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Assessment of environmental, social and economic sustainability of a hydrographic basin in the Brazilian semiarid region

Avaliação da sustentabilidade ambiental, social e econômica de uma bacia hidrográfica do semiárido brasileiro

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ABSTRACT: The objective of the present study is to evaluate the environmental, social and economic sustainability of the Apodi/Mossoró River hydrographic basin (RN) located in the Brazilian semiarid region. The basin was divided into four sections: *upper course*, *upper middle course*, *lower middle course*, and *lower course*. The sampling sites were distributed along the hydrographic basin to obtain the values of the following limnological variables: dissolved oxygen, total nitrogen, total phosphorus and thermotolerant coliforms. Information related to economic and social indicators was acquired from the Brazilian Institute of Geography and Statistics (IBGE). Sustainability was assessed using the conceptual model implemented with the aid of the software Multisectorial, Integrated and Operational Decision Support System for Sustainable Use of Water Resources at the Catchment Scale (MULINO mDSS). In the Apodi/Mossoró river basin, the most sustainable stretch was the lower course, with less variation amplitude between the scores of the economic, environmental and social dimensions. This stretch was considered potentially sustainable, with better performance in the social and economic dimensions; however, comparatively, it showed lower score for the environmental dimension than the other sections of the hydrographic basin. This fact shows that the lower course section has greater economic and social development, however, presents more environmental problems. The upper course section was classified as having low sustainability. The upper middle course section stood out in the environmental dimension, but because it did not present proportional scores in the social and economic dimensions, its overall index was of low sustainability. The lower middle course section showed average sustainability. Thus, it was shown that environments that are more economically developed tend to have more environmental problems, however, they can still be considered more sustainable due to greater economic and social development.

Keywords: aquatic ecosystems; water resources; eutrophication; Apodi-Mossoró River.

RESUMO: O objetivo do presente estudo foi avaliar a sustentabilidade ambiental, social e econômica da bacia hidrográfica do rio Apodi/Mossoró (RN), semiárido brasileiro. A bacia foi dividida em quatro trechos: alto curso, médio curso superior, médio curso inferior e baixo curso. Os locais de amostragens foram distribuídos ao longo da bacia hidrográfica para obtenção dos valores das seguintes variáveis limnológicas: oxigênio dissolvido, nitrogênio total, fósforo total e coliformes termotolerantes. As informações relacionadas aos indicadores econômicos e sociais foram adquiridas junto ao Instituto Brasileiro de Geografia e Estatística – IBGE. A sustentabilidade foi avaliada por meio do modelo conceitual implementado com o auxílio do *software Multisectorial, Integrated and Operational Decision Support System for Sustainable Use of Water Resources at the Catchment Scale* (MULINO mDSS). Na bacia hidrográfica do rio Apodi/Mossoró o trecho mais sustentável foi o baixo curso, com menor amplitude de variação entre os escores das dimensões econômica, ambiental e social. Este trecho foi considerado como potencialmente sustentável, apresentando melhor desempenho nas dimensões social e econômica, no entanto, comparativamente, exibiu menor escore para a dimensão ambiental do que os demais trechos da bacia hidrográfica. Isto evidencia que o trecho de baixo curso possui maior desenvolvimento econômico e social, entretanto, apresenta mais problemas ambientais. O trecho de alto curso foi classificado como de baixa sustentabilidade. Já o trecho de médio curso superior se destacou na dimensão ambiental, mas por não apresentar escores proporcionais nas dimensões social e econômica, o seu índice geral foi de baixa sustentabilidade. O trecho de médio curso inferior apresentou média sustentabilidade. Assim, foi evidenciado que ambientes que são mais desenvolvidos economicamente tendem a apresentar mais problemas ambientais, entretanto, ainda podem ser considerados mais sustentáveis devido ao maior desenvolvimento econômico e social.

Palavras-chave: ecossistemas aquáticos; recursos hídricos; eutrofização; rio Apodi-Mossoró.

1. Introduction

The hydrographic basin comprises structures and functional processes that result from the interaction between geomorphology, hydrology, and socioeconomic aspects (Barbosa et al., 2012). The conservation of hydrographic basins is becoming increasingly relevant, as the inadequate protection of their water resources can lead to contamination of groundwater and surface water due to pollution by metals, organic matter, nitrogen, and phosphate compounds, causing environmental degradation and problems for the social and economic development of the region (Moura & Henry-Silva, 2015; Jablońska-Czapla et al., 2016; Pavão & Nascimento, 2019).

Sustainability is by definition and by necessity a comprehensive concept (Osmundsen et al., 2020); as such, the concept of sustainability involves habitable environments that are maintained over time (WCED, 1987). Sustainability involves three pillars: economic, social and environmental (Zarghami & Fatourehchi, 2020), meaning that, for an environment to be considered sustainable, it must be economically developed, low in environmental degradation, and socially beneficial. In this context, to assess the sustainability of a hydrographic basin, it is necessary to have knowledge about the situation in which it finds itself, considering the complex of social, economic conditions and the environmental changes to which it is submitted to guide management and administrative decisions (Bezerra et al., 2013; Debastiani Júnior & Nogueira, 2016).

The hydrographic basins are suffering from deforestation, expansion of agricultural land use, incorrect exploitation of soils by agriculture (Seitzinger et al., 2010; Rocha & Santos, 2018), input of domestic, industrial and agricultural effluents (Elmi et al., 2004; Singh et al., 2005; Sindilariu et al., 2009; Diamantini et al., 2018), and climate change, which affect both the hydrology and biogeochemistry of aquatic environments (Dodds, 2002; Wagena et al., 2018).

The exploitation of water resources and the preservation of aquatic environments and their biodiversity impose the need for cooperation between different administrative spheres and the constitution of a new institutional arrangement with the alteration of certain paradigms; for example, the need for legislation and norms that focus not only on the quality of water for human consumption, but that also consider the ecological quality of aquatic ecosystems, as has been happening in the European Community, which established an ecosystem approach to watershed management (Siqueira & Roque, 2010; Behmel et al., 2018; Wang et al., 2019; Gusmão & Pavão, 2019; O'Hagan, 2020).

Studies have been developed to evaluate the sustainability of hydrographic basins through environmental, economic and social indicators, enabling the transformation of complex technical data into information that is easy to understand for the general public and decision makers (Heink & Kowarik, 2010; Tscherning et al., 2012; Maes et al., 2016; Silva et al., 2016). These indicators can be used in the DPSIR theoretical framework (Driver-Pressure-State-Impact-Response) that was proposed by the Organization for Economic Cooperation and Development, aiming to assist mainly in decisions regarding the environmental conservation of hydrographic basins (OECD, 1993; Liu et al., 2019).

In this causal model, social and economic development are the driving forces that exert pressures and generate changes in the state of the environment, causing impacts on the quality of life of human beings and biodiversity (Atkins et al., 2011). The difference between DPSIR and other conceptual models is the increment of the impact variable which describes the effects of pressures on the current state of the environment in the studied area (Moura et al., 2016; Vannevel, 2018; Zare et al., 2019). In this context, the objective of the present study is to evaluate the environmental, social and economic aspects of the Apodi-Mossoró hydrographic basins located in the Brazilian semiarid regions through the application of a set of indicators and the DPSIR conceptual model.

2. Material and methods

The study was developed in the hydrographic basins of Apodi/Mossoró, which is located in the western micro-region of the state of Rio Grande do Norte in Brazil, occupying an area of 14,276 km² (26.8% of state territory), with 618 dams, totaling a volume of 469,714,600 km³ of water, equivalent to 27.4% of the total number of dams and 10.7% of the water volume accumulated in the state (IGARN, 2020). In the hydrographic basin, activities are carried out in the industries of oil extraction, sea salt production, irrigated agriculture and fruit growing, extensive livestock, limestone mining, among others, such as commerce and industry (Carvalho et al., 2011).

The definition of sampling sites occurred from field visits, surveys carried out in the region, and satellite images. Sampling sites were selected, divided into four sections delimited according to the topographic conditions of the basin and the political-administrative limits of the municipalities. These four sections are the upper course (1,208.92 km²), medium upper course (4,176.76 km²), medium lower course (6,132.47 km²), and low course (3,176.03 km²), as described by Carvalho et al. (2011) (Figure 1).

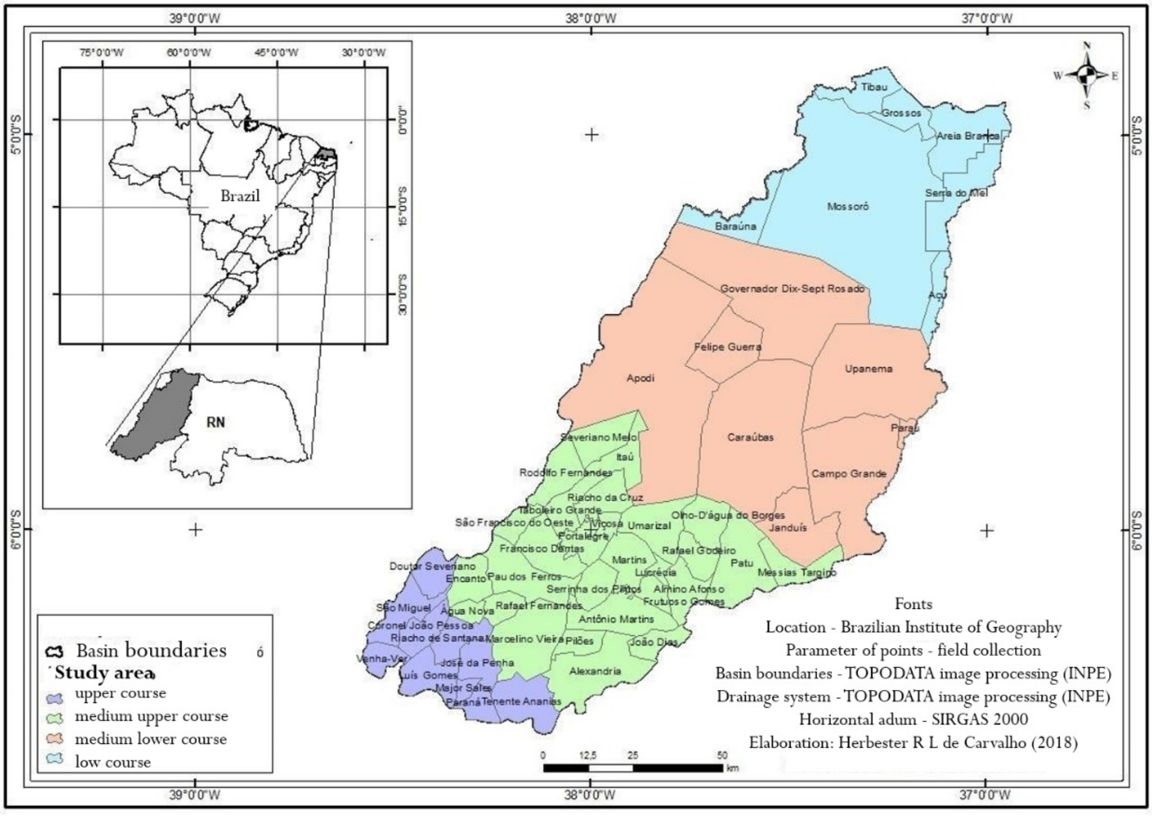

FIGURE 1 – Map of the four sections delimited according to topographic conditions and political-administrative areas of the Apodi/Mossoró river basin, in the state of Rio Grande do Norte, Brazil.

To measure sustainability, the conceptual model was implemented with the help of the Multi-sectoral, Integrated and Operational Decision Support Systems for Sustainable Use of Water Resources at the Catchment Scale (MULINO mDSS) v5.12 (Giupponi, 2007). As input data for this model, 26 sustainability indicators were used, distributed among the three social, economic, and environmental dimensions (Table 1) (IBGE, 2010; Henriques *et al.*, 2015).

TABLE 1 – Indicators of economic, environmental, and social sustainability used to assess the sustainability of the different sections of the Apodi/Mossoró hydrographic Basin.

SUSTAINABILITY INDICATORS		
ENVIRONMENTAL DIMENSION	**SOCIAL DIMENSION**	**ECONOMIC DIMENSION**
Thermotolerant Coliforms	Demographic density	Gross Domestic Product per capita – GDP
Dissolved oxygen	Enrollments in elementary and high school	Income of formal workers
Total Nitrogen	Number of elementary and high school institutions	Revenue
Total Phosphorus	Child mortality	Outgoing
Volume of Weirs	Hospitalizations for diarrhea	Busy personnel
Agricultural establishments	Health Units - Unified Health System (UHS)	Number of active companies
Technical assistance		Municipal Human Development Index - HDI
Use of pesticides		
Permanent and temporary crops		
Natural pastures		
Woods and natural forests		
intended for permanent preservation or legal reserve		
Access to basic sanitation		
Urbanization of public roads		

The dissolved oxygen data were obtained in the field through the multisensor of limnological variables. For the determination of total nitrogen, total phosphorus and thermotolerant coliforms, water samples were collected in the field and later analyzed in the laboratory. For the determination of total nitrogen, the amount of nitrite, nitrate (method described by Mackereth et al., 1978), and total nitrogen, the Kjeldahl acid digestion method was employed (Carmouze, 1994). The phosphorus total was obtained through the method described by Golterman et al. (1978). The thermotolerant coliforms of the samples were obtained through the multiple tube method according to the National Health Foundation (FUNASA) (Brasil, 2013). Data on the volume of reservoirs were obtained through the reservoir monitoring system of the National Water Agency (ANA). All other information on the indicators was acquired from the website of the Brazilian Institute of Geography and Statistics (IBGE).

The indicators were selected to reflect the sustainability of the watershed in the four sections evaluated. The selected indicators served as input into the software and were grouped according to the DPSIR criteria, which consider:

I – Indicators of driving forces;

II – Pressure indicators on the ecosystem;

III – State indicators of the current conditions of the studied system;

IV – Indicators of impacts caused to the environment; and

V – Possible responses in terms of management to mitigate the impacts generated.

Indicators such as thermotolerant coliforms, dissolved oxygen, total nitrogen, and total phosphorus are indicators representing the state in which the environment is at a given moment in time. Such indicators are extremely important to analyze the level of pollution in environments. These indicators also consider impacts in terms of investigating damages to the environmental quality of a particular place. The volume of reservoirs indicator represents the state in which that reservoir is currently located.

The status criterion is assigned to the indicators of gross domestic product, municipal human development index, income of formal workers, and income and expenses of the region, because these indicators represent the status of the population and region. The indicators of number of active companies, agricultural establishments, and extraction of natural resources contribute to the increase in environmental pollution. For this reason, they are classified within the pressure criterion. The driving force criterion is used for the indicators of access to basic sanitation, urbanization of public roads, population density, enrollment in primary and secondary education, number of educational institutions, health care clinics, and employed personnel. This criterion is adopted because such indicators are underlying factors that influence the other variables. The response criterion is adopted for the infant mortality and hospitalization for diarrhea indicators, as it represents a response that is received from the pressure imposed on the environment and the population.

When there is a quantitative reduction in crops, natural forests destined for permanent preservation or permanent and temporary legal reserves, natural pastures, and forests, it implies the alteration of natural resources. Therefore, these indicators are classified within the pressure criterion (Table 2).

TABLE 2 – Indicators used as input in MULINO for DPSIR modeling

Indicators	**Criterion**	**Primary Dimension**
Thermotolerant Coliforms	State/Impact	Environmental
Dissolved oxygen	State/Impact	Environmental
Total Nitrogen	State/Impact	Environmental
Total Phosphorus	State/Impact	Environmental
Volume of reservoirs	State	Environmental
Agricultural establishments	Pressure	Environmental
Technical assistance	Driving force	Environmental
Use of pesticides	Impact	Environmental
Crops, natural forests intended for permanent preservationor permanent and temporary legal reserve	Pressure	Environmental
Natural pastures	Pressure	Environmental
Woods	Pressure	Environmental
Access to basic sanitation	Driving force	Environmental
Urbanization of public roads	Driving force	Environmental
Demographic density	Driving force	Social
Enrollments in elementary and high school	Driving force	Social
Number of elementary education institutions	Driving force	Social
Child mortality	Response	Social
Hospitalizations for diarrhea	Response	Social
Health Units - Unified Health System (UHS)	Driving force	Social
Gross Domestic Product per capita	State	Economic
Municipal Human Development Index	State	Economic
Revenue	State	Economic
Outgoing	State	Economic
Busy personnel	Driving force	Economic
Number of active companies	Pressure	Economic

A sensitivity analysis was performed using the MULINO software. This analysis evaluates the behavior of the scenarios modeled in response to changes in each of the indicators individually and points out which indicators are the most important to the system, being more relevant those whose small changes in their values strongly influence the sustainability of the system. Considering this, the MULINO software performed a comparative analysis between the four subdivisions of the hydrographic basin (high course, medium upper course, medium lower course, and low course) so that the performance of the indicators was calculated for each subdivision and assigned a scale from 0 to 100, with 0 being the least sustainable scenario and 100 the most sustainable among the options considered.

Thus, at the end of the modeling, the four subdivisions of the watershed were classified according to their sustainability in the environmental, social and economic dimensions, with each scenario being assigned a sub-index for each dimension evaluated and an overall sustainability index (Table 3). Principal Component Analysis (PCA) was applied to order the sampling sites based on the correlation matrix of the indicators used to assess the sustainability of the hydrographic basin. The aforementioned statistical analysis was performed in the free software R Core Team (2020).

TABLE 3 – Performance scale applied in the assessment of the sustainability of the modeled scenarios.

Scale	Classification
0-20	Not sustainable
21-40	Low sustainability
41-60	Medium sustainability
61-80	Potentially sustainable
80-100	Sustainable

SOURCE: Moura et al., 2016.

3. Results

The modeling revealed that the upper course and upper course sections showed low sustainability. In turn, the lower middle course section showed average sustainability, and the low-course stretch was considered potentially sustainable, because the closer the scenario approximates to the center of the triangle, the more sustainability is evenly distributed (Figure 2). The low course section, despite not having the highest index in the environmental dimension, was considered more sustainable due to the social and economic dimensions presenting the highest rates (Table 4).

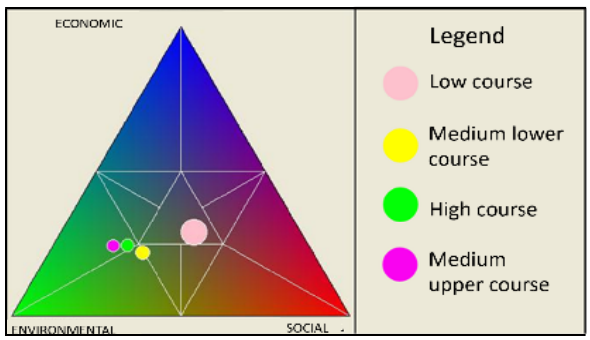

FIGURE 2 – Triangle of sustainability for the four sections evaluated (low course, medium upper course, medium lower course, and high course).

TABLE 4 – General sustainability scores and indices for each dimension considered in the four analyzed sections. Scores in bold indicate the most sustainable scenario for each dimension and the index in bold indicates the most sustainable scenario.

Sections	**Scores**			**Index**
	Environmental	**Social**	**Economic**	
Upper course	53	22	25	31
Medium upper course	**58**	18	24	24
Medium lower course	50	28	22	60
Low course	32	**39**	**29**	**67**

The Principal Component Analysis (PCA) summarized 80.12% of the total variability of the indicators used to verify the sustainability of the hydrographic basin in its first two axes; the first axis explained 55.15% of the total variance found; and the second axis 24.97%.The indicators that showed greater importance for the ordering of the sections of the hydrographic basin and that were positively related in Axis 1 were: use of pesticides, infant mortality, and hospitalization due to diarrhea.

The indicators technical assistance, forests and legal reserves, schooling, enrollment in schools, educational institutions, GDP, HDI, income, revenue, expenses, employed persons, and active companies were negatively related to Axis 1. The thermotolerant coliform indicators, volume of dams, agricultural establishments, and urbanization of roads were positively related to Axis 2, while demographic density and infant mortality were negatively related to the same axis (Figure 3 and Table 5)

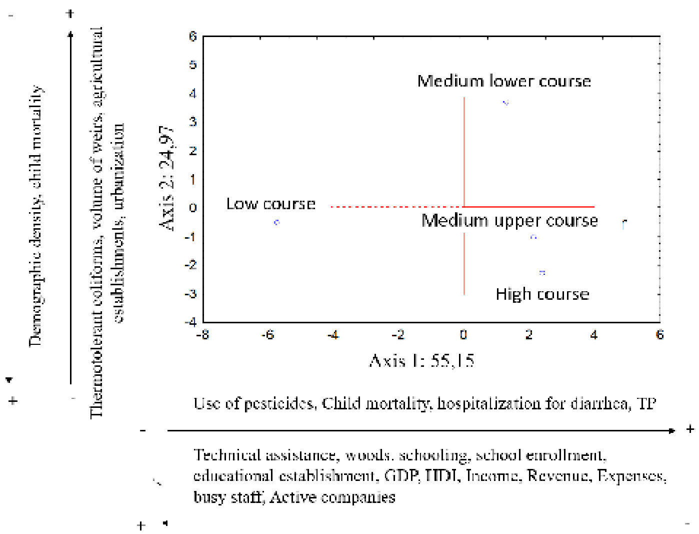

FIGURE 3 – Principal Component Analysis for the indicators used to verify the sustainability of sections of the Apodi-Mossoró river basin.

TABLE 5 – Factorial coordinates of the indicators, based on correlations from the analysis of principal components.

Indicators	Axis 1	Axis 2
Thermotolerant coliforms	0.330017	0.943951
Dissolved Oxygen	0.381536	0.294263
Total Nitrogen	0.232540	-0.451143
Total Phosphorus	0.662403	-0.743518
Volume of reservoirs	0.338780	0.903277
Agricultural establishments	-0.470118	0.869901
Technical assistance	-0.797674	0.190924
Use of pesticides	0.971462	0.186821
Crops	0.323433	0.366911
Pastures	0.266798	0.190196
Woods	-0.711419	0.665334
Sanitation	-0.235502	0.263863
Urbanization	0.203423	0.973504
Demographic density	-0.498781	-0.828983
Schooling	-0.807807	0.489997
School enrollment	-0.992472	-0.113114
Educationa linstitutions	-0.995949	-0.075019
Child mortality	0.704497	-0.703709
Hospitalization for diarrhea	0.862233	-0.146118
Health care clinics	-0.955099	-0.267001
Gross domestic product per capita	-0.994701	0.101709
Municipal Human Development Index	-0.999939	0.008803
Income	-0.691573	-0.380267
Revenue	-0.993548	-0.107623
Outgoing	-0.994349	-0.100805
Busy personnel	-0.993965	-0.109419
Number of active companies	-0.994015	-0.109222

The upper course and upper course sections present several agricultural establishments that use pesticides, high percentage of infant mortality, and hospitalizations due to diarrhea when compared to other sections of the hydrographic basin. The low-course stretch has more technical assistance provided to rural producers, in addition to having more areas of woods and natural forests destined for permanent preservation or legal reserve. As for education, the low-course stretch has a higher number of schools, a higher number of enrollments in primary and secondary schools, in addition to having more educational institutions.

As for education, the low-course section has a higher number of schools, a higher number of enrollments in primary and secondary schools, in addition to having more educational institutions. Regarding health, this stretch has more health care clinics when compared to the other sections. Regarding the economic aspect, the low course section presented larger values of GDP, HDI, population income, expenditure, and revenue. In addition, it also presented the largest number of companies and, consequently, the largest number of employed persons. Therefore, the lower stretch of the hydrographic basin is more economically and socially developed when compared to the other sections evaluated. The CPA also showed that the lower middle course section has larger amounts of thermotolerant coliforms, more agricultural establishments, and higher volumes of water accumulated in reservoirs. The largest total phosphorus values were found in the upper course section.

4. Discussion

The economic, environmental, and social dimensions are referred to as the three pillars of sustainability (Frankic & Hershner, 2003). Thus, for a stretch of the hydrographic basin to be considered fully sustainable, it is necessary that it be economically developed, low in environmental degradation, and socially beneficial. It is worth noting that a given stretch can be sustainable in just one, two or three dimensions of the Apodi/Mossoró River. In the hydrographic basin it was found that the most sustainable stretch was the low course, with lower amplitude of variation between the scores of the economic, environmental, and social dimensions being considered potentially sustainable. Although this stretch performed better in the social and economic dimensions, had the lowest score in the environmental dimension. This shows that this stretch is more developed in the economic and social aspects, according to the indicators used; however, it presents more problems related to the environmental impacts related to anthropic activities, likely as a result of economic development.

Bezerra et al. (2013) highlighted that human activities contribute to the pollution of the Apodi-Mossoró River, and the main activities that impact water systems are the release of domestic and industrial effluents, agricultural activities, and animal husbandry on the banks of the river, which, by increasing phosphorus concentrations in aquatic ecosystems can trigger the eutrophication process. It is important to highlight that although the low course is not the most environmentally sustainable stretch, it contains larger areas of woods and natural forests intended for permanent preservation or legal reserve, for example, the Furna Feia National Park, which is the only National Park in the state of Rio Grande do Norte, located between the municipalities of Mossoró and Baraúna. The preservation of vegetation cover, mainly from the riparian forest, alleviates problems such as silting of rivers that would significantly alter the environmental integrity of the river ecosystem, causing imbalance of the environment and local biota by reducing the availability of habitats and food, in addition to being able to reduce flooding and contamination of rivers by agricultural effluents such as fertilizers and pesticides (Vidon et al., 2010; Feld et al., 2018).

The low-course stretch is the most socioeconomically developed in the hydrographic basin of the Apodi-Mossoró River. The region corresponding to this section has the highest values of GDP, HDI, workers' income, greater number of companies and consequently, more busy people. According to Kayano & Caldas (2002), a high GDP is an indicator of economic growth, although the presence of economic growth alone does not prove that there is social development in the stretch. Thus, the set of high GDP and HDI values, the better workers' incomes, greater number of companies, and people employed evidence the social and economic development of the low-course stretch when compared to the other analyzed sections.

The stretch corresponding to the middle upper course proved to be more environmentally sustainable. Although, according to the model, the same stretch is less socially and economically sustainable. Thus, the general index classified this stretch with low sustainability in the general context of the hydrographic basin. Environments that are less economically exploited tend to be more conserved in their environmental aspect, as urbanization stimulated by economic development directly impacts the quality of water (Ren et al., 2014; Carstens & Amer, 2019). Cerqueira et al. (2020) showed in their study that urbanization represents the type of land use with the greatest negative effect on water quality, as it alters the concentrations of dissolved inorganic nutrients in water bodies.

The section corresponding to the lower middle course was classified as average general sustainability. This stretch presented the largest volumes of water present in the reservoirs. The lower middle course section holds the two largest reservoirs in the hydrographic basin of the Apodi-Mossoró River, which are Umari and Santa Cruz. The availability of water is an extremely important factor for the well-being of the population, as well as being relevant for economic development, as water is indispensable for agriculture, livestock and fishing activities. (Assis et al., 2013). Although the lower middle course has a greater number of agricultural establishments, when compared to the other sections of the hydrographic basin, it showed a high concentration of total phosphorus in the water, and this may be related to the fact that this stretch has areas of riparian forest that are relatively more preserved. Studies indicate that agriculture developed in the drainage network of the hydrographic basin increases the levels of deposited fine sediment (Conroy et al., 2016) and promotes the entry of nutrients, mainly in the form of phosphorus and nitrogen, into water systems (Cesoniene et al., 2019; Namaalwa et al., 2020). Nonetheless, when aquatic systems have riparian forest, the negative impact on water quality is minimized (Vidon et al., 2010).

The high-course stretch has low overall sustainability, having a higher score in the environmental dimension than in the social and economic dimensions. Despite that, the stretch presents high use of pesticides, likely because it is a region with an economy focused on agriculture. This fact can generate serious problems for the population who live near areas cultivated with pesticides, who are at risk of consuming contaminated water or food. In addition, toxic substances that may be present in the air can be inhaled. (Neto & Sarcinelli, 2009). The exposure to toxic substances can cause problems with the liver and central nervous system, such as headaches, dizziness, irritability, involuntary muscle movements; problems with the cardiovascular and reproductive systems, with some evidence of endocrine disruption and problems with the eyes, kidneys, spleen, anemia, and an increased risk of developing cancer (IARC, 2007; ATSDR, 2007).

The Principal Components Analysis showed that the sections corresponding to the upper course, upper course, and lower course have more social problems, including the highest infant mortality rate, frequent hospitalizations due to diarrhea, lower levels of schooling and fewer health care clinics, when compared to the low-course stretch. Themodeling in MULINO also showed that the scenarios corresponding to the high course, medium upper course, and medium lower course are less socially and economically sustainable. The infant mortality rate, for example, is an indicator of the living and health conditions of a population, because in addition to expressing biological causes, it mainly expresses socioeconomic problems (Vermelho et al., 2009). Economically less developed regions have fewer financial resources to invest in health and education and, consequently, experience more social problems. Poorer areas commonly do not have basic sanitation, and this influences the health of the population, including the frequency of diarrhea, which is related to the sanitary aspect, as the existence of basic sanitation is associated with a reduction in the frequency of diarrhea. (Wolf et al., 2018).

5. Conclusions

In the Apodi/Mossoró hydrographic basin, the most sustainable section was the low course, because it presented a smaller amplitude of variation between the scores of the economic, environmental, and social dimensions. This section was considered potentially sustainable according to themodeling, showing better performance in the social and economic dimensions; however, with a lower score in the environmental dimension. This shows that the lower stretch of the hydrographic basin has greater economic and social development, however, it presents more environmental problems. The high course section was classified as having low sustainability, presenting a higher score in the environmental dimension and lower scores in the social and economic dimensions. The upper middle course section had the highest score in the environmental dimension. However, as it did not present proportional scores in the social and economic dimensions, the general index was the lowest when compared to the other analyzed sections, thus, this stretch presented low sustainability in the overall context of the hydrographic basin. The lower middle section was classified as a stretch with medium sustainability, with higher scores in the environmental dimension and lower in the social and economic dimensions. Thus, for these three sections to become more sustainable, it is necessary to improve the social and economic conditions in the region.

The assessment of the environmental, social and economic sustainability of the Apodi-Mossoró hydrographic basin through the application of a set of indicators and the DPSIR conceptual model provided information on the sections of the hydrographic basin that present greater social vulnerability and/or environmental problems to the different administrative spheres. Such information may be instrumental to suchentities as they may carry out actions aimed at improving the socio-environmental aspects of the sections through social public policies and the elaboration of new laws aimed at conservation of water resources and aquatic ecosystems, among other social and environmental actions. In addition, it allows the administrative spheres to visualize the sections of the hydrographic basin that require greater investments for the development of the economy. Thus, this research is useful for providing information that can support more efficient and better directed planning by the administrative spheres.

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