POSSIBLE SUSTAINABLE MEASURES TO BE APPLIED IN THE COMMUNITY OF LAGO DO CATALÃO IN IRANDUBA, BRAZIL

MEDIDAS SUSTENTÁVEIS A SEREM APLICADAS NA COMUNIDADE DO LAGO DO CATALÃO EM IRANDUBA, BRASIL

MEDIDAS SOSTENIBLES QUE SE APLICARÁN EN LA COMUNIDAD DEL LAGO CATALÁN EN IRANDUBA, BRASIL

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ABSTRACT

This investigation addressed the environment where residents of the Lago do Catalão Community live in the municipality of Iranduba, in the state of Amazonas, from the sustainability perspective. The justification is that it is in a floodplain, subject to the Solimões River’s seasonality since it is a completely floating community. In this sense, this work presents possible sustainable measures that can be applied in this community. We used the observation method to analyze sustainable activities in the community and their implications for the implementation of ecological actions, investigating the reason for failures in conducting ecological movements in the community so that sustainable practice options could be suggested for residents, considering that the community is a crossroads for tourist routes. The steps of the method were a) collecting data about the community, b) conducting dialogues with the community representative, c) identifying the main difficulties in implementing sustainable projects, d) analyzing these difficulties, and e) designing solutions capable of overcoming these difficulties. The results showed that a) an experimental structure for a dry toilet in the community was created and approved, b) a river water treatment system for domestic consumption was proposed, c) another proposal was the implementation of Handy Pod systems to filter wastewater and c) the implementation of aquatic macrophytes was suggested for phytoremediation of the area. The conclusion shows that the waters are the primary source of life for everyone in the community; as they get their food from them, through them, they move around, and around them, their lives revolve and constantly adapt to their reality. Therefore, caring for and preserving rivers and lakes is necessary. Each Lago do Catalão community resident is aware of their responsibility towards their environment.

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Keywords: Sustainability; Catalão Lake; sustainable activity; floodplain; sustainable measures.

RESUMO
Esta investigação abordou o meio onde vivem os moradores da Comunidade do Lago do Catalão, no município de Iranduba, no estado do Amazonas, sob a ótica da sustentabilidade. A justificativa se dá pelo fato de estar localizada em uma planície de inundação, estando sujeita à sazonalidade do Rio Solimões, uma vez que é uma comunidade totalmente flutuante. Neste sentido, este trabalho apresenta possíveis medidas sustentáveis a serem aplicadas nessa comunidade. Foi utilizado o método da observação para analisar as atividades sustentáveis na comunidade e as suas implicações na implementação das atividades ecológicas, investigando-se o motivo das falhas na realização de atividades ecológicas na comunidade para que se pudesse sugerir opções de práticas sustentáveis para os moradores, tendo em vista que a comunidade é passagem de rotas turísticas. As etapas do método foram a) levantamento de dados sobre a comunidade, b) realização de diálogos com a representante da comunidade, c) identificação das principais dificuldades na implantação de projetos sustentáveis, d) análises dessas dificuldades e e) desenho de soluções capazes de superar essas dificuldades. Os resultados mostraram que a) foi criada e aprovada uma estrutura experimental para banheiro seco na comunidade, b) foi proposto um sistema de tratamento da água do rio para consumo doméstico, c) outra proposição foi a implantação de sistemas Handy Pod para filtrar águas residuais e c) foi sugerida a implantação de macrófitas aquáticas para a fitorremediação da área. A conclusão mostra que as águas são a principal fonte de vida para todos na comunidade, pois dela tiram seu alimento, por meio dela se locomovem, em torno delas suas vidas estão girando e constantemente se adaptando a sua realidade. Por isso, se vê a necessidade de cuidar e preservar os rios e lagos. E cada morador da comunidade do Lago do Catalão tem consciência da sua responsabilidade para o seu meio.

Palavras-chave: Sustentabilidade; Lago do Catalão; atividade sustentável; planície de inundação; medidas sustentáveis.

RESUMEN
Esta investigación ha abordado el entorno en el que viven los habitanites de la Comunidad del Lago Catalán, en el municipio de Iranduba, en el Estado de Amazonas, desde el punto de vista de la sostenibilidad. La justificación es que está ubicada en una llanura de inundación y está sujeta a la estacionalidad del rio Solimões, ya que es una comunidad totalmente flotante. A este respecto, este trabajo presenta posibles medidas sostenibles que se deben aplicar en esa comunidad. El método de observación se utilizó para analizar las actividades sustentables en la comunidad y sus implicaciones para la implementación de actividades ecológicas, indagando la razón de las fallas en las actividades ambientales en la comunidad para sugerir opciones de prácticas sustentables para los residentes, con la visión de que la comunidad está pasando por rutas turísticas. Las etapas del método fueron: a) la reunión de datos comunitarios, b) el diálogo con el representante de la comunidad, c) la determinación de las principales dificultades para ejecutar proyectos sostenibles, d) el análisis de esas dificultades y e) el diseño de soluciones para superar esas dificultades. Los resultados mostraron que: a) se creó y aprobó una estructura experimental para los retretes secos en la comunidad; b) se propuso un sistema de tratamiento del agua para el río para el consumo interno; c) otra propuesta fue la aplicación de sistemas Handy Pod para filtrar las aguas residuales; y c) se sugirió el despliegue de macrófitas acuáticas para la fitorremediação de la zona. La conclusión muestra que el agua es la principal fuente de vida para todos en la comunidad, porque a partir de ahí toman su comida, a través de ella se mueven,
a su alrededor sus vidas giran y se adaptan constantemente a su realidad. Por esta razón, se ve la necesidad de cuidar y preservar los ríos y lagos. Y cada habitante de la comunidad del Lago Catalán es consciente de su responsabilidad hacia su medio ambiente.

**Palabras clave:** Sostenibilidad; Lago Catalán; actividad sostenible; llanuras de inundación; medidas sostenibles.

1. Introduction

Implementing ecological activities can be challenging in several Amazon region communities. However, on water, these challenges become even more significant. It is essential to understand the reasons behind failures to conduct these activities so that practical solutions can be proposed. Furthermore, it is necessary to consider the implications of these activities in implementing sustainable practices (Chaves et al., 2020). An in-depth analysis of waste discarded in Lago do Catalão can reveal residents' main obstacles and provide insights into how to overcome them. Based on these analyses, it was possible to suggest options for sustainable practices that are viable and appropriate for the community. It is essential to highlight that implementing sustainable practices benefits the environment and brings economic and social benefits to the community (Moreira; Manzatto, 2023).

By adopting sustainable practices, residents can reduce their environmental impact and contribute to the preservation of the region, as the Amazon region is home to the most extensive river system with the most significant liquid mass on earth, being covered by the largest tropical rainforest (Ferreira; Saraiva, 2009; Lameira, 2023; Mesquita, 2023; Ramirez et al., 2023). Concern about the environment and environmental sustainability has recently grown (Sartori et al., 2014). This topic in Brazil still needs to be explored more thoroughly. Due to its rich biodiversity and environmental challenges, the country has sought policies and initiatives to promote sustainability in the Amazon (Avelar et al., 2023; Costa et al., 2023; Guimarães et al., 2023). With this, we see the need to seek means and technologies to preserve the environment.

The community of Lago do Catalão, in addition to being a tourist route crossing, is 100% with floating houses (Souza, 2020). Therefore, it is essential to analyze sustainable activities in the region concerning the disposal of toilet waste...
generated by the community. The general objective is to present some possible sustainable measures that can be applied in the Lago do Catalão community in Iranduba, state of Amazonas, in the Brazilian Amazon. It is a type of social technology that, according to Silva and Nascimento-e-Silva (2020), is notable for being focused on its users and characterized by care for the environment. Hopefully, this scientific article will provide an understanding of this sustainable activity, essential in the Catalão community, the disposal of toilet waste, investigating the reasons behind failures in conducting ecological activities, and suggesting options for sustainable practices for residents. This can help promote more effective sustainable development in the region and improve residents' quality of life (Pedro, 2022).

2. Literature Review: Living on Rivers and Its Challenges

The types of Amazonian rivers that are well-known so far are white-water rivers (muddy water), clear-water rivers, and blackwater rivers (Sioli 1985). The Solimões/Amazonas River is the main water collection channel for the world's largest and most voluminous river basin. Modeling the river relief during its route along the longitudinal profile influences the lives of the Amazonians (Pacheco et al., 2012). In this sense, it is essential to point out that

It is an object of concern for today's Geography to understand the natural environment in which man survives and the behavior of human societies, their relationships with nature, and their socioeconomic and social relationships (Queiroz et al., 2018, p 109).

We constantly see the need to be careful and take a more delicate look at our environment, according to Sorre (1967), who studied the relationship between man and the environment through its spatial organization and the techniques used. For him, space would result from the cohabitation of man and nature, surrounded by intentionality (Braga, 2007). Given this, Santos (1988) states that reorganizing space and the different relationship forms with the environment require learning and experience (Louzada et al., 2018).

[...]. a dependence on the water environment of native peoples was noted; waters were vital for transportation, production, and hunting, among other determining factors for social interactions (Queiroz et al.,
According to Serrão et al. (2020), to study nature and its natural processes and thus apply this knowledge to the conservation and preservation of natural environments, it was necessary to create a term that, according to him, specifically for ecology, makes it easier for us to know which more fragile environments, which support fewer environmental changes. This way, we can create natural reserves and parks to preserve them for the future, preventing them from destruction. For Vasconcellos (2019), sustainability can be defined as an environmental support capacity based on a logic that satisfies present human needs without compromising the ability of future generations to meet their own needs. This will require a balance between three pillars: the social, economic, and ecological dimensions simultaneously (Elkington, 1994; D oliveira et al., 2021; Sartori et al., 2014), thus having as fundamental characteristics the equity in the distribution of goods economic and ecological (natural resources).

Environmental problems represent one of the most debated topics in contemporary times. Some of the main challenges faced are encouraging change and habits, raising awareness among the population, and encouraging the adoption of pro-sustainability behaviors (Oliveira; Brasil, 2020). Through an environmental perception, the central representations about water were essential for the present and future and maintaining survival (Kuhnen; Becker, 2010). According to Kuhnen and Becker (2010), water quality is a measure capable of diagnosing the state of conservation of the environment through its analysis of the degree of soil erosion, organic releases, pollution by sewage, and even air pollution. For no other reason, river basins are used as environmental management planning units (Graff, 2000; Freitas, 2000).

2.1 Basic Sanitation and Water Quality in Lago do Catalão

According to Neu et al. (2016), the contamination of water bodies advances with economic and population growth (Barros; Amin, 2007). The lack of adequate sanitation in rural and urban areas is another critical source of water contamination. Basic sanitation directly interferes with the balance of ecosystems and is essential for controlling and reducing diseases, directly affecting the quality
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of life of populations (IBGE, 2010).

According to Ribeiro and Rooke (2010), most health problems affecting the world population are intrinsically related to the environment. More than a billion people on Earth do not have access to safe housing and essential services, even though every human has the right to a healthy and productive life in harmony with nature. In Brazil, diseases resulting from the lack of or an inadequate sanitation system, especially in impoverished areas, have worsened the epidemiological situation (Brazil, 2006).

The appropriate disposal of human waste aims to avoid pollution of the soil and water sources and the contact of flies and cockroaches (vectors) with feces, controlling and preventing diseases related to them. Basic sanitation is a service that, like health and education, influences the lives of individuals directly and visibly. This is because linked to sanitation practices are issues of housing, food, health, and working conditions, or in a more summarized way, they touch all fundamental spheres of human life. (Ferreira; Garcia, 2017).

Among the situations experienced by community members is the lack of basic sanitation for floating buildings and the absence of a water reservoir for the dry period (Jesus et al., 2022). There is a lack of initiatives from public authorities to apply technologies that meet these needs, such as, for example, the lack of regularity in the collection of solid waste, which takes place once a month or even once every two months for City Hall. The dynamics established in the experiences of this population point to challenges in thinking about urban and peri-urban areas in the Amazon and how public authorities have been recognizing local experiences for appropriate regional planning (Quaresma, 2022).

During drought, the water in the lake becomes unfit for use. Another situation to be highlighted is that of sanitary sewage, which is conducted improperly, and the continuous supply of water that does not exist. Since essential sanitation services are not offered in this community as required by Law 11,455 (Brazil, 2007), and the lack of them causes problems for the health of the population, it is necessary to create alternative proposals and equipment that can be implemented in Lago do Catalão (Brandão, 2023).
2.2 Disposal of Bathroom Waste and Sustainability

According to Neumann (2023), without sanitation options, human waste is directly released into the water from which the community lives. It is the same water where people bathe, wash clothes and dishes, recreate, and, sometimes, obtain food and water for consumption. As such, people in these floating communities regularly suffer from diarrheal illnesses caused by sewage-related pathogens (Andrews, 2018; Pandey et al., 2014). Located in Peru, there is a community that has a similar scenario to our study area, called the Claverito community, which does not have access to drinking water, sanitation, and waste management, among other infrastructures and improved conditions (Bachman, 2020). Providing drinking water and managing sewage are persistent problems for floating communities due to the technical challenges associated with life on the water (Neumann, 2023).

According to Neumann (2023), a non-profit organization called Wetlands Work took advantage of an idea to develop a successful sanitation system for floating communities in Cambodia called HandyPod, which captures sewage inside a floating container populated with water hyacinth (murumuru). Eichhornia crassipes (Wetlands Work, 2013). The water around Claverito has a high load of fecal contamination, which negatively impacts the community’s health. Water hyacinth was able to maintain concentration at safe levels in shallow waters. Wetlands, known as humid zones, are little explored in Brazil but contribute significantly to a healthy environment (Cohen et al., 2016; Richardson et al., 2016). Wetlands retain water primarily during dry periods, thus keeping the water table high and moderately stable. Orimoloye (2020). They can contribute to the landscape by generating flows, retaining nutrients and sediments, and supporting biodiversity, according to Cohen et al. 2016. Wetlands play an irreplaceable role in regulating the global climate, maintaining the global hydrological cycle, protecting ecosystem diversity, and safeguarding human well-being (Xu, 2019). Wetland ecosystems are an efficient and low-cost solution, especially in rural areas.

Due to the need to provide better disposal for the waste produced in floating homes, thinking sustainably, in 2016, a project was proposed as a test for the implementation of an ecological bathroom in the community of Catalão,
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which took place at the Lago do Catalão Municipal School, which is floating. The Community of Lago do Catalão has approximately 370 people and 115 houses; the installation of this ecological bathroom was carried out in the community's school, which receives, in addition to children from the community, students from a part of Xiborena and another part from students from Manaus, specifically from the neighborhood, of Mauazinho, who attend school, in the morning there is primary school 1, in the afternoon there is primary school 2, and in the evening there is technological education.

An attempt to generate a sustainable practice with the dry toilet, where instead of mixing waste with water, the system installed at the school would use lime and sawdust, and everything deposited in the toilet would not go into the water as bathrooms do. The mixture is accumulated and removed from the other floating houses in the community every specific period. The school set up an experimental structure, and a bathroom was built with fiber walls, adapted to the local reality. The community's residents liked and embraced the idea of the dry bathroom, considering that they live on the water and there is a pressing need to take care of their livelihood rationally and sustainably so as not to pollute their waters (Mesquita et al., 2023).

3. Methodology

The floating community of Lago do Catalão, as shown in Figure 1, is in the floodplain of the Negro River at the confluence with the Solimões River, forming part of the municipality of Iranduba, in the state of Amazonas, in the Central Amazon (Ramos et al., 2014). This area includes a lake connected to the rivers above, approximately 3 km from the port of Ceasa in Manaus (Leite et al., 2006).
In the lake, there is a floating community that houses 115 families; the topography of the area is uniform and flat due to river accumulation, being formed by the domains of the province of Cenozoic deposits, made up of Quaternary sediments represented by alluvium of Holocene origin, presenting altitudes that rarely exceed one hundred meters. As its main characteristic, the region has lowlands containing a chain of lakes close to or connected, which, depending on the seasonal variation in water levels, can flood completely or dry out completely (Brito, 2006).

The research was exploratory, as information about the community and sustainable practices was collected. It can be defined as a prior study whose objectives are to gather and expand knowledge about the object analyzed by the researcher (Noll, 2020). The investigative practice was carried out in two moments, the first part being a bibliographical survey of articles, magazines, dissertations, and reports referring to the area of interest, following the recommendations of Nascimento-e-Silva (2023), and the second was the visit in the field in the study area that was the floating community. Gil (2019) says that bibliographic studies are conducted on already published material, which deals with the themes of a given textual production under construction. In turn, Vergara (2013) states that field research represents the moment in which the investigator has more significant contact with his object of study, which allows him to make
more assertive conclusions during his investigative course. The field research aimed to understand the problems faced by the community residents and the school with which the ecological bathroom test project began and the sustainable practices they carried out to better care for their environment.

4. Results and Discussion

Many technologies have been developed worldwide to reduce population contamination and water consumption in the conventional basic sanitation system, which uses hydraulic models. One of these alternatives is the dry bathroom, a bioconstruction that does not require water. According to Castro and Castro (2019), the North American Green Building Council (US Green Building Council - USGBC) establishes that the dry bathroom is one of the technologies with the most significant potential today. Its mechanism consists of using sanitary waste for composting and transforming the waste into humus through synthesizing microorganisms and cleaning the compost.

The idea of implementing dry toilets as a sustainable solution was of great relevance as, in addition to collaborating with the environment, excessive water consumption produces inputs that can be used to fertilize plants, and thinking about Water was one of the solutions designed to help these residents preserve their environment, considering that they do not have basic sanitation and are in direct contact with the water. All their waste is deposited in the river, as Neumann (2023) discussed.

The big problem presented in the dry bathroom taken to the Community of Catalão was its large structure, which, according to the community residents, was the main barrier. The community representative tried to insert it in several different environments, first in a restaurant. They attempted to install it at the school and to put an end to it, the representative tried to put it on her floating one, but its large structure made it heavy. Hence, the floating one would somehow sink in every place where they thought of installing the ecological bathroom. It also took away a good part of the necessary space; even a school with a large structure could not maintain it for a long time; as shown in Figure 2, you can see the form of the access to the bathroom.
Due to these difficulties, the bathroom was never used. When taken to school, the students showed great admiration and curiosity. Still, it was not managed, as they already had in mind the significant obstacle that would come later, as the bathroom would need correct handling within the time stipulated according to its use. Because there was no instruction, the school managers thought it best not to use it. However, it is essential to highlight that there was no prejudice against the possibility of using the bathroom, neither by children nor by adults. During the on-site visit to the school, the structure of the toilet was observed. Although the float was significant, it could still not support the weight of the bathroom installed there, as its large design affected the float itself. It was then removed and given another destination outside the community, leaving only the place where it was installed (Figure 3).
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Figure 3: Location where the ecological bathroom was initially installed.

When the possibility of installing a dry bathroom arrived at the community, it was widely accepted, considering that they live in floating houses. Hence, their dynamics and reality are different, just like Serrão et al. (2020) raise the approach of applying knowledge about the conservation and preservation of natural environments. Its resource is water, and it is known to be a finite resource and extremely necessary for survival (Silva et al., 2023). So, they assume that everything goes towards the care and better preservation of the rivers and lakes that the residents of this community are incorporating into their practices, trying to be more sustainable and contributing in some way to preserving the environment (Pedro, 2022).

Because the structure of the ecological bathroom taken in the community was not successful, a specific project could be worked on thinking about the community and thus meeting its needs in terms of size and material to be built so that it could be possible for residents to use this idea of a dry bathroom in their homes, have the necessary training to handle the inputs generated and thus apply a sustainable practice that is beneficial to the residents themselves and the environment. Figure 4 demonstrates the structure of the ecological bathroom installed in the community.
With this practice, people residing in the community would pass on ethnoknowledge, a term that refers to knowledge, traditions (culture) passed from generation to generation in traditional societies, learned through everyday life and direct interaction with the environment in which they live, fence and its natural phenomena (Nascimento, 2013). The case of the unsuccessfully installed bathroom leads to a rethinking of a lighter and smaller design. With extensive training in handling and maintenance. Future generations living in the community would grow up and be familiar with this sustainable habit, thus increasingly valuing the environment (Pedro 2022).

In the Catalão community, the population does not have easy access to drinking water, as their waste is thrown in naturally under their floating homes, as discussed (Neumann, 2023). The significant desire of the community's residents is to conduct a project that would implement a river water treatment system, as for them to have water for consumption, they need to cross from the other side of the river. In addition to the difficulty of transportation, the cost of gasoline is high. But, during the rainy season, they collect the water on the roofs for consumption.

Corroborating with Quaresma (2022), residents have significant challenges, especially with public authorities, to better think about regional planning with the specificities of a 100% floating community. The community
representative reports that even living in the middle of the water, it is painful to know that the main problem is the contamination of the water with waste and the lack of adequate treatment for portability, and in some periods, the water becomes even more unhealthy and it is not possible to even for washing clothes, dishes and other purposes (Gonçalves; Domingos, 2019). Due to the lack of basic sanitation and waste being deposited directly into the river, there are times when everything is evident in the waters; in addition to polluting the river landscape, it causes illnesses for the residents themselves due to improper consumption (Meschede, 2018).

Another solution for disposing of toilet waste is techniques that can be implemented, such as Handy Pod. It is a water treatment system that filters wastewater in floating communities using natural vegetation. It is inserted under the bathroom of a houseboat, capturing raw sewage in an expandable bag called a digester, a successful project for floating communities in Cambodia, which have characteristics like Lake Catalão.

It is also suggested that aquatic macrophytes, which can help absorb substantial amounts of nutrients responsible for the eutrophication process, be implanted, thus contributing to the phytoremediation of the area. Aquatic macrophytes, according to Diniz (2021), regions with aquatic macrophytes play a significant role in processing nutrients, adsorbing, and absorbing toxic substances, and regulating hydraulic flow. In Brazil, several studies have been carried out to examine the role of macrophytes in improving water quality; the first studies were developed by Manfrinato (1989), who verified the efficiency of Eichhornia crassipes in decontaminating the waters of the Piracicaba River, SP, making it possible to apply the reality of the residents of the Catalão community, as this species is found in the location.

5. Conclusion

As presented in this research, it is notable how the lack of basic sanitation in areas with a dynamic dependence on water is of great concern to their inhabitants. The lack of drinking water and the constant search for a sustainable solution requires a look at the specificities of the locals. Address techniques that
can be adapted to the reality of the residents of Lago do Catalão, not only with their waste but also a way for them to have “cleaner” water.

The techniques presented are feasible. However, joint action is necessary between the proposed infrastructure, management provided by the public authorities about basic sanitation, and academia with training, information, and implementation of the community’s sustainability culture. It is also noteworthy that the initial project presented to the community here, an ecological bathroom, can be implemented as a sustainable practice. Still, the design, measurements, and adaptation must be resized to the reality of floating houses. For future studies, we suggest a survey of water preservation projects focused on the existence of Amazonian communities.

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