegetation	Deforestation	5	6	74
	Loss of biodiversity	4	6	
	Siltation of water bodies	3	5	

Table 5 Interaction matrix for the Cidade Nova urban center.

Environmental indicator	Environmental variable	Weight	Value	Ueqi
Population growth	Birth rate	2	3	61
	Mortality rate	1	1	
	Job creation	3	6	
	Urban furniture	3	4	
	Migration	3	8	
Basic sanitation	Water supply	2	8	46
	Sewage system	2	7	
	Population health	3	6	
	Pest Control	1	2	
Use of water resources	Bathing	2	4	64
	Potability	2	4	
	Surface contamination	2	3	
	Flooding	3	6	
	Drainage	4	6	
Waste production	Waste collection	3	8	58
	Final disposal	2	8	
	Urban sanitation	2	9	
Environmental education	Schooling	2	3	33
	Environmental awareness	3	5	
	Quality of life	2	6	
Vegetation	Deforestation	4	7	50
	Loss of biodiversity	3	6	
	Siltation of water bodies	2	2	

Column 5 displays the UEQI. These in turn were the result of the sum of the indicators that were partially multiplied by their weights. Accordingly, the results obtained were evaluated using a comparative table, as elaborated previously. It should be noted that, in this case, the proportionality relationship was inverse, since the lower the UEQI value, the higher the level of urban environmental quality.

(9) Calculation of Means, Standard Deviations, and Coefficients of Variation

Using this data, the average UEQI was calculated for each environmental indicator to compare the two urban centers, that is, each value obtained by the calculation reflected the average between the values of the indicators of both centers, according to the following equation:

$$X = \frac{UEQI\ y\ +\ UEQI\ z}{2} \qquad (2)$$

Where:

X: Mean

UEQIy: Urban environmental quality index for the Marabá Pioneira Urban Center.

UEQIz: Urban environmental quality index for the Cidade Nova Urban Center.

The mean values obtained for each environmental indicator between the two urban centers listed in Table 6. The Excel for Windows program version 16.06741 used to calculate standard deviation.

3. Results and Discussion

The comparison of environmental impacts indicated that the Marabá Pioneira Center presents the most worrying Urban Environmental Quality Index (Fig. 2).

Table 6 Mean UEQI obtained for each environmental indicator.

Environmental indicator	Mean Ueqi	Standard deviation
Population growth	65	6.36
Basic Sanitation	64	25.4
Use of water resources	73	12.2
Waste production	59	15.7
Environmental education	42	8.5
Vegetation	62	18.2

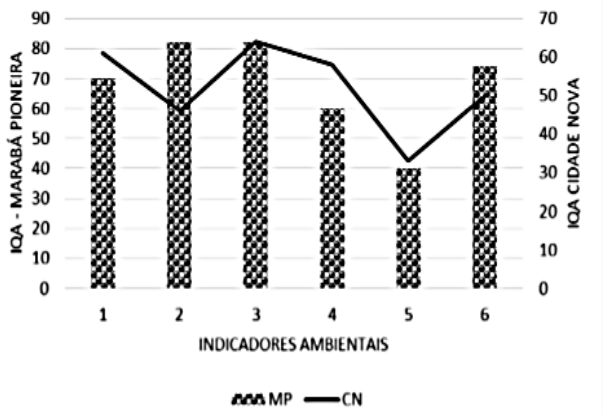

Fig. 2 Urban environmental quality indexes for the Marabá Pioneira and Cidade Nova urban centers.

Legends: 1. Population growth; 2. Basic sanitation; 3. Use of water resources; 4. Waste production; 5. Environmental education; 6. Vegetation.

XX: Environmental Indicators

YY1: Ueqi Marabá; YY2: Ueqi Cidade Nova

The analysis indicated that the population growth in the Marabá Pioneira urban center obtained a value of 70 for the UEQI. Compared with the Cidade Nova urban center (UEQI = 61), the difference was equal to 9. Both UEQI values indicated a "poor" classification, although the Cidade Nova urban center was less affected because it presented a lower value than that of the Marabá Pioneira urban center. A study conducted by Ribeiro (2017) [11] revealed that high population growth rates indicate a decrease in the mortality rate and an increase in the birth rate. The reflection of this indicator is demographic expansion. In this sense, growth is a determinant factor for the degradation of the environment because the demand for products and services will increase, that is, the consumption of natural resources is higher and the quality of life of the population will be negatively affected.

Regarding basic sanitation, the analysis indicated that this indicator obtained a UEQI score of 81 for the Marabá Pioneira urban center, compared to 46 for the Cidade Nova Urban Center, which was a difference of 9. The former values classified as "fair", but the latter value classified as "poor". In relation to the first, the classification is "fair," but the second is classified as "poor." Therefore, the Cidade Nova Urban Center presented better conditions in the water supply, sewage network, and population health.

In a survey conducted in the municipality of Igarapé-Açu by Sousa et al. (2016) [12], the evaluation of water capture and treatment for human consumption considers the sanitary sewage practices routinely performed by the population, as there are direct implications on the health of the local population. Thus, the municipalities of Pará are more vulnerable to environmental impacts in water bodies, since investments in sanitary infrastructure are still incipient.

The analysis of the data on use of water resources revealed a UEQI of 82 for the Marabá Pioneira urban center, compared to a value of 64 for the Cidade Nova urban center, with a difference equal to 18. Both UEQI values indicated a "poor" rating. However, this problem is greater in the Marabá Pioneira urban center because the index is higher.

In a study conducted by Montaño (2016) [13], the availability of resources in terms of quantity, quality, and time of recurrence is an increasingly important factor for economic and social development. In this perspective, there is a need to plan for the sustainability of resources and to act in a preventive manner for management of demand, i.e., incorporating environmental feasibility (spatial and temporal) in decision-making processes.

Regarding waste production, the Marabá Pioneira urban center obtained a UEQI of 60, while the Cidade Nova urban center obtained a UEQI of 58. There was greater similarity between both locations for this indicator, since the difference between the two was equal to 2. These values indicated a "fair" classification and expressed common problems in relation to waste collection, final waste disposal, and urban cleaning. In a study conducted in the municipality of Candói-PR by Monteiro (2017) [14], environmental variables incorporated into the generation of waste expressed the degree of urban sustainability, which evaluated the distance between the current status of a society and its development goals. It also provided a guide for the

formulation of policies and practices. Therefore, an indicator is more than a statistic because the dimensions of sustainability are grouped and include issues related to the minimization of the use of natural resources and waste generation.

The data indicated that environmental education at the Marabá Pioneira urban center obtained a score of 40, while the Cidade Nova urban center obtained a score of 33, with a difference of 7 between them. These values indicated a "fair" classification, although the environmental variables of the Cidade Nova urban center indicated a higher quality in terms of level of education of the population and environmental awareness.

In a study conducted by Barchi (2016) [15], environmental education was considered one of the means through which it was possible to mitigate environmental impacts and promote a new form of coexistence in society. Accordingly, the institutionalization of environmental education is of fundamental importance for the creation of sustainable and just societies to drive decision-making and contribute to the improvement of the quality of life of inhabitants. In the municipality of Marabá, this environmental indicator suggested that alternatives to promote sustainable development are still incipient, as social actors are not insertion in the stages of urban planning.

Regarding vegetation, the data indicated that the Marabá Pioneira urban center had a UEQI of 74. In contrast, the UEQI value obtained for the Cidade Nova urban center was 50. This reflected a divergence of 24 in the UEQI. Both values indicated a "poor" classification. However, this indicator is of more concern in the Marabá Pioneira urban center, as the value is higher. In this aspect, there was a higher incidence of environmental variables related to deforestation, loss of biodiversity, and the silting of water bodies.

Ferreira (2016) [16], in a study conducted in the state of Goiás, argued that the intense occupation of cities contributes to the removal of vegetation cover and influences the hydrological behavior of the environment. Such changes produce significant impacts on water flow, since soils with unprotected surfaces are vulnerable to compaction, which decreases their infiltration capacity and favors sediment carriage to the river. The result is a change in the basin, which as a consequence changes the minimum and medium water flows. This situation is observed frequently in Marabá, where the activities of residents near Marabá Pioneira are directly affected by the alteration in the water flow. This indicates that the balance of volume of the basin is the result of upstream processes.

As verified by the data obtained, environmental indicators are tools capable of synthesizing information about a given situation. In this sense, the values listed for each UEQI were satisfactory, insofar as they reflected the reality of the municipality of Marabá, as well as the disparities between the urban centers.

Thus, the analysis of the data agreed with the studies of Marins (2017) [17], as according to this author, the indicators were quantified, of a scientific nature, and easy to understand, which makes them useful as an evaluation tool for certain phenomena and for assessing tendencies and developments that change over time.

4. Conclusion

The comparison of recurrent environmental impacts in the Marabá Pioneira and Cidade Nova urban centers indicated that, although both centers obtained similar classifications in UEQIs, Marabá Pioneira obtained the highest values. Therefore, the negative effects resulting from environmental changes have higher incidences in this urban center, since the increase in the UEQI will result in a reduction in the quality of life of the population.

Therefore, population growth was the environmental indicator of greater relevance, as demographic expansion is responsible for changing the dynamics of the environment, as well as the influence that it exerts

on society. Thus, it is understood that the increase in demand of natural resources will be directly proportional to the environmental impacts caused. Therefore, it is necessary to adopt control mechanisms that aim to establish sustainable societies. Accordingly, environmental management is the main pillar to ensure good environmental governance.

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