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A PROPOSAL FOR RENATURALIZATION OF URBANIZED FLOODLORDS IN PARINTINS (AM)

UMA PROPOSTA DE RENATURALIZAÇÃO DE VÁRZEA URBANIZADA EM PARINTINS (AM)

UNA PROPUESTA PARA LA RENATURALIZACIÓN DE LAS ZONAS DE INUNDACIÓN URBANIZADAS EN PARINTINS (AM)

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ABSTRACT

The city of Parintins-AM had its urban expansion based on the occupation of other neighboring islands through landfills built by the city government on the border of neighborhoods with urban wetlands. The water quality of these urban floodplain areas was compromised, triggering environmental, social and economic impacts that can be avoided if the necessary measures are taken to achieve sustainable development goals 6 and 11, which aim to ensure the availability and sustainable management of water and sanitation for all, as well as to make cities and human settlements inclusive, safe, resilient and sustainable. The area studied is the headquarters of the municipality of Parintins – AM, located in the middle course of the Amazon basin, on the right bank of the Amazon River, which is situated on the border between the states of Amazonas and Pará. The general objective of the research intends to develop a theoretical-methodological proposal for the renaturalization of the urban floodplain in the filled-in stretches that interconnected the islands for the expansion of the city of Parintins-AM, developed from exploratory, explanatory and empirical research. The use of remote sensing helped to develop the history of the occupation of the floodplain areas and the renaturalization projects of degraded urban floodplains around the world and in Brazil served as a basis for the elaboration of the proposal. As a result, an organizational chart was generated containing the stages of the renaturalization process of the urbanized floodplain

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of Lago da Francesa and Lago do Macurany with alternative intervention solutions in the analyzed stretches.

Keywords: Renaturalization of Urban Floodplains. Sustainability. Wetlands.

RESUMO

A cidade de Parintins-AM teve sua expansão urbana a partir da ocupação de outras ilhas vizinhas através de aterros construídos pela prefeitura no limite de bairros com as zonas úmidas urbanas. A qualidade das águas dessas áreas de várzea urbana foi comprometida, desencadeando impactos de ordem ambiental, social e econômica que podem ser evitados se tomadas as medidas necessárias para alcançar os objetivos do desenvolvimento sustentável 6 e 11, que visam assegurar a disponibilidade e a gestão sustentável da água e saneamento para todos, bem como tornar as cidades e os assentamentos humanos inclusivos, seguros, resilientes e sustentáveis. A área estudada é a sede do município de Parintins – AM, localizada no médio curso da bacia Amazônica, margem direita do rio Amazonas, que está situada na divisa do estado do Amazonas com o Pará. O objetivo geral da pesquisa tenciona elaborar uma proposta teórico-metodológica de renaturalização da várzea urbana nos trechos aterrados que interligaram as ilhas para a expansão da cidade de Parintins-AM, desenvolvido a partir de pesquisa exploratória, pesquisa explicativa e empírica. O uso do sensoriamento remoto ajudou a desenvolver o histórico da ocupação das áreas de várzea e os projetos de renaturalização de várzeas urbanas degradadas ao redor do mundo e no Brasil, serviram de base para a elaboração da proposta. Como resultado, gerou-se um organograma contendo as etapas do processo de renaturalização de várzea urbanizada do lago da Francesa e lago do Macurany com soluções alternativas de intervenção nos trechos analisados.

Palavras-chave: Renaturalização de Várzea Urbana. Sustentabilidade. Zonas Úmidas.

RESUMEN

La ciudad de Parintins-AM experimentó una expansión urbana basada en la ocupación de otras islas vecinas mediante vertederos construidos por el ayuntamiento en los límites de barrios con humedales urbanos. La calidad del agua de estas zonas de llanura aluvial urbana se vio comprometida, lo que generó impactos ambientales, sociales y económicos que podrían evitarse si se adoptan las medidas necesarias para alcanzar los Objetivos de Desarrollo Sostenible 6 y 11, que buscan garantizar la disponibilidad y la gestión sostenible del agua y el saneamiento para todos, así como lograr que las ciudades y los asentamientos humanos sean inclusivos, seguros, resilientes y sostenibles. El área estudiada corresponde a la sede del municipio de Parintins-AM, ubicado en el curso medio de la cuenca amazónica, en la margen derecha del río Amazonas, en la frontera entre los estados de Amazonas y Pará. El objetivo general de la investigación es desarrollar una propuesta teórico-metodológica para la renaturalización de la llanura aluvial urbana en los tramos rellenados que interconectaron las islas para la expansión de la ciudad de Parintins-AM, a partir de una investigación exploratoria, explicativa y empírica. El uso de la teledetección contribuyó al desarrollo de la historia de la ocupación de las llanuras aluviales, y los proyectos de renaturalización de llanuras aluviales urbanas degradadas en todo el mundo y en Brasil sirvieron de base para la elaboración de la propuesta. Como resultado, se generó un organigrama que contiene las etapas del proceso de renaturalización de la llanura aluvial

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urbanizada del Lago da Francesa y el Lago do Macurany, con soluciones alternativas de intervención en los tramos analizados.

Palabras clave: Renaturalización de llanuras aluviales urbanas. Sostenibilidad. Humedales.

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INTRODUCTION

The floodplain is a natural phenomenon that is influenced by hydrographic, climatic, edaphic and floristic factors. Due to these factors and the variable in the time of permanence of the flood in each area, there are different ecological characteristics and the use of natural resources for each region of the Amazon, which is why it is considered a floodplain, formed by a strip of variable width, along the Amazon River (Sioli, 1967, Junk, 1989). In the Amazon Region, throughout the historical process of floodplain occupation, riverine populations have adapted to the large fluctuations imposed by flood dynamics, making integrated use of both the various floodplain environments and those adjacent to the terra firme (Pereira and Fabré, 2009). Many cities in the Amazon have emerged on the banks of rivers and their population still maintains a very strong link with the waters, both in relation to the generation of income from fishing or extraction of products from the floodplain forest, and linked to living in this environment.

The foundation of what is now Parintins was no exception to this rule. According to Bittencourt (2001), the city located on the right bank of the Amazon River is one of the islands where the Tupinambás lived when they fled Peru due to persecution. Parintins, therefore, developed on the Tupinambarana island, which is an archipelago, since in the flood season it is intersected with lakes, holes, sandbanks, paranás and igapós. The urban area is located on one of these islands, approximately 45 km2 in extension, geographically formed by a group of islands, among them: Santa Clara Island, Santa Rita Island, and Parananema Island (Souza, 2013). It had its urban expansion from the occupation of these islands through landfills built by the city hall on the border of neighborhoods with the wetlands of Lake Macurany and Lake Francesa, which are like natural reservoirs and participate in the hydrological regime of the Amazon River, however, the quality of the waters of these urban floodplain areas were directly compromised, since they had stretches landfilled without any planning and management of water resources, nor aligned with the municipality's master plan.

This process of grounding areas, which previously had their natural courses, contributes to the impermeabilization of the soil, causing a large increase in the volume and speed of surface runoff, rapidly increasing hydrological levels during heavy rains and the overflow of this runoff. According to Tucci and Mendes (2006), the greatest impacts generated due to urbanization are the amount of solid waste in water bodies, eutrophication of rivers, erosion and siltation, the reduction of native biodiversity and the inadequate

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discharge of domestic sewage, triggering environmental, social and economic impacts. Sánchez (2003) recommends that cities should first comply with a series of technical and legal standards that meet environmental guidelines, before their expansion occurs, since the use and occupation of land in a disorderly manner result in processes of loss and fragmentation of habitats, altering various biological processes and weakening ecosystems (Reno and Novo, 2013).

In an attempt to implement water resources management linked to land use and urban planning, Farias (2005) suggests that the management of urban water bodies be articulated with the regulations provided for in the Municipal Master Plans and State Plans, in addition to highlighting the importance of zoning through the delimitation of watersheds as management units. However, with each administrative administration, the city expanded with the occupation of urban floodplain areas, preventing the natural passage of water during the period of flooding of the Amazon River through the landfills, in disagreement with the Municipal Master Plan and the National Water Resources Policy (PNRH).

In this context, the general objective of this work is to elaborate a proposal for the renaturalization of the urban floodplain in the landfilled stretches that connected the islands for the expansion of the city of Parintins-AM. The possibility of returning to the city of Parintins its revitalized urban floodplain and within the standards of sustainable development, contemplating the various uses of water, the Amazonas State Water Resources Plan and the Municipal Master Plan, are the basis of this work. One of the issues addressed is the overview of the situation of water dams on the expansion islands of the city of Parintins and whether it is possible to ensure the sustainability of the riverside occupation in the floodplain. The theoretical-methodological proposal, in addition to influencing the management and regulation of the water dams of the urban floodplain, aims to reestablish the relations between the water body and the landscape in a functional way, that is, to unblock the original flow of the canal, giving it life again, without depriving it of other uses.

METHODOLOGY

FIELD OF STUDY

The seat of the municipality of Parintins – AM, located in the middle course of the Amazon basin, on the right bank of the Amazon River, is located on the border of the state

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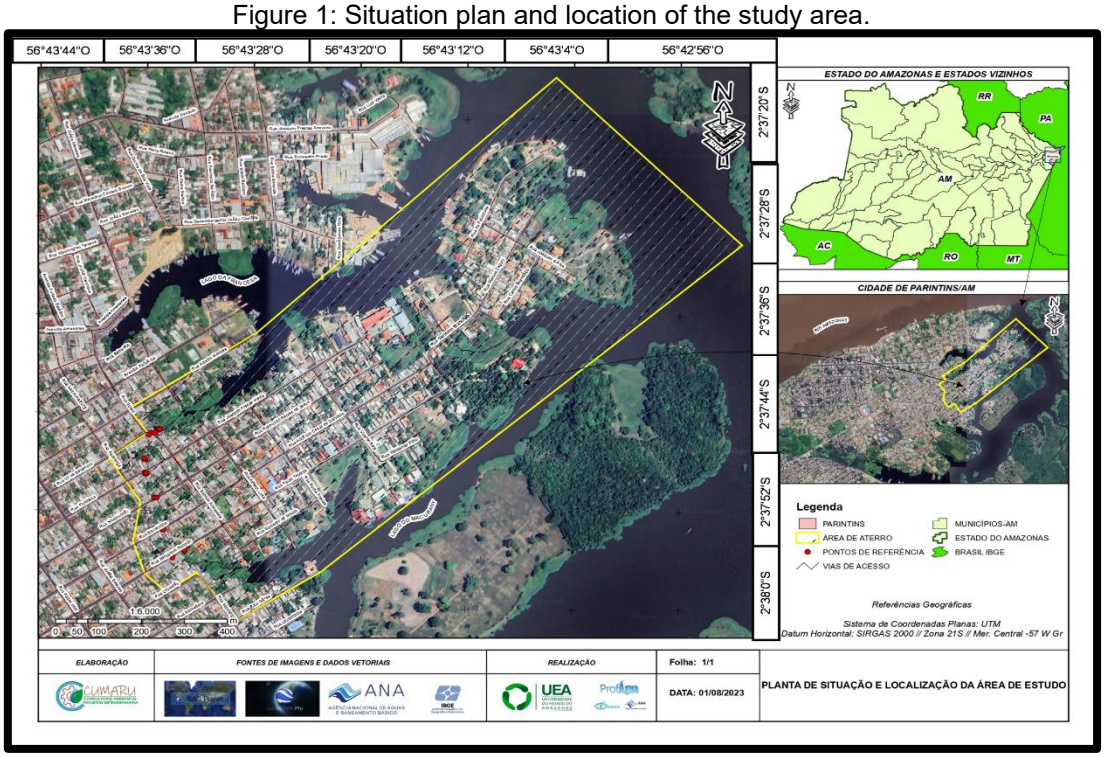
of Amazonas with Pará, at a distance of 368.80 km from the capital of Amazonas, in a straight line, and 420 km, by river, in the Tupinambarana archipelago.

Due to its location in the city of Parintins, Lake Macurany has in its surroundings farms, farms and farms, in addition to being a great attraction in the flood season for bathing purposes. It is considered a lentic and intermittent ecosystem, as it is a stationary water environment, but which varies according to seasonality, and because it has stretches with a flow equal to zero, it is part of the so-called Amazon floodplain undergoing different processes during the two fluvial regimes of the river (flood and ebb).

In this context, in Parintins, some neighborhoods expanded due to the interconnection with smaller islands and had some form of damming of water bodies, especially the neighborhoods of Santa Rita and Palmares, where the natural course that had passage from Lake Macurany to Lake Francesa was also grounded.

Figure 1: Situation plan and location of the study area.



Prepared by: Fernando Viana Ribeiro RNP 00468751238 – CRT 01 (2023).

METHODOLOGY

The work was developed from explanatory and exploratory research, in order to provide a closer contact with the problem of water impoundments in the urban floodplain of Parintins, clarifying the points listed in the research to build hypotheses directed to the most precise solutions. Examples of revitalized urban floodplains and a bibliographic survey on

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the subject were analyzed. According to the theoretical-methodological proposal, empirical research was also used, in order to provide practical proof of the situation in which the analyzed water landfills were located, through observation, analysis and data collection in the field.

For the evaluation and occupation of the impacts of water impoundments that occurred in the urbanized floodplain of Parintins, geographic bases were acquired from the Municipal Department of Sustainable Development and Environment of Parintins – SEDEMA, detailed maps were developed to verify the occupations in the riparian areas of the water body, seeking if possible to observe factors such as hydrography, street layout and configuration of lots (buildings), also analyzing images from the Google Earth software to observe variables, such as the presence or absence of vegetation.

It was sought to survey the legal framework that helps in the protection of wetlands and promotes permanent preservation areas, Forest Code at the federal level, also consulting municipal urban planning instruments such as the city's Environmental Master Plan, the city's Environmental Code and legislation regarding the discharge of effluents, in order to draw a comparison of the current situation and the situation provided for in the legal instruments.

After the identification and determination of the site, field visits were carried out to delimit the area with GPS equipment, which scored the coordinates of the exact location of the embankments to be worked on in the computer program in order to analyze the changes in the terrain and hydrological modeling (modeling the movement of water on and on the terrain) and analysis of the area that should receive renaturalization interventions.

The various unstructured exploratory visits were also intended to carry out a reconnaissance of the urban floodplain of Parintins, to confirm the environmental impacts existing in the areas visualized in aerial images by means of drones and collected in the literature review, as well as to observe the type of housing, experience and coexistence of local populations with urban rivers, as well as to identify economic activities, the sources of pollution and the conflicts (existing and potential) in the region studied.

From bibliographic reviews, resulting from research on the main experiences of wetland rewilding in the world, the delimitation and diagnosis, identification, evaluation, comparison and applicability of intervention alternatives in the delimited stretches, alternative intervention solutions for the renaturalization of the urbanized floodplain stretches analyzed were proposed.

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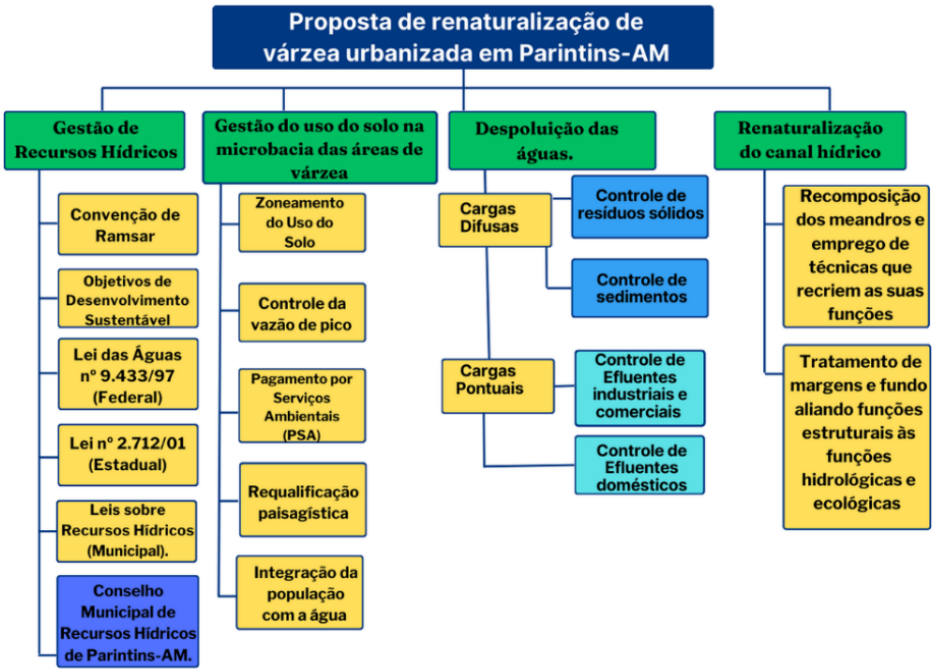
RESULTS

PROPOSAL FOR THE RENATURALIZATION OF URBAN FLOODPLAIN IN PARINTINS.

The proposal with the purpose of solving the existing problems in the stretch of the Macurany lake and the French lagoon, contains the indispensable principles for the renaturalization of the urbanized floodplain of Parintins-AM, illustrated in the organizational chart of Figure 2.

Figure 2 - Proposal for the renaturalization of an urbanized floodplain in Parintins-AM.



Source: Prepared by Tierre Santos (2024).

DISCUSSION

WATER RESOURCES MANAGEMENT

The management of water resources in the urbanized floodplain of Parintins must take place in the pillars of all existing legislation on wetlands, whether international, national, state and municipal, so that future actions are solid and positive.

Thus, at the international level, the Ramsar Convention, an intergovernmental treaty that establishes the framework for the conservation and rational use of wetlands and their resources, encourages contracting countries to set up national committees for wetlands. In Brazil, the National Committee on Wetlands - CNZU is an established collegiate that, among some competencies, can suggest and evaluate the inclusion of new sites in the List of Wetlands of International Importance, enabling the accreditation of the study area, since

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the urbanized floodplain of Parintins has characteristics that make it a wetland with potentially favorable criteria to be indicated as a Ramsar site.

With regard to the Sustainable Development Goals (SDGs), the rewilding proposal allows the achievement of two SDGs that contribute to the 2030 Agenda in Brazil. The first is to ensure availability and sustainable management of water and sanitation for all, striving by 2030 to improve water quality, reduce pollution, eliminate dumping and minimize the release of chemicals and hazardous materials, halve the proportion of untreated wastewater, and substantially increase safe recycling and reuse globally, which constitute the Sustainable Development Goals 6. The second is SDG 11, more inclusive, safer, sustainable cities and resilient to disasters or unusual events are the goals of this goal, which seeks to be achieved in the renaturalization of the Macurany lake, which suffers due to anthropic actions, in periods of drought and flooding of the Amazon River.

At the federal level, ANA, as the regulatory agency of the Water Law in Brazil, Law 9.433, of January 8, 1997, provides that water as a resource is protected from a legal perspective, through the National Water Resources Policy, which defines the Hydrographic Basins (BH) as the management unit and coordinates the implementation of the National Water Resources Policy.

The water resources management body is the State Secretariat for the Environment (SEMA) in the state of Amazonas, and the executing body of the water resources policy is the Amazonas Environmental Protection Institute (IPAAM), both bodies discipline the management of water resources in the state of Amazonas. The legal regulations at the state and municipal levels support the management and regulation of water resources.

As a way to increase the scope of measures that benefit the wetlands of Parintins, it is suggested to establish a Municipal Council of Water Resources (CMRH), in order to achieve goals and objectives of water resources management, which provide advice for the adequate development of the city preserving and/or conserving the waters that are part of it. Therefore, the constitution of the CMRH would result in advances in the management of water in the municipality of Parintins, in addition to fertilizing the soil for the implementation of a future municipal secretariat of water resources.

In view of the above, it will have the possibility of achieving better positive results, a renaturalization proposal that complies with the legal framework regarding water resources and that is built respecting the participation of all, decentralization and integrates the management bodies.

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LAND USE MANAGEMENT IN THE WATERSHED OF FLOODPLAIN AREAS

Land Use Zoning

The occupation of the banks of the urban floodplain of Parintins reveals that the use and occupation of the land around Lake Macurany and the Francesa Lagoon took place privately by residences, farms, farms and farms, as well as by commercial points, hotels, shipyards and pontoons that sell petroleum-derived fuels, with public access for the rest of the population to water bodies, limited to the few ends of streets that reach the lakes (Figure 3).

On the stretches of the canal landfilled to connect the islands, residences were built and in their backyards septic tanks and the dumping of solid waste, effluents and domestic garbage contaminate the soil and consequently the water bodies. It can be stated that the municipality had difficulties in aligning the integration between land use, occupation and conservation with federal and state policies on water resources, making it difficult to promote the sustainable development of the city of Parintins, as well as in evidencing the importance of zoning through the delimitation of watersheds as management units.

Therefore, it is suggested to discipline the use of the land with the application of public policies and techniques of basic sanitation, engineering and other sciences that work on the detailed zoning of the watershed, identifying the floodplain areas so that the vegetation and the natural flow of water can be conserved.

Figure 3 - Occupation of the banks of Lake Macurany

Source: Expedito Calisto (XP), 2023.

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Peak Flow Control

The urbanization process that occurred in the study area modified the dynamics of water runoff, causing floods, water and soil pollution. As a consequence, environmental disasters, waterborne diseases, interference in the hydrological cycle and other socio-environmental problems cause great damage to the population and water bodies.

In response to this problem, the peak flow technique brings together methods that are essential to understand and manage the hydrological behavior of the microbasin, as the control of peak flow ensures the efficiency of hydraulic works, especially in drainage systems, canals, culverts and dams, preventing erosion, flooding or structural failures when the water velocity is reduced. It is based on the estimate of the highest water flow that can occur at a given point in a river or watercourse during an intense rainfall event. This concept is important for the renaturalization of urbanized floodplain areas in Parintins, because a project that is concerned, for example, with the sizing of drainage channels, culverts and reservoirs, can be done in order to ensure that they have sufficient capacity to handle the maximum flow without overflowing or collapsing. The peak flow technique is also crucial to define the construction materials and the inclination of the structures, in order to ensure efficiency and durability.

Payment for Environmental Services (PES)

Payment for Environmental Services (PES), a specific type of financial incentive aimed at promoting the conservation and sustainable use of water resources, is based on the principle that healthy ecosystems, such as forests, wetlands, and springs, play a crucial role in maintaining water quality and availability.

Vegetation and water bodies regulate the flow of water in the watershed, generating relevant benefits for society in terms of maintenance, recovery or improvement of environmental conditions and water quality, increasing water availability and valuing sustainable practices, which is why it can be considered a provider of environmental services.

In practice, any person, community or company that develops a project designed to maintain the balance of the hydrological cycle can receive financial resources or any other form of remuneration for the service provided, through a contract with the government, private agent or civil society organization.

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Landscape requalification

Areas that receive daily surface runoff can be transformed into pleasant and functional public spaces by creating green and blue infrastructures along water bodies, which meet both the demand for services to the population, as well as enable coexistence with the periodic floods of the water body, in this way, the population can relate to nature and enjoy outdoor activities.

The landscape requalification of water landfills is an important step to improve the quality of life in cities, as it connects people and the environment, as well as integrates the city with the natural landscape, well-being and quality of life. To reestablish natural processes in urbanized floodplain areas in Parintins-AM, the green and blue infrastructure presents techniques that control surface runoff and promote the ecological functioning of the territory in natural open areas.

Therefore, including in the proposal for the renaturalization of urbanized floodplains in Parintins the concepts of green and blue infrastructure and sustainable drainage, as a way to requalify the landscape, can stimulate the expansion of an urban ecological corridor that concentrates species of fauna and flora, improving the environment and benefiting society.

Integration of the population with water

The involvement of the population in the renaturalization of the floodplain areas of Parintins-AM is the guarantee that the proposal will become solid and lasting, resulting in the consolidation of the control of land use, with the peak flow and the landscape requalification of the microbasin, because the way the population interacts with the water body directly impacts the urbanized floodplains. At this stage, there are multiple strategies to involve the population in this process.

The implementation of parklets stands out, in order to promote living spaces in the floodplain areas of Parintins-AM, such as leisure structures along the watercourse with observation points, benches, flower boxes, tables and chairs; service areas such as restaurants and kiosks; engagement in sports and recreational activities, such as bike paths, walking paths, sports equipment; recreational fishing and picnics; in addition to contributing to urban mobility, it can be used as a point to charge cell phones and free *Wi-Fi* access , as shown in Figure 4 generated by the *Image Generator Pro tool*.

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Figure 4 - Area of implantation of parkets on the banks of a river.

Source – Generated by Image Generator Pro, on 11/10/2024.

DEPOLLUTION OF WATER

The process of decontaminating the waters of Lake Macurany and Lake Francesa requires efforts to exclude pollutants that act on the degradation of water quality. To reverse this problem arising from natural and anthropic action, it is necessary that the measures be directed to the control of diffuse loads (solid waste control and sediment control) and punctual loads (control of commercial and industrial effluents and control of domestic effluents).

It is also important to monitor water quality through the use of physical-chemical and biological indicators, before, during and after the depollution process in order to identify the degree of initial degradation of the water body and monitor the evolution of the rewilding process.

REWILDING OF THE PHYSICAL CHARACTERISTICS OF THE CANAL

Achieving the goal of renaturalizing the floodplain areas that have suffered water landfills in Parintins involves the total commitment of all agencies and local society. The actions generate giant impacts on the physical, social and environmental structure of the city. To bring back the original characteristics of these areas that have been modified, a high financial investment is needed to fund the stages of a project focused on the requalification of the physical structure of the canal and the use of techniques that recreate its original functions.

The renaturalization of the physical characteristics of the canal ensures the reestablishment of its ecosystem functions and the landscape and environmental integration of the canal, through the use of techniques that recreate the functions of the old meanders and that requalify the hydrological functions of banks and bottom.

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Recomposition of the intricacies and use of techniques that recreate their functions

In Parintins, many residences were built at the exact points of the landfills that connected the neighborhoods of Palmares with the neighborhood of Santa Rita and the residents of these areas face every year the resistance of the waters that had their natural course interrupted during the historical process of use and occupation of the floodplain areas. In view of this premise, it is essential to completely remove irregular housing in floodplain areas with the provision of relocating these people and compensating them within a plan provided for in the project.

The opening of the water landfills would require the complete deconstruction of the streets, which is an important circulation axis, which connects the neighborhood of Palmares with the neighborhood of Santa Rita de Cássia. The roads, in the landfilled sections, do not resist the dynamics of the rising waters during the flood period, not being able to avoid the flooding of the roads and residences, so the reopening of the water body and the removal of the houses from the canal, would make the problems related to flooding and heavier rainfall less chaotic. Next, to restore the original course of the river, it is important to remove the water embankment entirely, demolish coatings and protections of banks and bottoms that are not suitable for renaturalization, reopening the landfilled channel, however, imitating the original sinuous curves of the Macurany lake and varying the width of the channel to simulate the characteristics of the meanders. The construction of bridges to connect the neighborhoods of Palmares and Santa Rita enables less intervention in water bodies and the integration between social, economic and environmental interests, benefiting both the population and water resources.

The use of techniques that recreate the functions of the margins of the Francesa Lagoon and the Macurany Lake reduce the erosive processes in the urbanized floodplain area and reconnect the landfilled area to the natural floodplains.

Treatment of banks and bottom combining structural functions with hydrological and ecological functions

The renaturalization of the banks and the bottom of the urbanized floodplain of Parintins brings together techniques with high potential to restore the health of water ecosystems, promoting structural functions and minimizing the environmental impact from the use of bioengineering that can stabilize the banks and renaturalize the ecosystem with

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the planting of native riparian vegetation on the banks, which has the function of stabilizing biodiversity, Reduce artificial eutrophication, create habitats, reduce erosion, contain river flooding, riparian vegetation filters sediments and nutrients, improving water quality, creating ideal conditions for wildlife refuge and providing excellent aesthetics and landscape.

Thus, it is suggested, for the requalification of the flora, the removal of invasive alien species and the replanting of native species that help in hydrological regulation and that act in the control of pollutants. Such measures aim to preserve biodiversity and play a vital role in regulating water cycles, as native species are adapted to the local climate and soil, ensuring long-term sustainability by maintaining ecosystem services essential to human life, in addition to making them more resilient to climate change and pests.

The adoption of reforestation techniques in vegetation areas, especially in areas that have been landfilled and on the shores of lakes, is essential to achieve the renaturalization of the urbanized floodplain, as a hydrographic basin generally depends on the forest to remain active, as well as the forest is dependent on water resources and both are crucial for the hydrological cycle (NOBRE, 2014).

CONCLUSION

The problematization of the occupation of the riverside territory of the city of Parintins-AM, composed of floodplain, river, island and terra firme, motivated the elaboration of the proposal for the renaturalization of the urban floodplain in the landfilled stretches that connected the islands for the expansion of the city, combined with sustainable development, with the objective of solving the problem.

The construction of the proposal for the renaturalization of the urbanized floodplain of Parintins-AM, was elaborated based on the studies and parameters of sources acquired in the methodological process that unified the engineering techniques with the knowledge of water resources management, and its main contribution was the application of these techniques in the municipality of Parintins. The study was structurally subdivided into four thematic axes: water resources management, control of land use in the watershed of floodplain areas, water depollution and renaturalization of the channel's characteristics.

According to the above, it is concluded that the proposal for the renaturalization of the urbanized floodplain of Parintins meets the proposed objectives and can be used to

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guide future work, both in academia and in the practical field, helping water resources managers and regulators to design more effective projects.

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