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Urban rivers and the free path of water: The challenge of applying Permanent Preservation Areas in consolidated urban areas

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Rios urbanos e o livre caminho das águas: O desafio da aplicação das Áreas de Preservação Permanente em áreas urbanas consolidadas

RESUMO

Objetivo - Fazer uma análise crítica, por meio de levantamento bibliográfico e mapeamento em geoprocessamento, das alterações nas políticas ambientais para a "proteção" dos rios urbanos, mais especificamente a Lei Federal nº 14.285, de 29 de dezembro de 2021, que incide sobre as Áreas de Preservação Permanente (APP) em áreas urbanas consolidadas. O estudo de caso é o Rio Piabanha, no município de Petrópolis (RJ), em ocasião do desastre ocorrido pelas chuvas em fevereiro de 2022.

Metodologia - Levantamento bibliográfico e análise por geoprocessamento, em dois trechos do Rio Piabanha. Os mapas foram produzidos através do programa Quantum Gis (QGis 3.28). Na análise final, foram feitos buffers, representando o limite de 30 e 50 metros, conforme a legislação do Código Florestal, considerando que a largura do rio varia entre 10 e 20 metros.

Originalidade/relevância - A temática sobre os rios urbanos e as APPs confluem sobre as problemáticas no meio urbano, sobre as vidas das pessoas e o impacto no meio ambiente. Com os eventos extremos acontecendo com cada vez mais frequência e intensidade, destaca-se a importância em observar e identificar os problemas de planejamento urbano que se intensificam com os desastres causados por chuvas intensas.

Resultados - Grande parte das áreas mais atingidas no desastre se encontram dentro da faixa de APP (30/50 metros em cada margem dos cursos d'água), enfatizando a urgência e a importância da preservação dessa faixa, deixando-a livre de construções e de outras interferências antrópicas que possam interromper o livre fluxo das águas.

Contribuições teóricas/metodológicas - A análise por geoprocessamento é uma importante ferramenta de observação do uso do solo urbano e identificação de falhas nas políticas urbanas e de proteção ambiental.

Contribuições sociais e ambientais - Os resultados mostraram alta vulnerabilidade no que diz respeito às ocupações nas margens dos rios analisados, tanto de caráter social, representando os riscos de perda de vidas, como de caráter ambiental, pois os rios urbanos estão totalmente negligenciados nas leis e ações voltadas para as políticas urbanas e ambientais.

PALAVRAS-CHAVE: Áreas de Preservação Permanente. Eventos Extremos. Rios urbanos.

Urban rivers and the free path of water: The challenge of applying Permanent Preservation Areas in consolidated urban areas

ABSTRACT

Objective – To conduct a critical analysis, through a bibliographic survey and geoprocessing mapping, of changes in environmental policies for the "protection" of urban rivers, more specifically Federal Law No. 14,285, of December 29, 2021, which applies to Permanent Preservation Areas (PPA) in consolidated urban areas. The case study is the Piabanha River, in the municipality of Petrópolis (RJ), on the occasion of the disaster caused by the rains in February 2022.

Methodology – Bibliographic survey and geoprocessing analysis of two stretches of the Piabanha River. The maps were produced using the Quantum Gis program (QGis 3.28). In the final analysis, buffers were created, representing the limit of 30 and 50 meters, according to the Forest Code legislation, considering that the width of the river varies between 10 and 20 meters.

Originality/Relevance – The themes of urban rivers and PPA converge on the problems in urban areas, on people's lives and the impact on the environment. With extreme events occurring with increasing frequency and intensity, it is increasingly important to observe and identify urban planning problems that are intensified by disasters caused by heavy rains.

Results – Most of the areas most affected by the disaster are located within the PPA strip (30/50 meters on each bank of the watercourses), emphasizing the urgency and importance of preserving this strip, leaving it free of constructions and other human interferences that could interrupt the free flow of water.

Theoretical/Methodological Contributions – Geoprocessing analysis is an important tool for observing urban land use and identifying flaws in urban and environmental protection policies.

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Social and Environmental Contributions – The results showed high vulnerability with regard to occupations on the banks of the rivers analyzed, both of a social nature, representing the risk of loss of lives, and of an environmental nature, as urban rivers are completely neglected in laws and actions aimed at urban and environmental policies.
KEYWORDS: Permanent Preservation Areas. Extreme Events. Urban rivers.

Ríos urbanos y el camino libre del agua: El desafío de aplicar Áreas de Preservación Permanente en áreas urbanas consolidadas

RESUMEN

Objetivo – Realizar un análisis crítico, mediante levantamiento bibliográfico y mapeo de geoprocesamiento, de los cambios en las políticas ambientales de "protección" de los ríos urbanos, más específicamente la Ley Federal nº 14.285, de 29 de diciembre de 2021, que se aplica a las Áreas de Preservación Permanente (APP) en áreas urbanas consolidadas. El caso de estudio es el río Piabanha, en el municipio de Petrópolis (RJ), con motivo del desastre provocado por las lluvias de febrero de 2022.

Metodología – Levantamiento bibliográfico y análisis por geoprocesamiento, en dos tramos del río Piabanha. Los mapas se produjeron utilizando el programa Quantum Gis (QGis 3.28). En última instancia, se crearon zonas de amortiguamiento que representan el límite de 30 y 50 metros, de acuerdo con la legislación del Código Forestal, considerando que el ancho del río varía entre 10 y 20 metros.

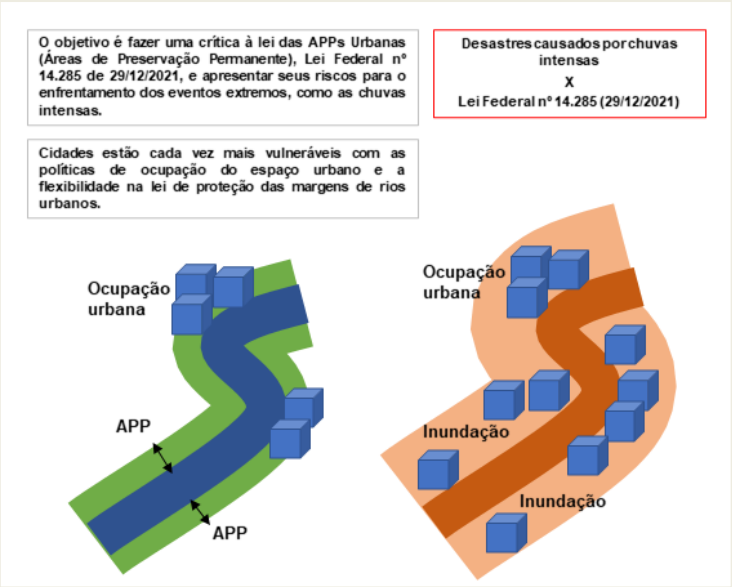
Originalidad/Relevancia – La temática de los ríos urbanos y las APP convergen en las problemáticas de las zonas urbanas, la vida de las personas y el impacto sobre el medio ambiente. Dado que los fenómenos extremos ocurren cada vez con mayor frecuencia e intensidad, se destaca la importancia de observar e identificar los problemas de planificación urbana que se intensifican por los desastres provocados por las fuertes lluvias.

Resultados – La mayor parte de las zonas más afectadas por el desastre se ubican dentro de la franja APP (30/50 metros en cada margen de los cursos de agua), enfatizando la urgencia e importancia de preservar esta franja, dejándola libre de construcciones y otras interferencias humanas que puedan interrumpir el libre flujo del agua.

Contribuciones Teóricas/Metodológicas – El análisis de geoprocesamiento es una herramienta importante para observar el uso del suelo urbano e identificar fallas en las políticas de protección urbana y ambiental.

Contribuciones Sociales y Ambientales – Los resultados mostraron una alta vulnerabilidad en relación a las ocupaciones en las riberas de los ríos analizados, tanto de carácter social, representando riesgo de pérdida de vidas, como de carácter ambiental, pues los ríos urbanos son totalmente desatendidos en las leyes y acciones dirigidas a las políticas urbanas y ambientales.
PALABRAS CLAVE: Áreas de Preservación Permanente. Eventos extremos. Ríos urbanos.

RESUMO GRÁFICO



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1 INTRODUCTION

This article's[1] theme is the urban rivers and the environmental protection, focusing on the transformation of rivers into urban structures, those being canalized, rectified, its borders being occupied and the space taken. The goal is to criticize the law of the urban PPAs (Permanent Preservation Areas) and to show its risks for the confrontation of extreme climatic events, principally for the concentrated and elevated precipitation in a short period of time. We make use of the title "Urban rivers and the free path of water", because this is the big challenge of water in the urban environment: having its paths respected, which means, free, protected and preserved.

The political actions in Brazil, within the scope of issues related to the environment, has been marked by regression with no precedents in the environmental protection legislations. Since the new Forestry Code's establishment, Federal Law nº 12.651 of May 25TH, 2012, there are many controversies related to the application limitations into Permanent Preservation Areas in urban rivers. In May 2021, the National High Court of Brazil (STJ)[2] understood that the non-buildable extent in consolidated urban areas PPAs should respect the article nº 4 of the Federal Law 12.651, 2012, which assured its full protection. This decision was contrary to the justifications presented in some Bill of Law (PL), principally the PL 2510/2019.

This Bill of Law has turned into Federal Law nº 14.285 of December 29TH, 2021, which changed the Federal Law nº 12.651 of May 25TH, 2012; the Federal Law nº 11.952 of June 25TH, 2009, which provides for the land regularization on federal lands, and the Federal Law nº 6.766 of December 19TH, 1979, which provides for the urban land division.

The Federal Law nº 14.285, named as Law for the urban PPAs, provides for the PPAs around water courses in consolidated urban areas and, also, "to define and improve the concept of consolidated urban areas, to treat for the water course's marginal strips at a consolidated urban area, and to consolidate the already finished buildings in these areas", which means, to reinforce and assure that in consolidated urban areas, the rivers that are already uncharacterized keep as it is, or get even more uncharacterized. Besides that, makes viable the regularization of properties that occupies PPAs, meaning that should be "non aedificandis" areas.

By defining the term "consolidated urban area", the law takes off the protection out of urban rivers framed under this term, and transfers the responsibility and autonomy into the cities for the limit definition of marginal PPAs of any water course, in its respective Master Plan. The law defines as consolidated urban area this that, at least, has two of the following infrastructure equipment: rainwater drainage; sewage disposal; drinking water supply; electric power and public lighting distribution; urban cleaning, collect and management of solid residues.

According to Tierno and Filho (2022, p.4), in the Federal Law nº 14.285, 2021, there is

[1] This article is part of the ongoing research for the author's PhD.

[2] News on the National High Court of Brazil website, with the first section's decision: Código Florestal define faixa não edificável a partir de curso d'água em áreas urbanas. Available at: https://www.stj.jus.br/sites/portalp/Paginas/Comunicacao/Noticias/11052021-Codigo-Florestal-define-faixa-nao-edificavel-a-partir-de-curso-d%E2%80%99agua-em-areas-urbanas--decide-Primeira-Secao.aspx. Access in: 08.05.2024

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unconstitutionality. According to the authors, who work in the juridical field, the law "[...] weakens the protection of Permanent Preservation Areas in urban areas, as if there is a distinction in the protection of the rivers' borders in rural and urban areas, creating a framework of legal uncertainty and environmental regression". The law is also being questioned as a Direct Unconstitutionality Action (ADI) nº 7.146/22 at the Federal Supreme Court (STF) with a request of precautionary measure. The initial petition states that it is "unconstitutional material, given that it is in contrariety with the articles 5th, caput, 23 caput and lines VI and VII, 24, c/c 30, line II, and 225 of Magna Carta" and argues that "the intention of the Law nº 14.285/2021 is professedly to make flexible the institute of environmental protection", explaining the vast importance of keeping the PPAs' ecological integrity for the preservation of ecosystems and biomes. Still on the document, the report describes about the overlap of norms and general hierarchy rules, making it unacceptable the municipal and station legislation being less protective than the federal laws.

The fragility of urban rivers becomes bigger more and more in front of those laws that should protect it. In contrary, are always put on debate in favor of the capital interests, being more specific, under pressure of the real state market's interests. In practice, the urban rivers are being increasingly canalized, covered and becoming invisible, I.e, limited, and the population's perception of the urban rivers highlights that negligence (Ribeiro, 2017). The urban PPAs has never been respected and, due to this loosening and also neglect, the urban rivers will keep getting suffocated by urban infrastructure.

According to the research made by MapBiomas (2022), Brazil's urbanized area tripled its size in the last 38 years. In 2022, Brazil had 123.000 hectares of occupancy in risk areas, and 425.000 hectares of urbanized areas up to 3 meters height in relation to the level of the nearest river. Of this occupancy, 68% has occurred in the last 38 years. The studies also show that, in the last 33 years, the incidence of disasters by urbanized areas increased more than five times. The more infrastructure and urbanization, the more impermeable, more discharge in the superficial flow of water, and when the events of extreme rainfall occur, where the accumulation of rainwater is way bigger than expected, in a question of hours the rivers overflow, flooding the cities. That intensifies within the climatic changes and the more frequent occurrence of those intense rain extreme events.

According to IPCC's (The Intergovernmental Panel on Climate Change) AR6 report, Earth's temperature has been significantly increasing due to human actions, mainly by deforestation, means of production, industrialization and consume, pointing that the extreme events are already happening more frequently, and being more intense around the entire planet (IPCC, 2021; Marengo, 2014). In that setting, the cities located in areas likely to risk of flood and landslide are extremely affected.

In a research of the Association of Research Iyaleta (Santana *et al.*,2023), based in IBGE's (Brazilian Institute of Geography and Statistics) data of the research of municipal basic information, the authors state that less than 30% of Brazilian cities' master plans contemplates preventive measures against floods and overflows. When it is preventive measures against landslides and soil slides, the rate is even smaller, only 13,11%. Yet, according to the same research, when compared to the other urban planning instruments, the results show that less a half of Brazilian cities have a law of zoning and specific plans for risk reduction. Which means,

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waiting that the cities have its risk areas set out, and the river PPAs preserved in those areas, according to what the law of urban PPAs indicates, may be an illusion, because the municipal management may understand that is should not protect, not putting any protection, if that's how it wants.

As a reinforcement and support to the Direct Unconstitutionality Action (ADI) nº 7.146/22, many Nongovernmental Organizations (NGOs) have united against the Federal Law nº 14.285/2021. According to the news on the website[3] of the Social-environmental Institute, one of the involved NGOs, many cities are reducing the protection areas, E.g, the city hall of Tiradentes do Sul (RS), that approved a municipal law setting river's marginal strips of 2,5 meters. The Permanent Preservation Areas are also fragile in rural areas when the legislation is allowed to do a suppression of the riparian forests for the building of dams and dikes. A news[4] published by the end of May of 2024, in the German news website DW (Deutsche Welle), shows that it is being debated in the Federal Supreme Court the questioning of Rio Grande do Sul's State Law nº 16111, which makes more flexible the rules to the construction of dams. According to the news, the dams are being made on water sources, impacting the rivers' entire hydrological flow.

Another relevant question refers to the understanding of what are disaster risk areas. Considering what happened in Rio Grande do Sul, in May of 2024, where most part of its urbanized area were seriously affected, probably counting with areas that were not even considered risky. The scenes seen in the extreme rain events transmitted on television channels, occurred in Brazil in the last few years, almost always will show a river overflowing and reaching to the residences, the stores, the streets, flooding the city as one, like it happened in Rio Grande do Sul, that left the State flooded, the same that happened in Petrópolis in February of 2022, with many spots of flooding and landslide.

In view of the necessity of comprehension of environmental and social subjects that involve the rivers' PPAs in urban areas, this text shows partial results of its empirical research, in the sense of proposing a observation about the theme, and introduce the city of Petrópolis and some aspects related to the social and environmental vulnerability provided by the occupations in Permanent Preservation Areas, having the events of extreme rainfall, occurred in January of 2011 and February of 2022, as examples.

Schäffer *et al.* (2011) elaborated a study right after the disaster, caused by the intense rain at Rio de Janeiro's Mountain Region, that occurred in January of 2011 and reached various cities. This study shows the relation between the Permanent Preservation Areas and the Conservation Unities, with the disaster risk areas. The study is a report made to the Ministry of the Environment, that inspected the affected areas in the tragedy. In the presentation of the study's results, Schäffer et al. (2011, p. 85) describes that "[...]It is stated as well that the areas that have been more intensely affected by the tragedy are those considered PPAs (margins of

[3] News in the Socio-environmental Institute's website about: ONGs apresentam dados ao STF para derrubar lei que altera APPs. Available at: <https://www.socioambiental.org/noticias-socioambientais/ongs-apresentam-dados-ao-stf-para-derrubar-lei-que-altera-apps-urbanas#:~:text=Com%20a%20lei%2C%20cada%20um,de%20impacto%20nessas%20%C3%A1reas%20sens%C3%ADveis>. Access in: 20/07/2024.

[4] News in the DW's website about: Por que preservação de margens de rios gera debate no STF? Disponível em: https://www.dw.com/pt-br/por-que-preserva%C3%A7%C3%A3o-de-margens-de-rios-gera-debate-no-stf/a-69215614 Acesso em: 20/07/2024.

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water courses, steep slopes and top of hills or mountains)." The authors cite about the necessity of following the Forestal Code of that time, and the minimum margin of 30 meters, that may vary to 500 meters, depending on the river's width, because it was identified that the occupations hit by the floods were in its majority in these limits. The study also shows that the number of victims in this disaster is directly related to the irregular occupation of protected areas, like the Permanent Preservation Areas.

The IV National Encounter of Disasters promoted by the Brazilian Water Resources Association, occurred in October of 2024, with the theme "the focus in the floods of Petrópolis/RJ". According to Lima and Assumpção (2023), referring to the lecture delivered by Professor Manoel Couto, of the Federal University of Rio de Janeiro, about his research using historical cartography, it indicated that the main Petrópolis' rivers have suffered suppression in its width along the years, reason that aggravates and increases the occurrence of floods and disasters. In that publication, which is the report of this technical encounter, many social actors have participated, from the civil society, people that are directly involved with the disasters' effects in Petrópolis, as well as the technicians, academics, Public Ministry, City Hall, Committee of the Piabanha River and others. The authors also report that They are presented with proposals to solve the problems caused by the rain, among those technical engineering measures, like structuring systems of draining and, also, proposals of solutions based on nature and the concept of sponge city.

There are many studies and movements of social groups (Lima and Assumpção, 2023) in the sense of searching for solutions to the preservation and adaptation to the rain extreme event in the city of Petrópolis. However, there is the necessary discussion around the Permanent Preservation Areas, the PPAs, and how to truly stablish it, as already alerted in the 2011 tragedy by Schäffer *et al.* (2011). Therefore, this article, by treating the theme in a critical way, will contribute to the reflections and incentive to the studies in this academic field, to reflect about the technical part of PPAs application, and to charge the public managers, on the adequate application of urban rivers PPAs.

1.1 Case Study

The following study uses the municipality of Petrópolis as a case study, for being a city located at the state of Rio de Janeiro's Mountain Region, with a fragile soil characteristic and susceptible to landslide, movement of material and flood. Petrópolis is known for suffering with huge impacts such as intense rain and the effects of these events.

According to the 2022 IBGE data, the municipality of Petrópolis has an estimated population of 278,881 people and the area of its territorial unit is 791,144 km2. The biome is characteristic of Atlantic Forest and is inserted in a region with twelve conservation unities, being in a federal level: the APA (Environmental Protection Area) Petrópolis, Serra dos Órgãos National Park (PARNASO), the Biological Reserve of Tinguá and Refuge of Wildlife, under the management of APA Petrópolis. In the state scope there is the Araras' Biological Reserve, and municipal the Padre Quinha Natural Park and the Pedra do Elefante Natural Monument, besides 5 RPPNs (Natural Heritage Private Reserves).

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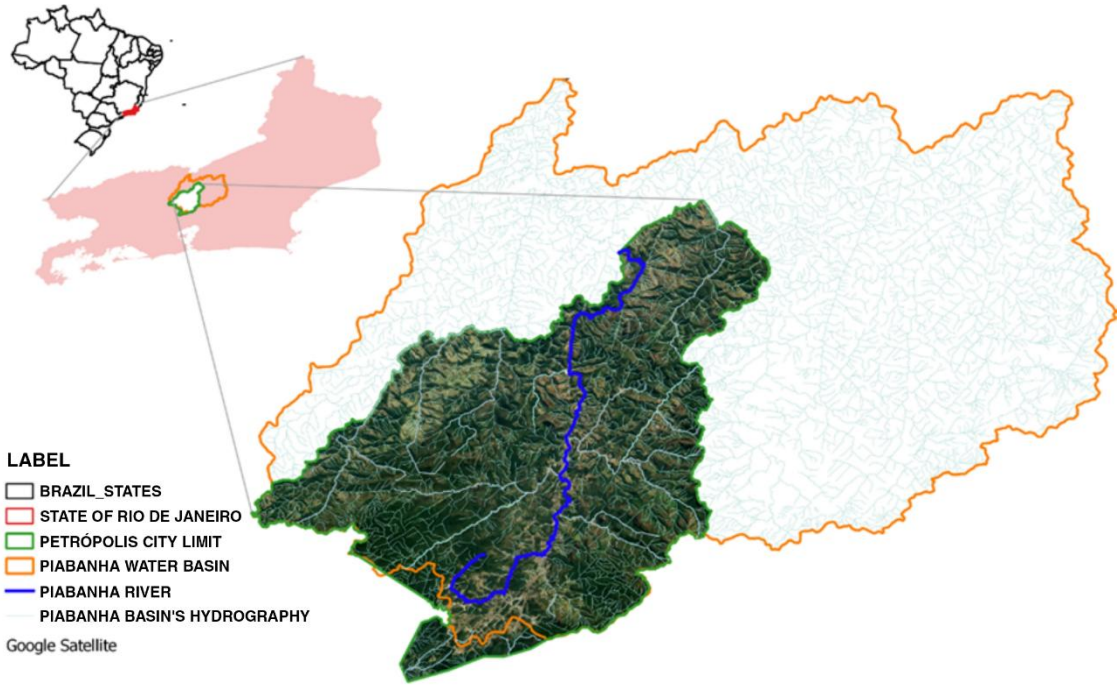
The municipality of Petrópolis has most of its territory over the Piabanha river water basin, which is an Paraíba do Sul river's tributary. The region's water basins are rich in tributaries and have a vast water system. The image 1 shows the location of Petrópolis city, in Brazil and State of Rio de Janeiro's context. In Petrópolis' city map are the main rivers, being the Piabanha river the biggest one that crosses the municipality, and the example used for the analysis.

Image 1- Petrópolis city's location, river Piabanha's water basin.



Source: Map produced by the author, 2024, using QGis program.

In this research we observe two moments of extreme rainfall events that caused damage, as well as material and human loss in the city of Petrópolis as one. On January 11th and 12th, 2011, a period of torrential rain occurred in the State of Rio de Janeiro's Mountain Region, resulting in a mega disaster. According to data collected about loss and damage in a study made by the World Bank (2012) more than 900 people have died in that tragedy that affected more than 300,000 people in all Mountain Region. Among the affected cities, Areal, Bom Jardim, Nova Friburgo, São José do Vale do Rio Preto, Sumidouro, Petrópolis and Teresópolis decreed calamity state. On February 15th, 2022, the city of Petrópolis was hit by large volumes of rain, registering 250 millimeters of rain in only three hours, according to Cemaden (Center of Monitoring and Early Warning of Natural Disasters). Once again, a disaster, which resulted in many soil slides and flood of rivers. In that extreme event, 235 people have died and thousands have been affected.

Schäffer *et al.* (2011) have already shown in a study and report made to the Ministry of Environment, after the 2011 Mountain Region's disasters, that the Permanent Preservation Areas with human occupation and/or action are the most affected and where the most loss or lives and material occur. The image 2 presents images of Cuiabá River's stretch, in Vale do Cuiabá, Petrópolis, result of one of the analyses made in that study, with aerial photos of before and after the disaster, where the water course PPAs have been delimitated with a strip of 30 meters

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in each side of the river, shown by the dotted yellow line.

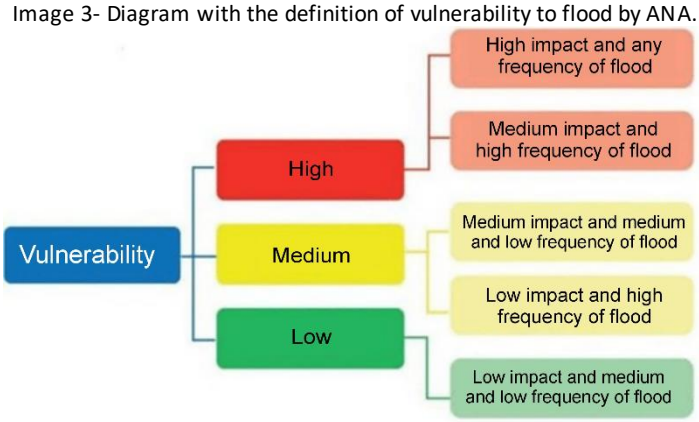
Image 2- Analysis made by Schäffer *et al.* (2011) of the Cuiabá River's PPA flood, in Petrópolis, before and after the January 2011 disaster.

Source: Schäffer *et al.* (2011).

The images show the PPA's delimitation of 30 meters, and the effects of the river's flood invading this area that should be protected, flooding and carrying homes and buildings. Most of the affected building were inside of the 30 meters strip. SCHÄFFER *et al.* (2011) also noticed that the margins that had preserved vegetation were less damaged by the flood. The researchers highlight the importance of preserving these areas and to maintain the vegetation coverage, areas where the river didn't invade.

The flood's vulnerability data made available by the National Agency of Water (ANA, 2014), shows that the Piabanha, Palatinado and Itamarati rivers present vulnerability of medium risk to the occurrence of flood. This classification is put by ANA as being of medium impact and medium to low frequency of flood, or low impact and high frequency of flood, according to the diagram in image 3.

Image 3- Diagram with the definition of vulnerability to flood by ANA.



Source: Souza *et al. (2021)*. (Free translation).

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Souza *et al.* (2021), in the research about the Piabanha river sub-basin's morphometry, conclude that this one is not susceptible of big floods, through this method of evaluation. Therefore, the analysis also considered the aspects that affect the rivers' dynamic, such as the use and occupation of soil. According to the authors, the consolidation of urban areas in the Piabanha River's margins, is the main reason of the increasing risk floods. With the information here presented, of researches that indicate that the main issue of the extreme events that cause flood are occupation at PPA areas, we follow to this research's analysis.

2 GOALS

The main goal of this research is to make a critical analysis, by bibliographical survey and mapping in geoprocessing, of the changes in environmental politics to the "protection" of urban rivers, the Permanent Preservation Areas, observing the occupation in those areas. This study takes in consideration the climate change and extreme precipitation events, using as case study the Piabanha River at Petrópolis city, in the State of Rio de Janeiro, in occasion of the disaster occurred by the rain in February 2022.

The specific goals are:

- To make a critical reflection about the theme, the involved laws and the actions taken;
- To map Petrópolis city's hydrological context, more specifically to analyze the urban rivers PPAs, of Piabanha River, and to select points, comparing aerial images of before and after the February 2022 rain;
- To analyze the PPAs occupation of the points.

3 METHODOLOGY

The methodology present in the research holds a bibliographical survey about the theme that treats the problematic of the urban areas PPAs and the existing legislation, approaching deeply the change in the Federal Law nº 12.651, with the sanction of Law 14.285 of December 29th, 2011, in order to reflect about the theme and its possible consequences.

Besides the theorical part, the study also analyzes, through geoprocessing, strips of urban rivers, more specifically the Piabanha River, located in the city of Petrópolis at State of Rio de Janeiro. The maps were produced using the program *Quantum Gis* (QGis 3.28) and in the final analysis buffers were made, representing the limit of 30 and 50 meters, according to the legislation and Forestal Code, considering that the river's width varies between 10 and 20 meters.

Two points of flooding that occurred in the PPAs through strips of the Piabanha River were identified and selected. The identifications were made through Google Earth Pro images of December 2021, February 2022 and February 2024. The dates of the images are according to the before and after of the disaster and it is possible to identify the location and flood comparing with the images. Occupations in the river's margins inserted in the areas of thirty and fifty meters strips were analyzed, because the river's varied widths were identified, from 10 to 20

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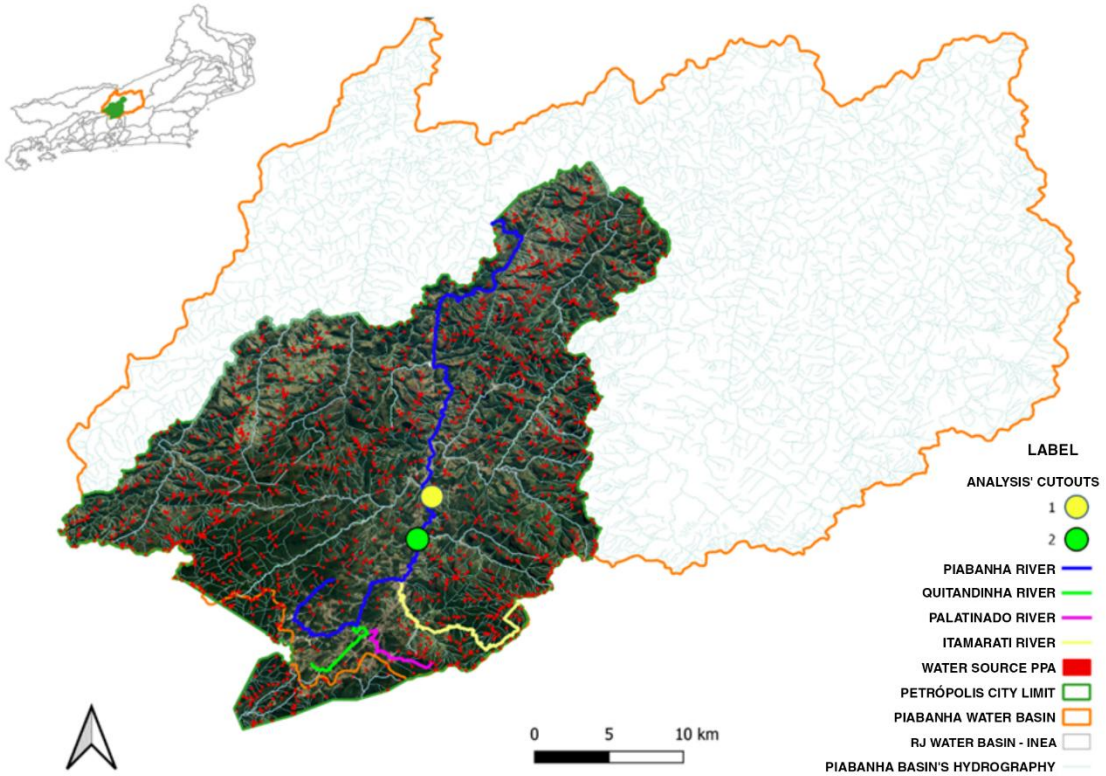
meters. The maps were elaborated with *shapefile* data, downloaded from the ANA, INEA (State Environment Institute) and GEO MPRJ (Rio de Janeiro Public Ministry) websites, with the INEA - GEOINEA geospatial databases.

4 RESULTS

Three maps were elaborated, according to the analysis sequence of Piabanha River. The image 4 map shows the city's main rivers, where it is possible to see how the water network is extremely intricate and the quantity of existing water sources in the Piabanha River's basin. The Piabanha River crosses the entire city of Petrópolis and it is where the urbanized area has consolidated through the years. Other rivers that are part of the water system in the urban areas are the Palatinado River, Quitandinha River and Itamarati River.

Image 4 – Water map of the Piabanha River's basin, the main rivers and the water sources PPAs.



Source: Map produced by the author, 2024, using the QGis program.

The image 5 shows one of the parts that was analyzed in the Piabanha river, located in the Glória neighborhood. This image, as well as the Schäffer *et al.* (2011) analysis, delimitates a protection strip and analyzes the before and after of the disaster, however, considering the strip delimitated by the Forestal Code, of fifty meter for rivers with a width bigger than ten meters. It is observed that the occupations in PPA areas were invaded by water, as seen in the mud stain of the areas that suffered with flood.

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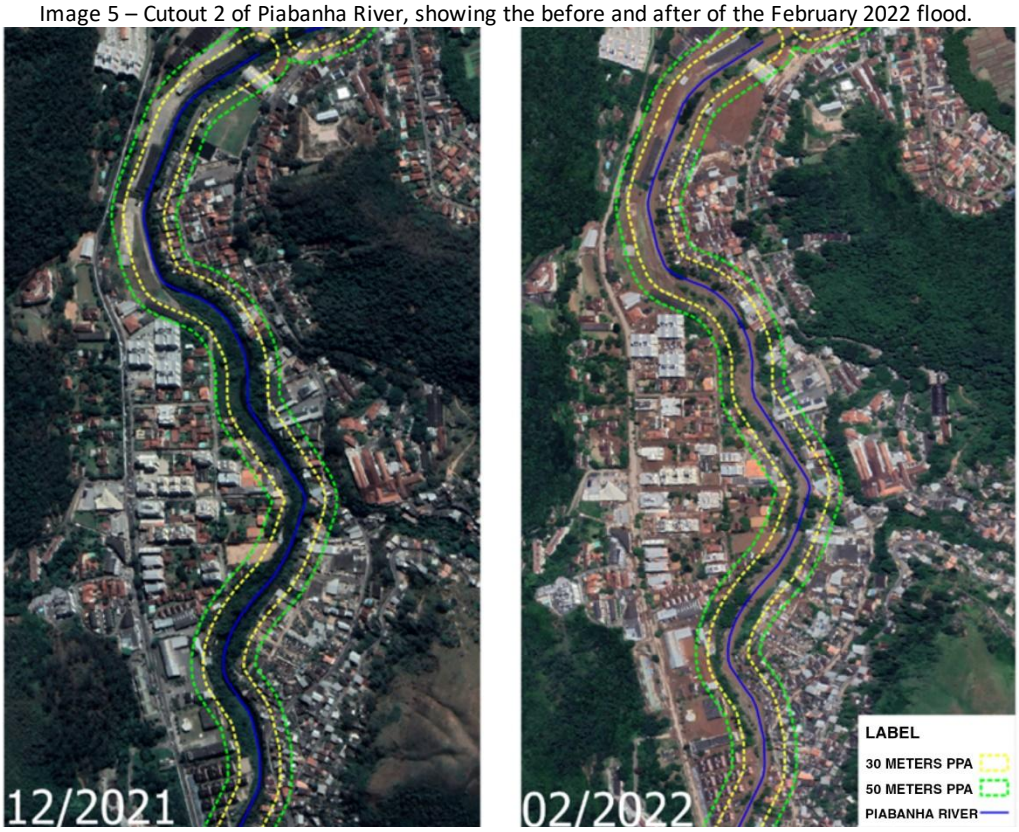
Image 5 – Cutout 2 of Piabanha River, showing the before and after of the February 2022 flood.



Source: Map with the images generated in the Google Earth Pro program and produced by the author using QGis, 2024.

The result of the analysis has revealed another cutout of Piabanha River, illustrated in image 6, where in this area, located at the Bonsucesso neighborhood, with aerial images dated from 2021, 2022 and 2024. A huge area of the flood is observed in the image of February 2022, going beyond the PPA's limit. As for the 2024 image, new buildings being lifted by the margins of Piabanha River are shown, inside of the limits of the thirty/fifty meters strips, and in an area that has already suffered from flood in 2022. These buildings could be considered irregular, as it is inside the limit stablished to the Permanent Preservation Area in the Forestal Code. After the law change, these buildings may be regularized, even when trespassing the minimum limit, and if it is on the interest of the municipal management, it might not even consider any protection margin. This location is of an area considered as consolidated urban, however, the occupations suffocate the river and a wide part of its path.

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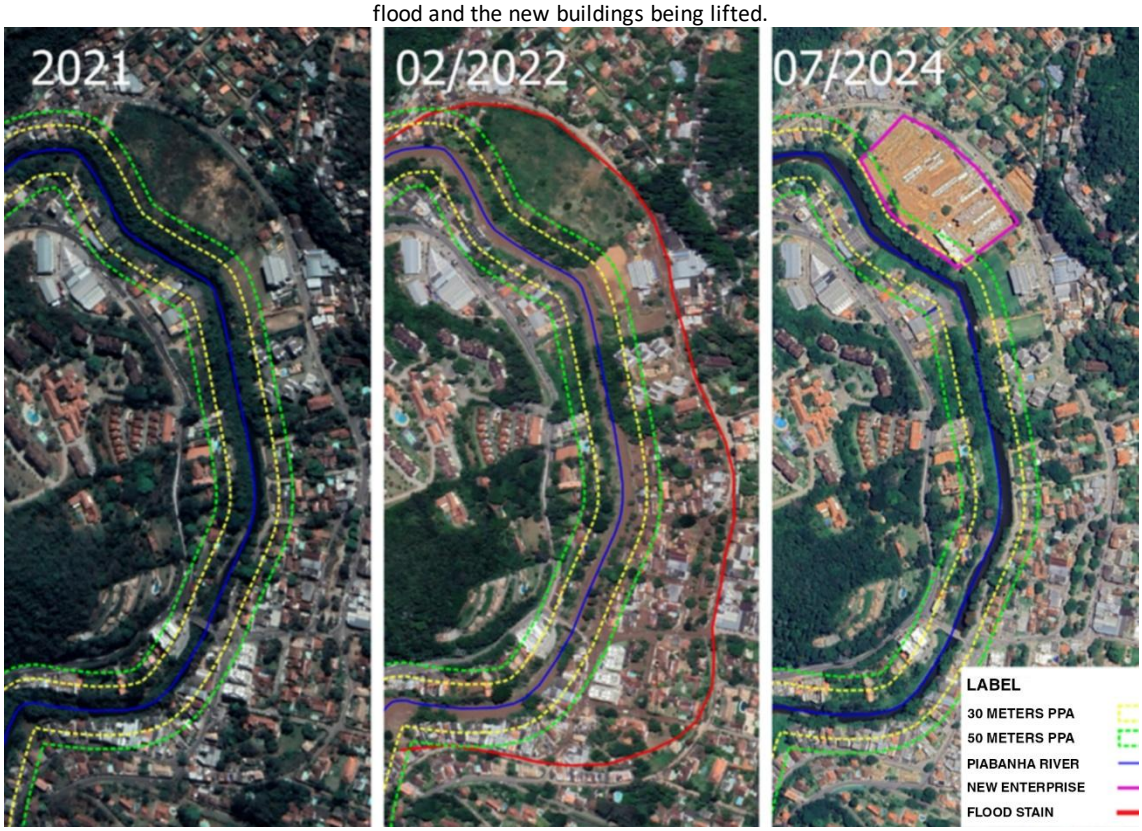
Image 6 – Cutout 1 of Piabanha River, with aerial images from 2021, 2022 and 2024, showing na area that has been flood and the new buildings being lifted.



Source: Map with images generated in the Google Earth Pro program and produced in the QGis program by the author is 2024.

As presented and analyzed in the maps, the existing occupations are possible to regularize and it is understood that the loss of protection only makes the rivers and the people more vulnerable. There is no likely justification, neither in social or economic order, for the guarantee the right of regularization of buildings located near to the rivers' margins, because, through the time and the forecasts, and the findings, related to the climate change, the life risk will be even worse. Risk of material loss, of lives, and damage to the environment, with a destruction impact in the local ecosystem.

As it can be seen and analyzed by the aerial images, in the rainfall of February 2022, the Piabanha River flood occupied its space in the flooding areas of its margins, mainly in the meander paths.

The analysis demonstrates that a big part of the most affected areas are found in the PPA's strip (30/50 meters in each margin of the water courses), emphasizing the urge and the importance of preservation in that strip, leaving it free of buildings and other anthropic interferences that may cut off the free flow of water.

5 CONCLUSIONS

The results have shown that the high vulnerability regarding the occupations in the rivers' margin analyzed, both in social character, representing risks of loss of lives, and in

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environmental character, because the urban rivers are totally neglected in the law and action aimed to the urban and environmental politics.

The value of property is prioritized, the real estate market and the taxes collected by the cities, when it should look out for solutions, in the sense of science has been demonstrating: that the cities need to adapt to the climate changes, through the structures that harmonize the most with nature, principally in the urban draining (Christofidis *et al.*, 2019).

Facing the environmental dimension that demonstrates a city surrounded by green, forests and preserved areas, cities like the one in the case study are environmentally fragile and, in this sense, this study focuses in bringing on arguments that provide debates to alert the city managers about the protection of rivers and all of the other Permanent Preservation Areas. With the new urban PPAs law, it is up to the responsibility of the City Halls to elaborate an efficient strategic plan, in the Master Plan and the zoning laws, of soil use, and ecological and economic zoning, in a sense of protecting the rivers and the people from a dangerous urbanization, that only aims to meet the market's interest. But principally, it is necessary and urgent that the city implement an Adaptation Plan to the climate change, as defined in the City Statute.

Free path of waters? Yes, the water needs to follow its path, if it is not found, if there are obstacles in its course, the damages may be catastrophic. The water looks for its space, we give back this space, or it will continually look out for this space. It is not the human being that imposes limits, it is the water that holds this power, it is nature. Depending on the rivers' width to the protection strips determined in the existing laws, it might not be enough to meet safely the water dynamic of many rivers, because the meanders vary through time. Naturally, this "dance" of the river makes it maintain a shape for a set up time, and the occupations are given after this shape, as if it is immutable. However, when the flood comes and it should "dance", which means, change its draining dynamic, the water invades the built areas. In that sense we observe how dangerous limiting and disrespecting the rivers and the force of waters and nature can be.

This research reveals to us the importance of stablishing laws that protect the marginal strips from flooding and that prevent that the adjacent areas change in the dynamic of water draining, mainly in urban areas, where the density of occupation makes it more sensitive to environmental disaster.

Is it necessary to expropriate the occupations in PPAs?

If we consider the necessity of maintenance of the free path that the waters need to run to its spaces in times of floods and intense rain, the answer is "yes" principally if we want to think about protecting lives and not have material damage. However, the sense of adapting to climate change may also be equated, in case of very dense urban areas that do not allow the urban reconfiguration with expropriations and reforestation.

There is a local and planetary relation between forests and rivers, that will dictate the water cycle, that will influence in the dynamic of water basin, that will produce flying rivers and rain in different locations with influence of actions and dynamics of water basins with a distance of millions of kilometers, even from other countries. This being said, it is more than urgent to stablish that the protection laws for rivers, for the water sources, to the top of mountains and hills, will be really to protect it. These areas need to be free of occupation and naturalized, to the water basin as a being, allowed to be a cycle, and not have this cycle interrupted, letting

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nature do what it does at best, be itself.

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STATEMENTS

CONTRIBUTION OF EACH AUTHOR

By describing the participation of each author in the manuscript, use the following criteria:

- **Conception and Design of Study**: Natália Fernandes Ribeiro.
- **Data Curation**: Natália Fernandes Ribeiro and Werther Holzer.
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- **Acquisition of Financing**: Natália Fernandes Ribeiro.
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- **Methodology**: Natália Fernandes Ribeiro and Werther Holzer.
- **Redaction – Initial Draft**: Natália Fernandes Ribeiro.
- **Redaction – Critical Review**: Natália Fernandes Ribeiro and Werther Holzer.
- **Review and final Edition**: Natália Fernandes Ribeiro, Werther Holzer.
- **Supervision**: Werther Holzer.

CONFLICT OF INTEREST STATEMENT

We, **Natália Fernandes Ribeiro and Werther Holzer**, declare that the manuscript entitled "Urban rivers and the free path of water: The challenge of applying Permanent Preservation Areas in consolidated urban areas":

1. **Financial Links**: There is no/there is financial links that may influence the results or understanding of the work.
2. **Professional Relations:** There is no/there is professional relations that may impact in the analysis, understanding or presentation of the results.
3. **Personal Conflicts:** There is no/there is personal interest conflicts related to the manuscript's content.