




# Sustainability Index of the Gruta do Lago Azul Natural Monument, Bonito Mato Grosso do Sul, Brazil

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## **Keywords**

Natural heritage  
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Barometer of Tourism  
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## **Abstract**

With relevant scenic beauty, the Gruta do Lago Azul is one of the most important caves with national speleological heritage and is a tourist attraction with worldwide visibility. This study aims to analyze the sustainability index of the Natural Monument of the Gruta do Lago Azul in Bonito, Mato Grosso do Sul state. The Barometer of Tourism Sustainability (BTS) and AMOEBA of Tourism Sustainability Indicators (ATSI) were used to analyze the level of sustainability. Twenty indicators were selected that resulted in the following indices: the Human System had an average of 48.62% and the Ecological System was 58.17%. The verified index is in an intermediate stage, proportional to 41-60%, and is considered satisfactory. Despite this, a Management Plan and an Environmental Education Program were absent, and these are required by the National System of Conservation Units (SNUC). Given the foregoing, it is inferred that the integrity of the level of sustainability of the Natural Monument of the Gruta do Lago Azul is still uncertain. Therefore, to promote authentic sustainable tourism in areas that provide essential environmental services to society, such as the Gruta do Lago Azul, it is necessary to implement a compatible level of development to meet the needs of current generations, without compromising the capacity of future ones.

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## INTRODUCTION

Tourism in natural cavities is characterized by visits to subterranean areas and has become an activity that is experiencing continual growth throughout the world. Besides their scientific and cultural importance, caves have an immeasurable value as natural heritage for humanity (LOBO; BOGGIANI, 2013).

Caves were first used for tourism over 400 years ago. The Postojna cave in Slovenia was the first to be structured to receive tourists (1818) and illumination was installed in 1918 (ARAUJO et al., 2017). During the XX century there was significant growth in demand for tourism in caves (CIGNA; FORTI, 2013). However, this growth was not accompanied by planning and management activities adequate for the visited sites, especially in fragile environments such as natural cavities (LOBO, 2014).

In Brazil this situation has been the same, and due to the natural characteristics associated with karstic landscapes (MORETTI et al., 2016), and the great potential for tourism in caves distributed throughout the national territory, visitation to caves has occurred over the last few decades across different Brazilian states such as São Paulo, Minas Gerais, Rio de Janeiro, Goiás, Bahia and Ceará.

Bonito, a city in Mato Grosso do Sul, is a karstic tourism destination (Lobo; Boggiani, 2013), and among the tourist attractions is the Gruta do Lago Azul (Blue Lake cave) which is a Natural Monument that has great scenic beauty and many admirable speleological characteristics.

This cave is important because it has great natural and scientific heritage, and has yielded relevant biological, geological, geomorphological, and paleontological contributions to science (LOBO, 2015). The Gruta do Lago Azul enjoys worldwide visibility and is one of the most visited tourist sites in the region (MORETTI et al., 2016).

This cave contains speleothems of rare beauty, and because of this continuous planning for tourism activities is needed to conduct them based on a rigorous set of criteria that conserves the fragility of this ecosystem (CORDEIRO et al., 2013). Furthermore, mitigation factors must be considered due to the high degree of solubility of the rocks, the fragility of the cave's formations, and the extensive subterranean drainage network (GRECHI et al., 2010).

Due to its importance, the Gruta do Lago Azul was listed as national heritage 1978 by the National Institute of Historical and Artistic Heritage (IPHAN). Additionally, through the state decree n° 10.394/2001, the government of Mato Grosso do Sul designated this area as a National Conservation Unit (CU) in the category of Natural Monument, which has as objective the conservation of natural sites that are rare, unique, or that have great scenic beauty (BRASIL, 2000), which has helped to guarantee the integrity of the caves of Lago Azul and Nossa Senhora Aparecida.

The Gruta do Lago Azul is considered one of the most important caves to Brazilian speleological heritage and one of Brazil's most notable natural attractions (BOGIANNI et al., 2009).

In this context, tourism has contributed to strengthening the connection of visitors with the importance of protected natural areas and can aid in increasing the environmental awareness of tourists with respect to conservation of the natural heritage of protected sites (SALAS et al., 2019). In this way, the development of sustainable tourism activities requires actions that are socially just, economically viable, and ecologically correct.

Thus, the establishment of sustainability indices represents a method to measure the effects of tourism activities, and to subsequently propose actions to mitigate negative environmental and sociocultural impacts. The creation of such indices will also assure that activities developed in natural spaces are planned and have the necessary support of basic environmental and social laws pertaining to sustainability. For these motives, tourism in protected natural areas must reconcile the principles of sustainable use of natural resources and the environmental dynamics that are necessary for achievement of sustainability (MATHEUS; RAIMUNDO, 2016).

In this context, the importance of this study is that it reflects upon sustainable tourism practices in a way that guarantees, in the long term, effective management of this natural attraction in a way that respects the needs of current generations without compromising those of future ones. Therefore, the objective of this study was to establish sustainability indices for the Natural Monument of the Gruta do Lago Azul, Mato Grosso do Sul.

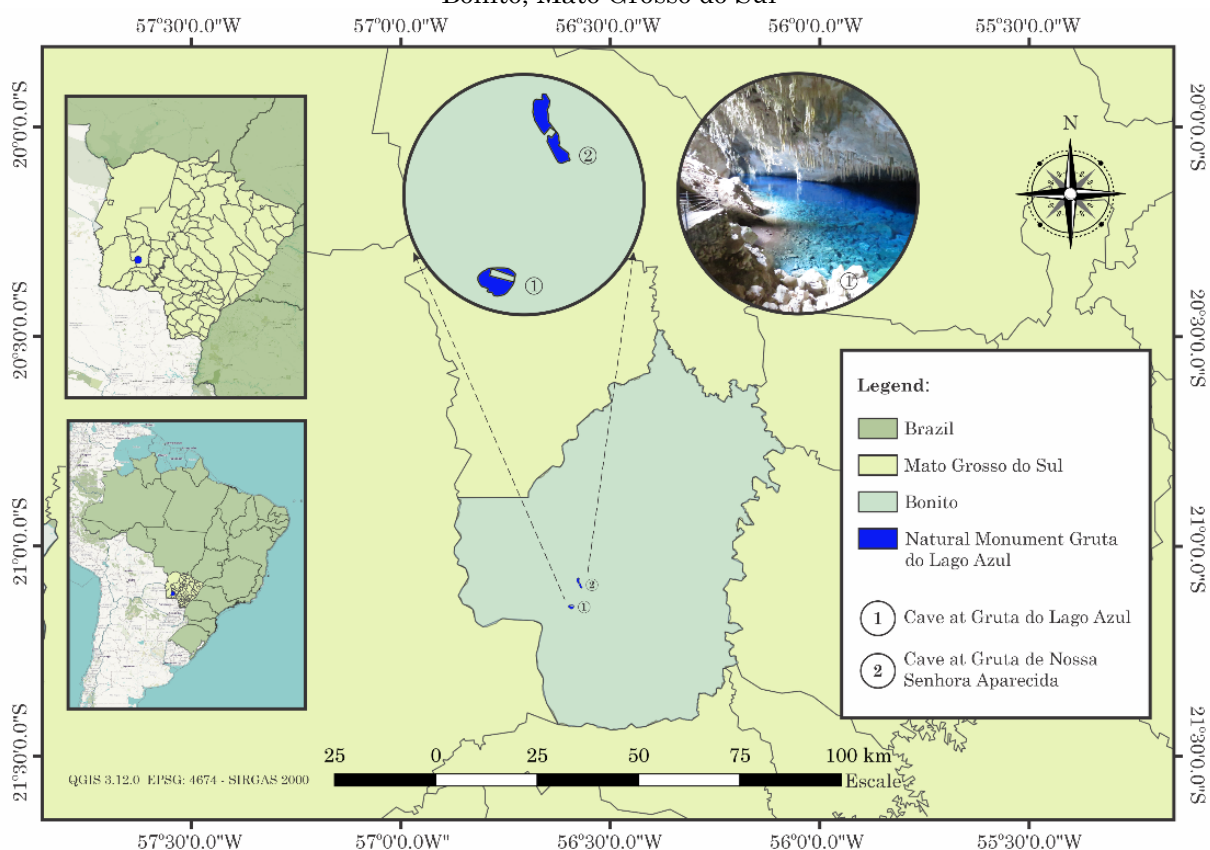
## MATERIAL AND METHODS

### Study area

The Natural Monument Gruta do Lago Azul is located in the municipality of Bonito, Mato Grosso do Sul at geographic coordinates 21°08'41"S and 56°35'27"W, between the watercourses Anhumas, to the north, and

Taquaral, to the south (Figure 1). This natural heritage site is comprised of two non-continuous areas that form the complex of the Caves of the Serra da Bodoquena, represented by the Lago Azul and Nossa Senhora Aparecida caves. Currently, only the cave at Gruta do Lago Azul can be visited, and due to issues related to cave security, the cave at Gruta de Nossa Senhora Aparecida is closed for visitation (BOGIANNI et al., 2009).

**Figure 1.** Map of the location of the Natural Monument Gruta do Lago Azul, in the municipality of Bonito, Mato Grosso do Sul



Source: organized by the authors, 2020.

The cave at Gruta do Lago Azul stands out because it is classified as a Conservation Unit in the National System of Conservation Units (SNUC) and is widely known nationally and internationally as a significant tourist site. Furthermore, besides being a natural heritage site, the cave at Gruta do Lago Azul is important for the provision of ecosystem services in the region.

### Data collection and analysis

The data analyzed in this study were from the period July 2017 to July 2019, and considering the seasonality of tourism, data were divided into high and low seasons. A questionnaire was

applied to visitors to the Gruta do Lago Azul, which received approval from the Committee for Ethics in Research of Anhanguera-Underp University, under case approval n° 2.526.285.

The methods used in data analysis consisted of the Barometer of Tourism Sustainability (BTS), and the Amoeba Model of Tourism Sustainability Indicators – ATSI, which is characterized by a graphical representation in the form of a radar. Both models aided in the verification of the level of sustainability of the Natural Monument Gruta do Lago Azul, with respect to environmental, economic, and social dimensions. In this type of analysis, it is recommended that the BST be used simultaneously with the Amoeba model, since

when these models are associated the efficiency of the description of indicators is greatly increased (KO, 2005).

The BST was adapted from the Barometer of Sustainability (BS), created by Prescott-Allen in 1997 with the purpose of measurement of global

and local sustainability by government and non-governmental agencies. This tool uses a scale that varies between 1 and 100, which facilitates comprehension of environmental and social sustainability (Table 1).

**Table 1.** Scale of values of sustainability for measurement of ecological and human well-being

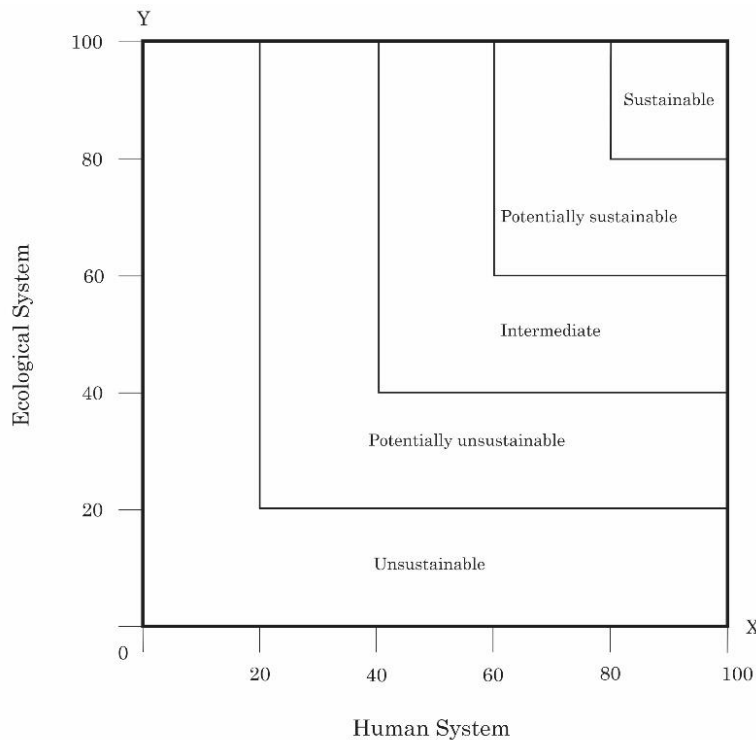
Sector	Value scale (%)
Sustainable (excellent)	81–100
Potentially sustainable (good)	61–80
Intermediate	41–60
Potentially unsustainable (poor)	21–40
Unsustainable (bad)	1–20

Source: adapted from Prescott-Allen (1997).

The use of BST and the Amoeba model (Figures 2 and 3) provides a general overview of the study area with respect to human and ecological systems. The graph resulting from these models concentrates information that is

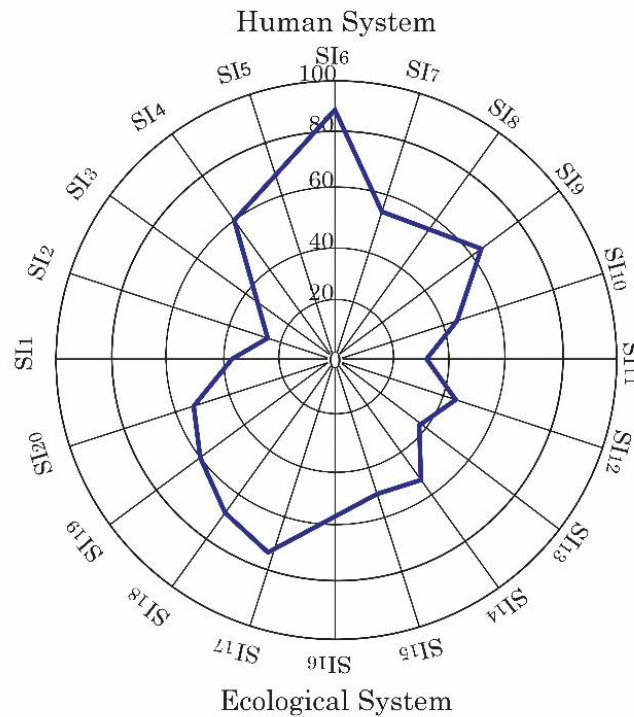
presented in an easily readable and intuitive graph that facilitates comprehension. Data were taken using parameters for each indicator based on the scale of Prescott-Allen (1997).

**Figure 2.** Graphical representation of the Barometer of Tourism Sustainability (BST)



Source: Modified from Ko (2005).

**Figure 3.** Graphical representation of the Amoeba of Tourism Sustainability Indicators (ATSI) model



Source: Modified from Ko (2005).

The choice of indicators was based on the questionnaire applied to a random sample (n=387), an interview with the manager of the area, current theoretical background from the literature, analysis of documents, and *in loco* visits.

Data were analyzed by evaluating the degree of the reliability of data collected from the questionnaires using the Cronbach Alpha test, as shown in (1). The coefficient of this equation is employed as a way to estimate the reliability of a questionnaire in a research study (HORA et al., 2010).

$$\alpha = \left[ \frac{k}{k-1} \right] \times \left[ 1 - \frac{\sum_{i=1}^k S_i^2}{S_t^2} \right]$$

Where:

**k** corresponds to the number of items in a questionnaire,

$S_i^2$  corresponds to the variance of each item, and  
 $S_t^2$  corresponds to the total variance of the questionnaire, corresponding to the sum of all the variances.

The consistency of the analyzed data corresponds to the Cronbach Alpha ( $\alpha$ ), together with a degree of significance, as shown in Table 2.

**Table 2.** Scale of values of the Cronbach Alpha

Cronbach Alpha	Internal consistency
$\alpha > 0.9$	Excellent
$\alpha > 0.8$	Good
$\alpha > 0.7$	Acceptable
$\alpha > 0.6$	Questionable
$\alpha > 0.5$	Poor
$\alpha < 0.5$	Unacceptable

Source: Adapted from George and Mallery (2003).

The credibility of the method used in the analysis of the sustainability index of the Gruta do Lago Azul, through the Cronbach alpha,

confirmed that the consistency of the questionnaire was significant (Table 3).

**Table 3.** Internal consistency of the questionnaire according to the Cronbach Alpha

Respondents	K	$S_i^2$	$S_t^2$	$\alpha$
387	16	17.85	92.39	0.86

Source: organized by the authors based on research data.

The validation of this method was confirmed by the value of the Cronbach alpha ( $\alpha = 0.86$ ).

## RESULTS AND DISCUSSION

The quantification of indicators allows for a visual (graphical) presentation of the results and

analysis, and this will aid in the elaboration of conservation programs and projects (OMT, 2005; VAN BELLEN, 2006). In this context, indicators were selected from human and ecological systems that represent the level of sustainability of activities carried out at the Gruta do Lago Azul (Table 4).

**Table 4.** Indicators selected to quantify the level of sustainability of tourism at the Gruta do Lago Azul, Bonito, Mato Grosso do Sul

	Indicators	SI*	Values (%)
Human System	Access (between the city and the cave)	SI1	50,50
	Customer service and reception (guides, monitors)	SI2	76,70
	Security equipment	SI3	57,40
	Information and promotion of tourist attraction	SI4	57,10
	Accessibility	SI5	41,80
	Internal infrastructure (ladders, handrails, boardwalks)	SI6	46,20
	Promotion of environmental education	SI7	56,50
	Care and attention to natural tourist attraction	SI8	72,90
	Risk management (PPEs, first aid, experienced guides)	SI9	27,10
	Creation and conduction of socio-environmental activities	SI10	0,00
Ecological System	Trash management	SI11	70,20
	Vegetation (general state of conservation)	SI12	65,90
	Effects of visitation on natural spaces	SI13	43,30
	Stress on local fauna which disturbs the equilibrium state	SI14	42,80
	Soil degradation	SI15	66,70
	Fragile environment of the cave	SI16	76,50
	Represents a vulnerable ecosystem	SI17	54,40
	Possesses relevant geological information	SI18	61,90
	Control of carrying capacity	SI19	100,00
	Management plan	SI20	0,00

SI\* = Sustainability Indicator. Source: elaborated by the authors using research data.

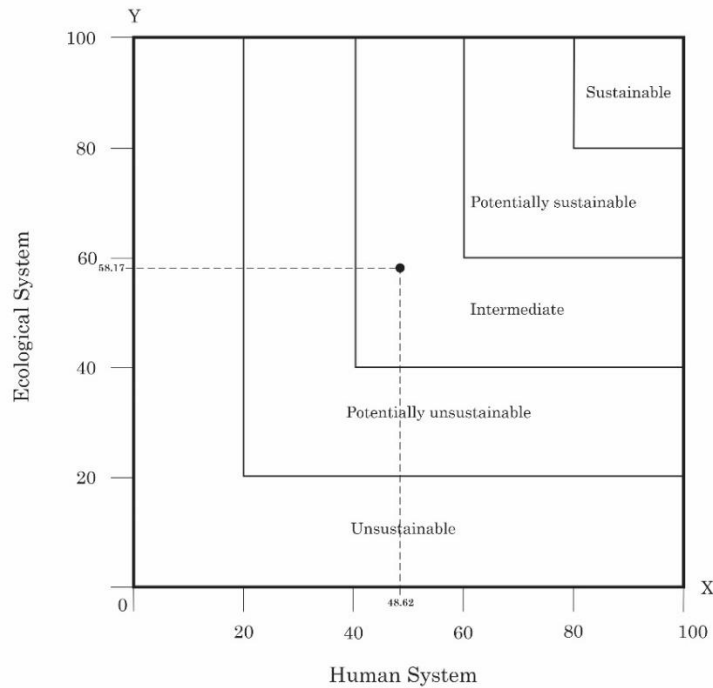
### *Sustainability level of the Gruta do Lago Azul*

Based on the 20 selected indicators an average was calculated, which represents the final score for the level of sustainability of activities at the

Gruta do Lago Azul. For the Human System, the average was 48.62%, and for the Ecological System it was 58.17%. These results were inserted into the BST and the AMOEBA model (Figures 4 and 5).



**Figure 4.** Representation of the sustainability level of the Gruta do Lago Azul, according to the Barometer of Tourism Sustainability

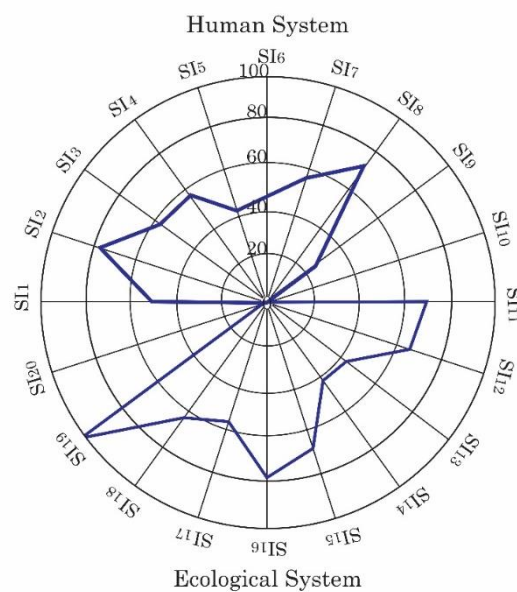


Source: elaborated by the authors using research data.

According to the BST graph (Figure 4), the sustainability level of the Gruta do Lago Azul Natural Monument is intermediate (41-60%). This level of the indicator is considered satisfactory on the sustainability value scale (PRESCOTT-ALLEN, 1997).

Despite this result, this evidence may be an alert signal, which would require that managers reconsider certain aspects with respect to environmental and social parameters of tourism at the cave.

**Figure 5.** Measurement of the sustainability level of each indicator applied to the Gruta do Lago Azul, using the AMOEBA model



Source: elaborated by the authors using research data.

Furthermore, since this site is classified as an Integral Protection Conservation Unit, the levels of the sustainability indicators reported in this analysis are not compatible with the objectives and requirements for such Conservation Units (CU), and this is a preoccupying situation. An example of this deficiency is the absence of a formal **Management Plan**, which is the principal technical planning and management instrument, the objective of which is to regulate the use of the area and manage its natural resources. This plan must also create an environment wherein the CU is integrated into the economic and social lives of the neighboring communities.

The management of protected areas does not involve only biophysical, cultural, and socioeconomic factors, but also includes a diversity of interested parties and social actors (HOCKINGS *et al.*, 2019), and these factors can greatly affect the conditions of the site and therefore the administration and management models.

Teles and Nogueira (2016) related that most protected areas in Brazil were created by governmental decree, and many of these areas do not have a management plan. The Gruta do Lago Azul is included in this situation, and since 1984 a project has been conducted called Projeto Grutas de Bonito, coordinated by the architect Clayton Ferreira Lino and a multi- and interdisciplinary technical team, which has been charged with the task of elaborating a management plan for tourism in the region (BOGGIANI *et al.*, 2009).

The lack of a management plan is also made evident by the public call for proposals called IMASUL n° 001/2019 process n° 71/403315/2018, for the selection of non-profit organizations to elaborate the management plan for the Gruta do Lago Azul Natural Monument, published in March 2019 in the Diário Oficial do Estado do Mato Grosso do Sul. The absence of an official management plan for the Gruta do Lago Azul Natural Monument is also manifested through data available on the Platform for the Registration of National Conservation Units (CNUC, 2020).

Furthermore, a legal process was opened by the State Public Prosecutor's Office of the state of Mato Grosso do Sul in 2018. This legal process was a Civil Action for Administrative Improbity with reference to a formal Obligation of Environmental Responsibility of the Environmental Institute of Mato Grosso do Sul, Bonito City Hall, and their respective representatives, due to irregularities associated

with the conservation and accounting for services rendered at the Gruta do Lago Azul Natural Monument.

In this case, the Gruta do Lago Azul Natural Monument, as a reference for CUs in Brazil, is deficient with respect to its obligations to the SNUC, since after the creation of this CU a management plan was required to be elaborated within five years after establishment (BRASIL, 2000).

It should be emphasized that the elaboration of the management plan must be conducted according to the results and recommendations of the Environmental Impact Study and the Environmental Impact Final Report, as well as the Norms and Technical Guidelines of Speleological Management Plans, which establish the main themes and minimal requirements for management plans for Conservation Units (BOGIANNI, 2007).

With respect to environmental conservation, the area of the Gruta do Lago Azul has passed through various transformations to be able to accommodate changing tourist demands. According to scholars and specialists with respect to this area, the most visited parts of the Gruta do Lago Azul have undergone intense modifications which have caused a series of negative impacts. In relation to speleological activities, monitoring and environmental licensing processes are still incipient, which is the case for most of the rest of the Brazilian states (CORDEIRO *et al.*, 2013). In the case of speleological activities, it is well known that the CUs in different regions of Brazil implement a wide variety of efforts and actions to monitor and regulate this activity (TOFETI; CAMPOS, 2019).

This situation also occurs in other countries such as Portugal, where, in some cases, no actions are taken to evaluate the impacts caused by a constant flux of people in subterranean environments (ARAUJO *et al.*, 2017). In Ecuador, due to a lack of monitoring, there is a high degree of degradation evident in caves that have been frequently explored and with some type of activity conducted within them, such as tourism (SÁNCHEZ-CORTEZ *et al.*, 2017).

In the case of the Gruta do Lago Azul, this type of degradation has not been observed. However, independent of the factors that may cause degradation, monitoring and management activities are necessary which can minimize the negative effects of tourism and maximize the benefits of this area in the long term to avoid a slow, deliberate march in the direction of commercializing the cave.



This study also revealed that a program of socioenvironmental activities does not exist. Such a program would include environmental education actions which would be free of charge to residents of the municipality of Bonito and surrounding municipalities. Such a program would help to train local citizens to be environmental stewards who are dedicated to environmental conservation. This possibility was discussed by Bogianni and Clemente (1999), who emphasized the necessity of such programs to be free of charge to residents of nearby communities. However, future environmental education programs conducted in this region should contemplate the incorporation of more inclusive opportunities, such as promoting visitation by tourists from a wider socio-economic range of the population.

With respect to amplifying actions related to environmental education in this region, it would be highly pertinent to implant a program of activities that would integrate educational actions by including students from public and private schools and the resident population in general. In this case, it is recommended that these activities follow the guidelines of the National Strategy for Communication and Environmental Education (ENCEA) with respect to the SNUC (MAMEDE, 2008).

Integrated educational actions should be continuously conducted so that the environmental education process reaches, over time, the largest possible number of social actors, whether they be from the sphere of public authorities, private enterprises, or organized civil society. Additionally, entities involved in tourism should be included in these actions, such as institutions, travel agencies, tourism guides, monitors, community members, visitors, and tourists in general. This is necessary because problems with environmental education related to the Gruta do Lago Azul have been shown (KLEIN et al., 2011).

In this way, the criteria used to establish this integrated educational system would train and educate citizens that are able to reflect and think critically about environmental questions, and who would understand that conservation and sustainability are components that are indispensable to environmental issues.

In this context, the implementation of an environmental education program is a highly relevant action that is needed for structuring tourism in caves since interpretation of cave characteristics is a form of informal education based on the total experience of the visit, and this could make knowledge about the

environmental characteristics of the cave more accessible to the public at large (ARAÚJO, 2019). Furthermore, in keeping with the norms and guidelines related to the establishment of this type of CU, the benefits that it generates should be shared by all social actors present in the region.

In this situation, social inclusion in tourism activities can contribute to sustainable development since this would create a set of conditions that favor solidarity and social integration (RUA, 2006). Access to protected natural areas needs to be democratized in a way that they are not seen as being untouchable natural areas that can be used only by certain social groups, and tourism can be one vehicle to accomplish this goal (DUTRA, 2017).

With respect to the indicators that were favorable for sustainability in this study, in relation to revenues, this CU has had satisfactory performance, principally because it has one of the highest fluxes of visitors among caves used for tourism in Brazil. According to the Tourism Secretary of Bonito (2020), visitation rates in 2017, 2018 and 2019 were 74,501, 73,810 and 74,794, respectively (OTEB, 2019). This situation is different than that of other Brazilian Conservations Units, where few of these are able to successfully manage their activities (GODOY; LEUZINGER, 2015) in a sustainable manner that balances tourism activities within and outside of the CU in economic, environmental, political, and social contexts (TELES; NOGUEIRA, 2016).

Specific guidelines used to organize visits to the Gruta do Lago Azul were created as a function of the carrying capacity for tourists visiting the cave, which is maintained at a maximum of 305 visitors per day in groups with a maximum of 15 people, not including the guide, with a minimum interval of 20 minutes between groups (BOGIANNI, 2007; KLEIN et al., 2011).

One sustainability indicator stands out as being especially important, the single voucher system of the municipality of Bonito. The use of this instrument has enabled the control of the support capacity of the cave by installing a more efficient process of making reservations for tourists, collection of statistical data, control of tax receipts, and the cultivation of a heightened awareness of the importance natural resources among the members of the tourism industry (GRECHI et al., 2010). In this sense, it is assumed that the financial condition of an entity, if adequately administered, favors not only economic sustainability, but also environmental

and social aspects related to the public use of the Gruta do Lago Azul.

The Gruta do Lago Azul, besides becoming an effective vehicle for conservation of biodiversity and protection of natural landscapes, offers to visitors the benefit of interaction between knowledge and well-being with respect to nature, valorization of local culture, and learning opportunities (LOBO, 2014).

Considering the foregoing, it is emphasized that policies related to conservation must advocate principles that promote sustainability as a concept that integrally includes the environmental, economic, and social dimensions. When these three spheres are interconnected in a coherent manner, sustainability will have been effectively achieved (BURSZTYN; BURSZTYN, 2013). For this reason, comprehension of the benefits that a CU offers to society indicates the possibilities and tendencies for its effective management.

Undoubtedly, the assumption behind the concept of sustainability is represented by a type of development that is compatible with meeting the needs of current generations without compromising the needs of future ones. In this sense, promoting an authentic sustainable tourism in areas that provide essential ecosystem services to society is a way to assure that the benefits of this tourism activity are shared in a just manner.

## FINAL CONSIDERATIONS

It is concluded that the completeness of the level of sustainability of tourism at the Gruta do Lago Azul Natural Monument has still not been effectively achieved, because the environmental, economic, and social dimensions that guide sustainability are not yet sufficiently intertwined, and this could be hindering effective management.

Despite this area being recognized as one of the most important caves in Brazil and that represents a national heritage site, and is one of the most visited natural attractions in the country with worldwide visibility, due to the rate of tourist visitation, it is necessary to search for better solutions to assure the sustainability of these activities while respecting the environmental and social dynamics of this Conservation Units.

In this context, it is fundamental that all planning and management activities be

adequate to the use of this natural resource, principally because it is a fragile environment and also because it can create a sense of well-being in visitors and strengthen the local and regional economies.

Therefore, it is suggested that in the elaboration of the management plan, an environmental education program be included, and that there is integration with the areas surrounding the Conservation Units in order to increase the sustainability of tourism. In this way, the criteria used to establish this integrated educational system would train and educate citizens that are able to reflect and think critically about environmental questions, and who would understand that conservation and sustainability are components that are indispensable to environmental issues.

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#### AUTHORS' CONTRIBUTION

Marta Regina da Silva-Melo conceived the study, collected and analyzed the data, wrote and reviewed the text. Neiva Maria Robaldo Guedes guided the preparation of the study and analyzed the data. Gleidson André Pereira de Melo elaborated the situation map, performed the statistical tests, and reviewed the text.



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