Anthropogenic Actions and Socioenvironmental Changes in Lake of Juá, Brazilian Amazonia

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Abstract: The Amazonia rainforest has natural spaces that have undergone extensive and intense transformations, mainly to meet economic demands, camouflaged in biological and social needs. As one of the consequences of this process, the production and expansion of the urban space stand out. In this context, this research describes the historical, spatial, and temporal aspects of land use and occupation in the surroundings of Lake of Juá, located in the municipality of Santarém, west of the State of Pará, Brazil, in order to highlight the main changes in the landscape and socioenvironmental changes arising from this dynamic. The study was conducted based on photographic records, elaboration, and analysis of cartographic data, in addition to the perceptions of residents and fishermen located in the study area, which, together, contributed to the understanding of the historical and spatial changes that led to the current socioenvironmental transformations in the surroundings of the lake. The residents and local fishermen of Lake of Juá, through semi-structured interviews, listed several socioenvironmental overlapping problems that had many impacts on this lake ecosystem, such as deforestation, silting, contamination of water resources and, consequently, fishing resources, loss of biodiversity and conflict of interest. The degradation and decharacterization of the landscape around the lake has compromised the maintenance of this lake ecosystem, as significant and even irreversible transformations have been caused in the community and in the ecological environment, especially when taking into account the absence of public policies or their inefficiency.

Keywords: landscape changes; environmental perception; lake ecosystem; water resources; urban lake; eastern Amazonia

1. Introduction

The Brazilian Amazonia is a large and rich region of the planet, being an important territorial reserve for Brazilian society, but its biodiversity and the delicate regional ecological balance make its development an unknown and challenge to world and national science [1].

The space must be considered an inseparable whole, in which we have on one hand geographical, natural, and social objects and on the other, the life that fills and animates them, that is, the society in movement [2].

Natural spaces have undergone extensive and intense transformations, especially to meet human demands, camouflaged in biological and social needs. A main example is the production and expansion of urban space.

Urban expansion contributes to interventions in aquatic ecosystems such as streams, rivers, lakes, swamps, among others, impacted by several simultaneous environmental stressors, associated with accelerated urban development and climate change [3,4].
Most Brazilian cities emerged on the banks of rivers, which reveal their important historical role. In that regard, the aquatic ecosystems are fundamental for establishing people in the city, however, have been exploited and degraded over the years [5].

Human actions have damaged Amazonian ecosystems, such as the urbanization process [6] and disordered urban growth, being necessary to create environmentally qualified cities, where man and the environment are in harmony [7], especially with regard to the water bodies present in these spaces.

Thus, the environmental issue and the notion of development emerge as fundamental issues in the processes of use and occupation of the soil on the margins of water bodies, in order to guarantee the conservation of the environment and the quality of life of the beings that inhabit it.

The Lago do Juá complex, located on the west side of the municipality of Santarém, in the State of Pará, like other Amazonian spaces, is recognized for its ecological, social, economic, and cultural importance, which have been put at risk as a result of the process urbanization of its surroundings.

It is exactly toward the west of the urban core of Santarém that an intense and accelerated urban expansion process is observed, with little and in some cases no type of planning on the part of the local government, with the advance of urban structures to the water bodies that integrate the city landscape [8].

Understanding this process and its dynamics makes it possible to identify the main variables of this movement and the forecast of possible future impacts, anticipating mitigating measures in order to protect and for the conservation the water sources.

In addition, case studies such as this one can contribute policy and practice recommendations aimed at the overall management of peri-urban landscapes and livelihood-based and socio-ecologically sound development [9], providing valuable information about the family life of the local population, their quality of life and their role in the local economy [10].

In this context, considering the socio-environmental and economic importance of Lake of Juá, the objective of this study was to describe the historical, spatial, and temporal aspects of land use and occupation in the surroundings of Lake of Juá, located in the city of Santarém, west of the State of Pará, in order to highlight the main modifications of the landscape and socio-environmental changes arising from this dynamic.

2. Materials and Methods
2.1. Area of Study

The research was carried out having as empirical reference Lake of Juá (Lago do Juá in Portuguese), which is situated at approximately seven kilometers from the urban center of Santarém, in the western region of Pará, in the Brazilian Amazonia. The analysis took into account five areas that directly influence the lake (Figure 1), to mention: Santarém International Airport, Environmental Protection Area—APA of Lake of Juá, Residential Cidade Jardim-Buriti, Residential Salvação and the Vista Alegre do Juá Occupation.

2.2. Data Collection and Analysis

The research is qualitative in describing the historical process of urbanization around Lake of Juá and identifying socio-environmental and quantitative problems through a semi-structured interview with 25 residents and fishermen of the Lake of Juá Community. These data were quantified according to the information given by the interviewees, which are the environmental problems and impacts around Lake of Juá, which affect the community, such as: Fires; deforestation; siltation of water courses, degradation of springs; solid waste disposal; pollution of water courses; sewerage system; access to clean water; noise pollution; predatory fishing; disorderly urbanization; invasion of areas; violence, among others that were reported by them.
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After identifying the problems and impacts with the interviewees, they accompanied us to the locations so that it was possible to carry out photographic records to identify aspects of the landscape according to the use and occupation of Lake of Juá; therefore, during this walk to the locations and interviews, participant observation was carried out.

The snowball sampling method was used, which is a method of selecting informants, which is useful in identifying potential interlocutors. It is better to work with a small group of good informants (“key informants”) than with a large group who has little knowledge of the subject. Subsequently followed by content analysis [11].

Data were analyzed using descriptive statistics, in which the relative frequency of responses given by respondents regarding the impacts they perceived was calculated [12]. To calculate the anthropogenic area around Lake of Juá, land use and land cover maps were generated. We used LandSat images from three periods (2011, 2015 and 2017), obtained free of charge, which were pre-processed and then supervised classified in the free software

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**Figure 1.** Lake of Juá and identification of areas of influence, in the city of Santarém, Pará, Brazil.
Spring version 5.2, of the National Institute for Space Research (INPE) [13]. The vector files generated, containing the calculation of the area occupied by each class in square kilometers, were imported into the free software Quantum Gis version 3.8, generating the thematic map of land use and coverage in the surroundings of Lake of Juá. With this information, it was possible to calculate the rate of increase in the anthropized area between 2011 and 2017, as well as obtain the gross value of each class in the same period. The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of Universidade do Estado do Pará (UEPA)- Campus XII-Tapajós (protocol code 2,447,030, 2017).

3. Results and Discussion

3.1. Brief History of the Urbanization Process around Lake of Juá

Until the 1960s, the city of Santarém, as well as the vast majority of cities in the Amazon, had their economic and social relations most associated with the river [14]. Over the years and gradually, its urban structure began to change, due to the implantation and densification of the road network in the region, with emphasis on the highways: BR 010 (Belém-Brasília), BR 230 (Transamazônica), BR 163 (Cuiabá-Santarém), PA 370 (Santarém-Curuá-Una) and the Fernando Guillon Highway [15].

In the case of Santarém, the highways had a great influence on its urban expansion process, as the city was limited by the streams of Urumary, to the east, and Irurá/Mapiri, to the west [16]. Currently, the municipality has stood out on the regional scene, not only for the natural beauty of its freshwater beaches, such as Alter do Chão, but also for the agricultural production and export of soybeans, made possible by the bulk port of Cargill, installed in the city in year 2000. This has been provoking an intense migratory process, altering the municipal urban space with the rise of new neighborhoods and increasing the value of the land.

The Fernando Guillon Highway has become an important urban expansion route to the west of the city, where Maestro Wilson Fonseca International Airport is located, implanted in 1974, the Eixo Forte Agroextractive Settlement Project—PAE, the State Highway Everaldo Martins (PA-457), which gives access to Alter do Chão Beach and Lake of Juá [15].

It is worth mentioning that the Eixo Forte Agroextractive Settlement is formed by sixteen traditional communities, located in the rural area, but that due to the proximity to the urban area of the municipality, it absorbs direct influences from the city [17].

On the margins of the Fernando Guillon Highway, new neighborhoods emerged, accentuating the peripherization in the municipal urban area, characterized by spontaneous occupation or invasions of private lands and/or areas of environmental protection and/or of environmental interest [15]. The neighborhoods Maracanã, Santarenzinho, Nova Vitória, Novo Horizonte, Conquista, São Cristovão, Alvorada, Maracanã I and Elcione Barbalho are around this highway [18].

As an example of occupations beside the highway and around Lake of Juá, there is the occupation called Vista Alegre do Juá, located between the coordinates 2°27′2.93″ S latitude and 54°45′37.15″ O longitude, it has a straight line of approximately 2.69 km, from the highway to the Tapajós River (Salvaçã o Beach) [16].

This occupation maintained, between the years 2016 and 2017, a distance of only 200 m from the Environmental Protection Area—APA of Juá, which leaves Lake of Juá increasingly vulnerable to this disorderly occupation process.

However, the occupation process around this lake began in 1953, with the arrival of the Santos Family, which constituted the Juá Community and which remains in the area until the present day.

It is a fact that the implementation of the Airport, in 1974, contributed to the increase in the flow of people, demanding the opening of new roads and branches, and access to the airport and the lake was only facilitated in 2003, when the first line bus that connected the city center to Santarém Airport started to function, thus helping the displacement of the residents of the Juá Community to other areas of the city and the access of those
“outside” the community, either to go to Juá Beach, for carrying out fishing activities, with the intention of occupying other areas around the lake, among other reasons.

In the community and on the lake, there is a strong presence of residents and fishermen from the communities of the PAE Eixo Forte (to name: Cucurunã, Pajuçara, Ramal dos Coelhos and Santa Maria) and neighborhoods in the city such as Mapiri and Maracanã, who make use of the lake mainly for artisanal fishing.

It is also important to highlight the implementation of private real estate projects such as Residential Cidade Jardim-Buriti, under the responsibility of Salvacão Empreendimentos Imobiliários Ltda. (SISA), whose trading name is Buriti Imóveis, since the year 2012. In addition to this project, mention is made of the implementation of Residential Salvacão, under the “Minha casa, Minha vida” (My Home, My Life) program of the Federal Government [8].

3.2. Landscape Changes and Socio-Environmental Impacts around the Lake

The use of the term socioenvironmental is intended to affirm the inseparable character of the relationship between society and nature, as it is believed that human life cannot be conceived without nature, independent and indifferent to the different levels of use of natural resources, considering the interaction of the most diverse social actors and the natural space, which is increasingly altered.

The landscape is considered here as a scenario and not as a passive background, that is, a system of spatialized meanings, fundamental to the discourse of human action and, in this perspective, it is necessary to interpret its manifestations about the landscape of the studied area and the consequences of these actions in the urban environment [19].

The dynamic and historical processes of use and occupation of urban land have strong social and environmental implications and directly imply social and environmental risk and vulnerability situations [20].

In various parts of the world, a rapid process of urbanization is taking place that generates numerous impacts on societies and the environment [21]. This urbanization process is increasing globally, as there is an incentive to live in cities, as it is suggested that in urban areas there are greater socioeconomic benefits, such as access to jobs or other economic opportunities, education, and health services, despite this, the authors stress that urbanization contributes to deforestation and landscape fragmentation, to air and water pollution and to the increase of impermeable surfaces [22].

In cities there are the means of production, wealth, political power, infrastructure, educational institutions, and a relevant portion of our cultural heritage are concentrated [23]. However, still for this author, the urbanization process in force in contemporary society is directed to accumulation of capital, which influences the unequal distribution of urban space and environmental problems such as the degradation of ecologically valuable lands, affecting more directly groups of people in social vulnerability who live in urban areas, thus generating social and environmental impacts in these spaces.

All respondents who participated in the survey reported that disorderly urbanization triggered different socio-environmental problems around Lake of Juá. In this context, based on participant observation and interviews, some social and environmental impacts are listed (Figure 2).

In 2014, with the installation of the Vista Alegre do Juá (Spontaneous Occupation), initiatives to invade areas around the lake were accentuated, but without success. This did not prevent the frequent presence of people in the community, especially for walks and views of the lake and Juá beach. The growing urbanization and the complexity of the problems arising from it point to a great challenge regarding the organization of urban space, such as the spontaneous occupation process that is promoted by the population’s initiative through the invasion of public land and areas of permanent preservation, which make the planning and implementation of infrastructure and basic services difficult [24].
With the intensification of the occupation processes in 2016–2017, the interviewees attribute to the Vista Alegre do Juá Occupation and the urbanization around the Highway Engineer Fernando Guilhon, the increase in the rate of violence, including small thefts, especially of fishing materials from artisanal fishermen who frequent the lake. Corroborating Cardoso et al. [25] in the statement that it is necessary to restore the safety of local residents, given the increase in violence in the area, such as the occurrence of theft of fishing equipment.

According to those interviewed, deforestation occurred sharply in 2012 with the installation of Residential Cidade Jardim Buruti, a period that justifies the increase in fires around the lake. Thus, deforestation (Figure 3) and conflicts of interest, which overlapped, triggered impacts on the sustainability of the lacustrine ecosystem, such as siltation and loss of biodiversity.

The deforestation can have unpredictable systemic effects on the environment, such as the loss of animal and plant species, and at a more global level, it can generate a drastic reduction in rainfall levels [26]. Deforestation in the vicinity, whether for the installation of real estate projects or due to disorderly occupation, resulted in several environmental impacts, as observed during the field data collection, such as: Loss of vegetation cover; removal of the soil’s fertile layer; soil impoverishment; reduction of fauna and flora; siltation of water resources, mainly.

Figure 2. Environmental problems identified by research participants, around Lake of Juá, Santarém, Pará, Brazilian Amazonia.

Figure 3. Deforested area around Lake of Juá, Santarém, Pará, Brazilian Amazonia. Source: First author (2017).
For those interviewed, the removal of vegetation cover and the runoff of rainwater from the Santarém Airport runway are the causes of the siltation of the lake. They emphasize that the deposit of materials is intensified during the rainy season, and they are dragged with the force of rain directly into the lake, becoming the main agent causing siltation in the lake in the perception of most respondents, being one of the sources of pollution in the lake.

It is worth mentioning that the suppression of the vegetation cover of an ecosystem compromises the biodiversity of the place and ends up contributing to the extinction of animal and plant species, many of them endemic which leads to the alteration of an ecosystem that may be lost in the future.

Furthermore, urban streams are complex and dynamic ecosystems that establish connections with other natural, urban, and social systems. These are environments that, historically, suffer degradation with the strangulation and waterproofing of its bed, suppression of riparian vegetation and inadequate disposal of effluents and solid waste [27].

As for basic sanitation services, such as running water, sewage system and garbage collection, the interviewees reported that they remain non-existent in the community since its occupation in 1953, which corroborates Cardoso et al. [8], who state that the services of a health center, piped water and electricity never existed in the Lake of Juá Community.

In addition to the aforementioned problem, which occurred in 2014, according to the interviewees, urban effluents from the residential Salvação were released, which generated great commotion in the municipality due to the visible aesthetic characteristics at the time.

The flows of effluents, that occur in different points of the lake, transport eroded sediments, causing their deposition in the lakebed (Figure 4).

![Figure 4](image-url)

Figure 4. Distinct images of Lake of Juá and the effects of anthropogenic actions, Santarém, Pará, Brazilian Amazonia. (A) sewage runoff and sludge appearance, (B,C) muddy stretches, (D) compacted soil. Source: First author (2018).

Such changes can still be seen in the lake ecosystem (Figure 5). The waste from the surroundings has changed the appearance and quality of the lake water.
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Figure 5. Urban effluents flowing into Lake of Juá, Santarém, Pará, Brazilian Amazonia. Source: First author (2017).

The clear and greenish color of the lake has become turbid and yellowish, which has directly influenced the quantity and quality of the fish in it, harming the main economic activity of the residents of the community, which is artisanal fishing. This is one of the oldest activities in Brazil, considered the main source of resources for many families from different communities [28,29]. In the Lower Amazon region, it is an activity of great socioeconomic and cultural importance, being responsible for generating food, employment, and income for the vast majority of users and community members in this region [30].

According to reports by former residents of the Juá Community, local fishermen also did ornamental fishing in the lake, but stopped doing it because ornamental fish decreased in number and lost quality. Among the ornamentals most cited by the interviewees were the species popularly known as xadrez, acará disco, botafogo, matogrossense and borboleta [25].

It is noteworthy that the ornamental fish of the Amazonia arouse great interest in aquarists from all over the world, so most of the production of these fish is destined for the international market [31,32]. As for artisanal fishing, the data corroborate the research by Corrêa et al. [30], which directs the capture of approximately 17 categories of fish in Lago do Juá, with emphasis on the jaraquis (Semaprochilodus insignis and S. taeniurus), which were very frequent and cited by the majority of fishermen interviewed in both studies.

As for the occurrence of predatory fishing, respondents claim that this problem is not as frequent as in other times, although a minority claim that it still exists.

Thus, the use and occupation of areas without planning entails problems of a social and environmental scope, since the appropriation of certain territories is intrinsically linked to the maintenance of natural resources in different ecosystems, which are impacted by the growing urban expansion, especially with regard to disorderly occupation on the urban banks of rivers, lakes, and streams.

The Juá Community does not have public cleaning or garbage collection and treatment, and thus many solid wastes are thrown directly along the road that gives access to the lake of the same name (Figure 6).

The environmental degradation of urban rivers and streams in large cities has led to the formulation of different public policies [33]. Urban environmental problems are related both to the processes of building the city and, therefore, to the different political and economic options that influence the configurations of the space, and to the conditions of urban life and cultural aspects, which shape the ways of life and relationships interclasses [34].
Anthropic interference without control and without planning affects the quality of human life in this space, and in the case of Lake of Juá, this aquatic ecosystem has been suffering from the changes that have occurred in the terrestrial ecosystems to which it is interconnected (residential buildings and irregular occupations in the vicinity).

The growth of Brazilian cities has been occurring in a disorderly way, producing different realities that vary according to the different regions of the country, making it necessary to create and implement public policies that consider the specificities of these regions in the sense of to build balanced development that takes into account the local reality [35].

In 2001, the Statute of Cities of Brazil was ratified, through Federal Law No. 10,257, which regulates articles 182 and 183 of the Federal Constitution and establishes the general guidelines of urban policy in Brazil, which guided the creation of the policy. urban with the objective of ordering the full development of the social functions of the city and urban property [36].

Among the guidelines that were established, we highlight the ordering of land use and occupation, which aims to preserve, conserve, and make the urban use compatible with the environment, observing its limits and potential.

In addition, the City Statute regulates urban policy instruments, such as the Municipal Master Plan, Discipline of Land Use and Occupation Parceling, environmental zoning, among other instruments for regulating urban activities. These instruments are essential to guide urban expansion, especially regarding the direction of the growth of cities towards risk areas, because, the various forms of organization are important, as they condition the formatting of the urban space, in this sense, it is essential that the government uses strategies to mitigate problems of land use and occupation in urban areas, in addition to reducing unequal and excluding access to housing and infrastructure [35].

To mitigate the problems of rapid and uncontrolled urban expansion, many cities around the world have been instituting several urban growth management policies, but highlight that the formulation of such policies, that provide sustainable results, is a difficult task for administrators of urban areas and has numerous flaws, and stress that it is a challenge to develop appropriate policies for sustainable urban growth. appropriate methods, which present indicators and political priorities that generate resolutions based on the local reality for the establishment of sustainable policies [21].

In addition, it is important to highlight that some people end up settling in places through spontaneous occupation, they do this even for lack of choice of place to settle their
homes, and it turns out that some of these people may not be aware of the importance of to keep the environment balanced, especially for the maintenance of life, in this sense, it is essential that greater inspection of the areas is carried out, as well as the promotion of environmental education, so that it is possible to make the population aware of the proper disposal of solid waste, therefore, formal and informal environmental education is an instrument with great potential to reach the greatest number of people, and create environmental awareness [37].

Although there are transformations arising from natural aspects such as floods, the research points out that urban expansion without planning has weakened the perspective of sustainable development both in the lake and in the Juá Environmental Protection Area (APA-Juá) which was established on December 28, 2012 by the Municipality of Santarém through Law No. 19,206, with an area of 1,538,502.82 m². According to Article 3 of the Law, the Juá Environmental Protection Area aims to:

I Preserve the geological and biological ensemble that makes up the entire APA in the Juá area, as well as protect biological diversity, water resources and natural heritage, ensuring the sustainable character of human activity in the APA area;

II Order the occupation of land and promote the protection of abiotic resources within their limits, in order to ensure the well-being of the human populations that live there, safeguard or increase local ecological conditions and maintain relevant landscapes and cultural attributes;

III To supervise the practice of scientific and ecological tourism activities, as well as economic activities compatible with environmental conservation;

IV Exercise environmental control and monitoring activities in order to allow, monitor and discipline, over time, interferences in the environment;

V Promote environmental education, scientific research and the conservation of cultural and historical values [38].

As already shown above, in recent years, as well as the lake, APA has received direct influence from adjacent areas, to mention again Santarém Airport, Vista Alegre do Juá Occupation, Residential Cidade Jardim-Buriti and Residential Salvaçã, which is evident in the intense and accelerated process of expansion of the Fernando Guilhon Highway, which is the access from Santarém to the Juá Community, which unfolds into neighboring areas to reach this location [15].

In a study on the impact of roads on development and occupation in the southwest of the Brazilian Amazonia, there was a strong relationship between deforestation and roads, as they are land access routes, thus strongly influencing deforestation in the Amazon region [39]. In this sense, these authors indicate that it is necessary to constantly monitor the expansion of roads to improve environmental and social control actions, therefore, they highlight the concern with the increase of roads in areas of Conservation Units.

Thus, it is observed from the temporal map of the surroundings of APA and Lake of Juá, that in the period from 2011 to 2018 (Figure 7) there was an increase in areas without vegetation cover, mainly east of Lago, reinforcing the perception of interviewed about the increase in human pressure and the recurrent environmental degradation around the lake.
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Figure 7. Temporal use and coverage map of the surroundings of Lake of Juá (Lago do Juá) in the period from 2011 to 2018, Santarém, Pará, Brazilian Amazonia. Elaboration: Authors (2021).

In the period between 2011 and 2017, the anthropized areas had an increase of approximately 39%, resulting, consequently, in the reduction of forest cover around the Lake (Figure 8).

Figure 8. Area by year around Lake of Juá (Lago do Juá), Santarem (PA) 2011 to 2017, Santarém, Pará, Brazilian Amazonia. Elaboration: Authors (2021) with infogram.com.
In research on land adequacy to guide landscape restoration in the Amazonia, mapping is a tool that can contribute to reducing deforestation, controlling forest degradation, promoting forest restoration, and improving practices [40]. In the Brazilian Amazonia, the social actors involved in the mapped areas can better organize and plan their landscapes and thus optimize their activities, adapting land use strategies for landscape restoration. Therefore, this is a strategy that can contribute to the reality of the residents and local fishermen of Lake of Juá in Santarém.

In this context, although recognizing the importance of creating this law, it is clear that the sustainability of the APA and, consequently, of the lake has not been guaranteed. The existing interests and power relations are a challenge to establish a balance in the relations between the different social actors involved in the internal environment and external to the APA.

About Amazonian indigenous lands, it was identified that threats related to forest loss (deforestation, forest degradation and fires) are more intense in buffer zones, that is, the areas surrounding indigenous lands [41]. In this sense, the authors emphasize that the resolution of environmental and social problems in these territories depends on the efficient execution of public policies, which are based on knowing the reality and specificities of the environmental threats that affect these spaces.

Managing a given area of environmental protection, in its physical, biotic, economic or social aspects, means exercising on it a set of political, legislative and administrative actions, so that, starting from a current reality, one can achieve a new scenario, previously planned, according to pre-established objectives points out that [42], which has not been happening at the APA of Lake of Juá. Thus, considering the context of the socio-environmental problems listed by the residents and local fishermen of Lake of Juá, it is essential that public policies take into account the particularities of the region and the place so that they are really effective.

In addition, the specific nature of different freshwater ecosystems is often ignored, which has consequences for people’s well-being, for biological aspects and makes cultural diversities that are linked to water and ecosystem services invisible [4].

It is also noteworthy that the policies for the recovery of aquatic ecosystems and the urban water management itself are inscribed in a context in which the policy and legal instruments are confronted with a logic of little articulation and intersectoriality of municipal management to implement responses effective and lasting [33].

Therefore, reintegrating urban rivers and other ecosystems into the landscape and providing an inclusive human relationship with water are challenges for Brazilian cities [43]. Many aspects must be considered to improve the quality of studies on environmental impacts, requiring better definitions of the terms of reference and the carrying out of more complete inventories of the species present in the directly or indirectly affected areas, so that future studies can become more analytical, less descriptive, and more useful [44].

Many cities around the world have been implementing revitalization projects to try to safeguard watercourses, especially those located within cities [5].

Thus, the natural processes of the springs must be known, conserved, and restored as much as possible, to improve the environment due to the aesthetic and health benefits of nature in the city, as well as improvements in the quality of water bodies [3].

Populations living in urban areas and rural areas continue to use and change resources, for a number of economic reasons, both have demands, but with profoundly different relationships, making it necessary to pay attention to the issue of lower occupation in urban areas, as data have shown patterns of destruction and unsustainable use of ecosystems [45].

With regard to public policies throughout Brazil, an essential element is missing: the government’s political will [26]. However, the recovery of environmental and social services of urban aquatic ecosystems has been a global trend in an attempt to make cities more sustainable, for example, cities in Europe, the United States, Asia and also in Brazil [27].
4. Conclusions

The residents and local fishermen of Lake of Juá listed several socio-environmental issues that, overlapping, had several impacts on this lake ecosystem, such as deforestation, silting, contamination of water resources and, consequently, fishing resources, loss of biodiversity and conflicts of interest.

Many endemic and rare species were lost due to deforestation, as well as the removal of other vegetation cover and the occupation around Lake of Juá, increasing the negative socio-environmental impacts.

The analysis of the photographic images and thematic maps shows the anthropic pressures on the natural areas, in which the changes in the landscape are linked to the history of occupation in the surroundings of the lake, either by the implementation of residential developments or by the irregular occupations in the surroundings.

Through the thematic maps, it can be observed that the degradation and decharacterization of the landscape around the lake compromises the maintenance of this lake ecosystem, as significant and even irreversible transformations were caused both to the community and the ecological environment, especially when taking into account the absence of public policies or their inefficiency.

The ecological, social, economic, and cultural importance of Lake of Juá and its surroundings leads to the need for studies related to its conservation and the preservation of its remaining vegetation cover.

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