


## THE IMPORTANCE OF DIAGNOSING URBAN PERMANENT PRESERVATION AREAS FOR WATER RESOURCES MANAGEMENT IN GOIÁS: A CASE STUDY IN ITUMBIARA-GO

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### ABSTRACT

The study aims to diagnose the Permanent Preservation Areas (APPs) in Itumbiara-GO, evaluating their conservation status and proposing measures for environmental preservation and recovery. The research focuses on the watersheds of the Água Suja, Trindade and Pombas streams, located within the urban perimeter of Itumbiara and belonging to the microbasin of the Meia Ponte River. The PPAs in these areas are inserted in the Cerrado biome, with phytophysiognomies of footpaths and riparian forests. The methodology adopted included the analysis of satellite images from 2023, on-site inspections with a camera and a DJI MAVIC-2 drone equipped with a thermal sensor to identify occupations. The APPs were evaluated according to their state of conservation, classified into five categories: Poor, Regular, Good, Excellent and Excellent. The diagnosis revealed degradation of the areas due to disorderly urbanization and irregular occupations, resulting in pollution, loss of biodiversity and increased flooding. Most APPs are in fair or poor condition, highlighting the lack of effective public policies. The study points to the urgent need for planned interventions to balance environmental preservation and sustainable urban development, suggesting the implementation of management and environmental education strategies to improve quality of life and protect natural resources.

**Keywords:** Environmental preservation. Urbanization. Microbasins.

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## INTRODUCTION

Most Brazilian cities have expanded in a disorderly manner, ignoring the preservation of vegetation on the banks of rivers, streams and springs. It is notorious in the urban environment, channeled watercourses with a total absence of vegetation protection strips. Soil waterproofing and vegetation suppression gradually extinguished the springs of urban areas, giving way to large residential, commercial, and industrial developments (Castro et al., 2018).

In the urban space, the watercourses and the vegetation that surround them are integral elements of the urban landscape and influence the cultural, social and economic aspects of the place. The (inter)relations between human beings and nature occur constantly in the urban environment and the absence of planning for these protected areas causes environmental degradation and the quality of life of the inhabitants, and consequently (re)produces urban spaces that are also deteriorated (MENEZES, 2007).

The clear definition of permanent preservation area was established from Federal Law No. 12,651 of 2012, as the Forest Code of 1965 did not do so, leaving to doctrinal and jurisprudential discussions whether or not degraded areas without vegetation cover should be included (FRANCO, 2003). In this context, a permanent preservation area (APP) is defined as "a protected area, whether or not covered by native vegetation, with the environmental function of preserving water resources, landscape, geological stability and biodiversity, facilitating the gene flow of fauna and flora, protecting the soil and ensuring the well-being of human populations" (Brasil, 2012). The intervention or suppression of native vegetation in these areas will only occur in the cases of public utility, social interest or low environmental impact provided for by the same law and with authorization from the competent environmental agency. Another novelty brought by the last forest code refers to the regulation of APPs in urban areas, which were not clearly defined in previous forest codes.

The public areas of permanent preservation of cities are often seen by managers as problematic and devalued, resulting in idle areas with a lack of planning and investment. In this context, there are invasions and irregular occupations of the APPs, by low-income people, homeless, small farmers who use the space to grow vegetables - considering the abundance of water and soil fertility in these regions - and by some opportunists who parcel out and sell lots in public areas and others who, although they own real estate, they build houses for leisure/party.

Some consequences of the irregular occupation of these physical spaces, protected by law, are the advance of the processes of environmental degradation of the APPs, pollution of springs and watercourses, loss of biodiversity, suppression of native vegetation, soil impermeabilization, reduction in the volume of water infiltration that favors the increase in surface water runoff, contributing to the increase in floods and the occurrence of floods.

The irregular occupation of urban APPs in the municipality of Itumbiara-GO, due to the disorderly urban expansion associated with the inefficiency of public socio-housing policies, has been compromising the environmental quality of the Meia Ponte River watershed and, consequently, of the Paranaíba River Basin. The proper use of APPs in urban space aims to promote the preservation of water, landscape, soil, fauna, and flora resources, in addition to significantly improving the quality of life of the city's inhabitants. On the other hand, the right that everyone has to an ecologically balanced environment cannot create more social injustices and violate the right to housing.

In this sense, the objective of this work was to analyze the conditions and types of occupations existing in the permanent preservation areas of the watershed of the three watercourses that surround the urbanized area of the municipality of Itumbiara-GO and to propose measures for the preservation and environmental recovery of these areas.

## **METHODOLOGY**

The present study was conducted in the municipality of Itumbiara-GO, which covers a territorial area of 2,447.014 km<sup>2</sup>, with an urban perimeter of 51,448,591.22 m<sup>2</sup> and a total population of 107,970 inhabitants, according to IBGE data (2022). Itumbiara is the most populous city in the southern region of Goiás. The area is crossed by important watercourses, including the Paranaíba, dos Bois and Meia-Ponte rivers, as well as the Trindade stream, Santa Maria stream, Água Suja stream and Pombas stream. The climate of the region is classified as tropical, characterized by two distinct seasons: a dry period from April to September and a rainy period from October to March, resulting in six months of dry season. The average annual temperature is 23.8°C, with peaks above 35°C between August and January (Alcântara; Stech, 2011). Itumbiara is located in the Cerrado and Atlantic Forest biomes, presenting a predominantly flat relief, with some mountainous and undulating areas. The main soil types identified are dystrophic red oxisols, dystroferic, red clayey latosols and haplic cambisols (Lemes; Chaves Filho, 2017).

The diagnosis was carried out in the permanent preservation areas (PPAs) of the watersheds of the Água Suja, Trindade and Pombas streams, which are located within the urban perimeter of Itumbiara and belong to the watershed of the Meia Ponte River, in the Paranaíba Hydrographic Basin, hydrographic region of Paraná. The PPAs of these watercourses are inserted in the Cerrado biome, characterized by phytophysionomies of footpaths and riparian forests.

For the analysis of the current situation of the APPs, satellite images from the Google Earth software from the year 2023 were used. Additionally, on-site inspections were carried out using a camera and a DJI MAVIC-2 drone equipped with a thermal sensor to identify the types of occupation present. This method allowed a detailed evaluation of the characteristics and conditions of the areas studied.

After the identification and inspection of the urban permanent preservation areas, they were evaluated for positive and negative aspects, as described in Chart 1. The APPs were then classified according to conservation status into five categories: Poor, Regular, Good, Excellent and Excellent. This classification was based on specific criteria that consider ecological integrity, the presence of native vegetation cover, water quality and the degree of human intervention.

**Chart 1:** Diagnosis of the urban APP's of Itumbiara regarding the positive and negative aspects for classification purposes.

Diagnosis of PPAs			
Negative aspects		Positive aspects	
1	Presence of residential buildings	The	Satisfactory vegetation cover
2	Presence of commercial buildings		Medium vegetation cover
3	Growing vegetables and other crops		Low vegetation cover
4	Irregular disposal of solid waste	D	Fenced and identified area
5	Presence of animals, pigs, chickens, cattle and/or horses)		
6	Grounding		
7	Siltation of the channel		
8	Low vegetation cover and/or absence of riparian vegetation		
9	Discharge of domestic sewage and/or industrial effluents		
10	Use of pesticides and fertilizers		

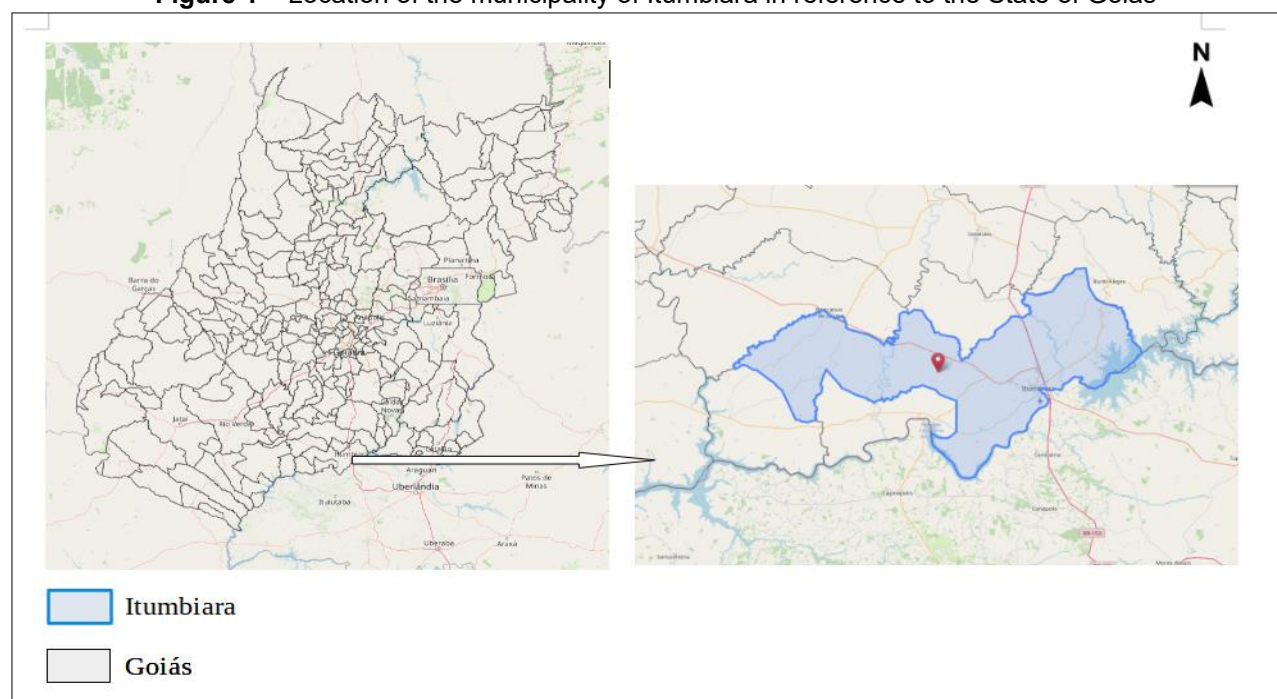
11	Areas to be reforested	
12	Abstraction/use of surface water without authorization	

**POOR** - Have a diagnosis of C, regardless of the number of negative items, or have a diagnosis of A or B and seven or more negative aspects; **REGULAR**: Have a diagnosis of A or B and a maximum of 6 negative aspects; **GOOD**: Have a diagnosis of A or B and a maximum of 5 negative aspects; **EXCELLENT**: Have two or more positive diagnoses or Have a diagnosis A or B and a maximum of two negative aspects; **EXCELLENT**: Not having any negative diagnosis.

## CHARACTERIZATION AND LOCATION OF THE STUDY AREA

Itumbiara is located in the South Goiano Mesoregion, borders the State of Minas Gerais, has a territory of 2,447.014 km<sup>2</sup> and an urban perimeter of 51,448,591.22 m<sup>2</sup>, according to Law 3,566/2007. It has 107,970 people (IBGE, 2022) and is considered the most populous city in the South region of Goiás. Two important highways pass through the municipality, BR-153 that crosses Brazil from north to south and BR-452 (Figure 1).

**Figure 1** – Location of the municipality of Itumbiara in reference to the State of Goiás



**Source:** Prepared by the authors from SIGA (2024)

The Paranaíba, Bois and Meia-Ponte rivers pass through the municipality, in addition to some watercourses such as the Trindade stream, Santa Maria, Água Suja and Pombas streams. The climate is tropical, characterized by two well-defined seasons, with dry periods between April and September and rainy from October to March, configuring six

months of drought. The average annual temperature is 23.8°C, and may exceed 35°C in the months of August to January (Alcântara; Stech, 2011). It is inserted in the Cerrado Biome and Atlantic Forest, with predominantly flat relief, with some mountainous and undulating regions. The main soil types are dystrophic red oxisols, dystroferic oxisols, red clay and haplic cambisols (IBGE, 2001).

Regarding infrastructure, the city has a water treatment plant, sewage, industrial center, public and private universities, shopping centers, tax office, civil and military public security institutions, shopping centers, agricultural park, soccer stadium, theater and museum. It also has a municipal airport, with a 1,752-meter runway that, after an agreement with the government of Goiás in 2024, underwent renovation and expansion to offer regional flights with regular lines between Itumbiara and São Paulo. It hosts the Furnas Hydroelectric Power Plant, with an installed capacity of 2,082 MW and in 2021 the first renewable hydrogen production plant, known as green hydrogen, with a production capacity of 100 kg/day, went into operation.

The study was carried out in the watershed of the Água Suja, Trindade and Pombas streams, located in the urban perimeter of the municipality of Itumbiara-GO, belonging to the microbasin of the Meia Ponte River, Paranaíba Hydrographic Basin, hydrographic region of Paraná. The permanent preservation areas of these watercourses are inserted in the cerrado biome, characterized by phytophysionomies, paths and riparian forests.

## RESULTS AND DISCUSSIONS

The municipality of Itumbiara, located in the state of Goiás, stands out for its rich hydrography, being bathed by the Paranaíba River and by four tributaries that run through its urban perimeter: the Ribeirão Trindade, the Água Suja Stream, the Pombas Stream and the Buritys Stream (Figure 2). The Ribeirão Trindade, with a total length of 19,580.219 meters, is the largest among them, with 3,229.722 meters within the urban area of Itumbiara (Lemes; Chaves Filho, 2017).

The channeling of watercourses in Itumbiara is alarming, with the channeled stretches of Ribeirão Trindade, Água Suja, Buritys and Pombas totaling 1,337 meters, 2,645 meters, 1,190 meters and 904 meters, respectively. The absence of riparian forest in these channeled areas compromises ecological integrity, as permanent preservation areas (PPAs) have been invaded by residential and commercial developments, resulting in environmental degradation and loss of biodiversity. Disorderly urbanization has contributed

to the suppression of native vegetation and soil impermeabilization, leading to an increase in surface runoff and flood events (Figueiredo et al., 2021).

**Figure 2** – Delimitation of the three watersheds of the Água Suja, Trindade and Pombas streams in the municipality of Itumbiara-GO.



**Legend:**

- Watershed of the Água Suja stream
- Ribeirão Trindade Watershed
- Microbasin of the Pombas stream

**Source:** Elaborator by Obede Alves from the Google Earth software (2024). Image date 10/05/2023.

The Água Suja Stream, in turn, is about 14,402 meters long, with 4,883 meters inserted in the urban perimeter. The Buritys and Pombas Streams are also relevant, with lengths of 3,285 meters and 7,424 meters, respectively. The Ribeirão Trindade, which is the largest of the watercourses analyzed, has a total length of 19,580.219 meters, of which 3,229.722 meters are inserted in the urban area, as indicated by Lemes and Chaves Filho (2017). In this way, the hierarchy of watercourses in the region is clearly established, with the Trindade Stream at the head, followed by the Água Suja Stream, Pombas Stream and Buritys Stream. Table 1 summarizes the characteristics of the mentioned watercourses.

**Table 1:** Characterization of the length of the watercourse channel - Itumbiara-GO

Watercourse	Full extension Weight Loss (M)	Urban perimeter canal extension (m)	Channeled Channel Extension (m)
Córrego Água Suja	14.402,0	4.883,0	1.337
Ribeirão Trindade	19.580,2	3.229,7	2.645
Córrego Buritys	3.285,0	3.285,0	1.190
Córrego das Pombas	7.424,0	3.650	904

With an urban area of approximately 600 hectares of PPAs, only 29 hectares were effectively integrated into management strategies through the creation of urban parks, according to municipal regulations. The rest of these areas have been the target of invasions and irregular occupations, where different social groups, including low-income populations and small farmers, occupy these zones for cultivation and housing. Such practices not only compromise water quality, but also generate social conflicts and hinder the implementation of effective public policies for environmental preservation (Motta; Souza, 2019).

Satellite images and on-site inspections reveal that the most critical areas of irregular occupation are located in the APPs of the Dona Marolina, Ladário Cardoso de Paula and Ferreira da Costa neighborhoods, in addition to the footpaths areas of Córrego das Pombas. The watershed of the Água Suja Stream, especially, has a vast area of native vegetation and paths, which extend through the southwestern region of the city. However, channeling this stream resulted in the loss of riparian vegetation, directly impacting the health of aquatic ecosystems and water quality (Cavalcante et al., 2022)

In the watershed of the Água Suja Stream, an extensive area composed of native vegetation and paths was observed, which extend from the northwest region of the city, descending and bordering the urban perimeter through the southwest area. This route covers the neighborhoods of Ladário Cardoso de Paula, Sonho Verde, Jardim Leonora, Setor Paranaíba and Ferreira da Costa. From the Brasília neighborhood, the Água Suja stream is channeled, resulting in the absence of riparian vegetation until its confluence with the Paranaíba River (Figure 3).

**Figure 3:** Image of the watershed of the Água Suja stream. Spring 6 represents the water contribution of the remaining area of the Ladário Cardoso de Paula neighborhood. East 7 recharge area in the Dona Marolina neighborhood and East 8 between Jd. Leonora and Nova Itumbiara



**Source:** Elaborator by Obede Alves from the Google Earth software (2024). Image date 10/05/2023.

The springs of the Água Suja Stream, located in the neighborhoods of Ladário Cardoso de Paula, Dona Marolina and Jardim Leonora, are particularly vulnerable to irregular occupations. The remaining area of the footpath in the Ladário Cardoso neighborhood, the largest in the region, is crucial for the maintenance of biodiversity and water quality, however, it has been threatened by anthropogenic activities and the lack of environmental inspection. The presence of residences and commercial activities in the vicinity of these springs compromises the integrity of local ecosystems and aggravates sanitation and pollution problems (Almeida et al., 2020).

The footpath located in the Ladário Cardoso de Paula neighborhood, recognized as a remaining area, represents the largest Buriti forest in the urban area of Itumbiara, covering an extension of 165,738.31 m<sup>2</sup>. This region is ecologically significant due to its abundance of water and the exuberance of the native vegetation that is preserved there. Within this remaining area, several springs of the Água Suja Stream, an important tributary of the Paranaíba River, are found, contributing to the maintenance of the local water system. The vegetation present in this footpath belongs to the cerrado biome and is characterized by its phytophysiology, which includes hydromorphic soils, outcrop of the water table and the marked presence of the palm tree *Mauritia flexuosa*, popularly known as Buriti.

The veredas play a crucial role in maintaining biodiversity and protecting the fauna of the cerrado, offering refuge, shelter and food sources for various species of terrestrial, aquatic and avifauna fauna. In addition, these areas are fundamental for the formation and regulation of watercourses (Martinez et al., 2020). The conservation of the wetlands is

imperative, since anthropogenic activities such as the discharge of sewage, deforestation and the use of pesticides can compromise their ecological integrity and, consequently, the quality of the water that supplies the community (Silva; Oliveira, 2021).

However, the spring areas in the Ladário Cardoso de Paula, Dona Marolina and Ferreira da Costa neighborhoods face serious problems resulting from irregular occupations. On-site inspections, complemented by the use of DJI MAVIC-2 drones, revealed the presence of residential, commercial and even leisure houses, as well as vegetable cultivation and marketing activities in these areas, as illustrated in Figures 6 to 8. In 2018, the Municipal Environment Agency of Itumbiara notified 17 invaders in the spring areas of the Dona Marolina neighborhood, and in 2022 12 more invaders were identified. In the remaining area of the Ladário Cardoso neighborhood, 30 cases of invasion were found.

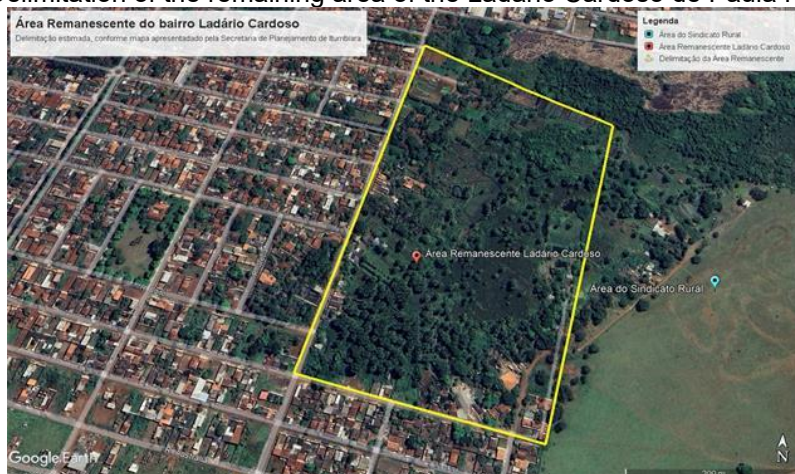
Streets 102, 109 and Paranaíba, located in the Jardim Leonora neighborhood, as well as Água Suja and R. 38 streets, are occupied by fish-pays, farms and commercial and residential establishments, invading the areas of footpaths and the APPs of the Água Suja Stream. Some of these occupations are invasions, while others are regular lots. However, even in regular lots, it is essential that the government exercises strict control over the activities allowed in these preservation areas.

In the APP of the Água Suja Stream, in the southwest region of Itumbiara, several irregularities were observed, including the opening of an unpaved street just 3 meters from the banks of the stream, the absence of riparian vegetation in stretches of the watercourse, accumulation of scrap metal in the APPs and the presence of seven residences less than 20 meters from the watercourse. In addition, deforestation and siltation activities have been found.

Irregular occupations and agricultural activities carried out within the APPs have caused significant environmental degradation, resulting in problems such as the grounding of the wetlands, the loss of native vegetation, the irregular disposal of solid waste, the potential use of pesticides in the cultivation areas and the release of untreated domestic sewage, which alters the quality of the water and pollutes the springs. The analysis of data obtained by thermal sensors allowed the identification of the points of greatest degradation, characterized by the absence of vegetation and the presence of residential and commercial buildings. The comparison between images from 2011 and 2023, presented in Figures 4 and 5, reveals a worrying expansion of anthropogenic occupation in the area.

In this context, it is evident that more effective urban and environmental planning is needed to balance urban development with environmental conservation. The implementation of public policies that integrate environmental protection and sustainable urbanization is essential to avoid the degradation of preservation areas and ensure the quality of life of the population (Cavalcante et al., 2022; File; Souza, 2023).

**Figure 4** - Delimitation of the remaining area of the Ladário Cardoso de Paula Neighborhood



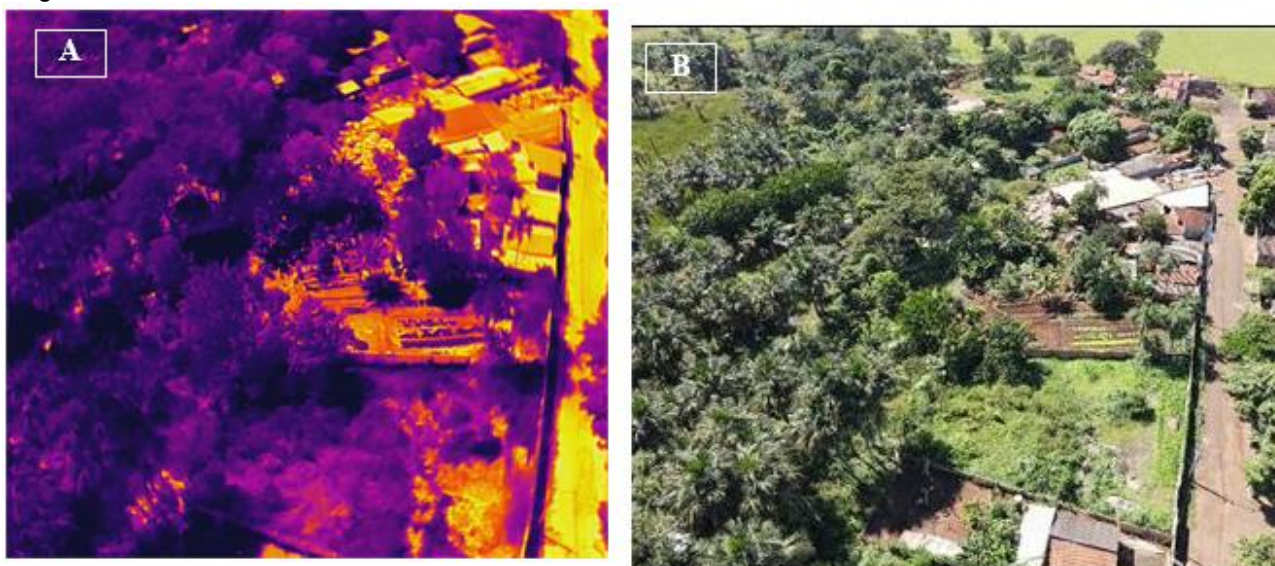
**Source:** Elaborator by Obede Alves from *the Google Earth software* (2024). Image date 10/05/2023. (Geographical coordinates 18°24'56.52" S 49°16'02.16" W). Total area of 165,738.31 m².

**Figure 5** - Remaining area of the Ladário Cardoso de Paulo neighborhood in 2011



**Source:** Prepared by Obede Alves from *the Google Earth software* (2023). Image date 06/07/2011

**Figure 6** - Aerial photograph with drone of the remaining area of the Ladário Cardoso de Paula neighborhood.



**Observations:** Image "A" was recorded using the drone's thermal sensor, being the same image as "B". The reddish-yellow colorations indicate points with higher temperatures, representing, in this image, the points within the remaining area with masonry and/or bare soil constructions. Darker colorations indicate areas with abundant vegetation, where the temperature is naturally lower. In this place, several residences, some commercial enterprises, a recycling company and vegetable cultivation were found.

**Source:** Matheus Prado, drone pilot (2023)

**Figure 7** - Recycling company installed within the remaining area. On Angola Street. At the back of the company it is possible to see a significant amount of water from the springs/outcrop of the water table that exists throughout the area.



**Source:** Matheus Prado, drone (2023)

**Figure 8:** More residential occupations on Peru Street, residences with swimming pools. The exuberance of *Buritis*, a native species of the flora of the Cerrado Biome, a bioindicator of flooded areas with an outcrop of the water table (*veredas*) is observed



**Source:** Matheus Prado (2023)

The microbasin of the Trindade stream presents a series of significant environmental problems, especially in the areas of springs (*veredas*) located in the Zenon Borges, Dom Bosco and Alto Trindade neighborhoods. These areas face irregular occupation by large animals, which contributes to soil degradation and compaction, impairing the regeneration of native vegetation (Santos et al., 2019). In addition, the irregular disposal of solid waste in the Permanent Preservation Areas (PPAs) and in the stream channel aggravates the situation, resulting in soil and water contamination (Silva; Oliveira, 2020).

Domestic sewage pollution is of particular concern during periods of intense rainfall, when sewage overflows occur in the paths. This situation is exacerbated by the lack of delimitation and fencing of the areas, making them vulnerable to invasions and irregular occupations (Medeiros et al., 2021). The APP between the Dom Bosco and Alto Trindade neighborhoods, characterized as a footpath, is home to a significant reserve of native flora species and grasses, which play a crucial role in maintaining local biodiversity and protecting water resources (Cunha et al., 2022).

In the Trindade APP, near Perimetral Avenue, an intense cultivation of vegetables was found, associated with the use of pesticides and the capture of surface water without the proper authorization. This practice not only compromises water quality, but also poses

a risk to public health and local biodiversity (Ferreira et al., 2020). The areas of springs 3 and 4, located near DIAGRI and the State University of Goiás, receive contributions from rainwater and/or effluents from unidentified polluting sources, resulting in an organic load that favors the uncontrolled growth of aquatic macrophytes and the eutrophication of the lagoons in the region (Lima et al., 2023).

The clandestine discharge of sewage negatively impacts the entire channel of the Trindade stream within the urban perimeter, compromising water quality and the health of aquatic ecosystems (Pereira et al., 2021). In 2023, the Municipal Environment Agency of Itumbiara collected water samples at five different points in the Ribeirão Trindade, and the results of the analyses indicated alarming levels of pollution (Itumbiara, 2023). The data revealed that the total coliform index ranged from 20,000 to 120,000 N.M. per 100 mL, while the *Escherichia coli* index ranged from 730 to 7,916 N.M. per 100 mL. These values significantly exceed the maximum standards allowed for class II watercourses, as established by CONAMA Resolution No. 357, which determines limits of 5,000 N.M. per 100 mL for total coliforms and 1,000 N.M. per 100 mL for *E. coli*. This situation highlights the seriousness of the contamination and the urgent need for environmental control and recovery measures in the watershed of the Trindade stream.

The intense urbanization on the banks of the Ribeirão Trindade has led to the suppression of numerous springs, while others still persist, despite the growing pressure of the real estate market. This phenomenon is of particular concern, as springs play a vital role in maintaining water balance and the quality of water available to the community. An emblematic example occurred in 2016, when a private area was dismembered for the construction of four residential lots. This area, however, was home to springs whose waters flow directly into the Ribeirão Trindade. Despite the notifications issued by inspection agencies, the construction works were carried out, resulting in serious structural problems for the residences later, due to the lack of adequate drainage works, which culminated in a significant accumulation of water in the lots.

Disorderly urbanization, especially in permanent preservation areas, compromises not only the integrity of springs, but also the health of the surrounding aquatic and terrestrial ecosystems. Soil waterproofing, a result of the construction of buildings and paving of roads, reduces the infiltration capacity of water, increasing surface runoff and contributing to erosion and siltation of watercourses (Motta & Souza, 2019). In addition, the absence of green areas and native vegetation undermines the regulation of the local

microclimate and affects biodiversity, since essential habitats are destroyed or fragmented (Figueiredo et al., 2021).

Another critical aspect to be considered is the vulnerability of buildings erected in areas of springs. The lack of urban planning that considers environmental preservation can result in significant risks, such as flooding and structural instability. The case of houses built in 2016 exemplifies how the absence of drainage and inadequate location can lead to serious problems for residents, in addition to generating high costs for repairs and emergency interventions (Almeida et al., 2020).

Therefore, it is crucial for urban planners and local authorities to adopt an integrated approach that considers both economic development and the protection of water resources and environmental preservation. Stricter regulation of permanent preservation areas and the implementation of sustainable land use policies are measures that can contribute to mitigating the impacts of urbanization (Cavalcante et al., 2022). In addition, environmental education initiatives and raising awareness among the population about the importance of preserving springs can be fundamental to foster a culture of respect and care for natural resources.

**Figure 9** - Drone image showing the springs inside the APP and the existence of neighboring buildings on the side of the Dom Bosco neighborhood



**Source:** Matheus Prado, drone pilot (2024)

**Figure 10** - APP between Dom Bosco and Alto Trindade neighborhoods, with emphasis on the location of one of the springs, neighboring lots and waste disposal points.



**Source:** Prepared by the authors from *Google Earth Software* (2023). Image Date 10/05/2023

With regard to the Buritys Stream and the Pombas Stream, urbanization and irregular occupations have generated severe impacts, such as siltation and water pollution, in addition to compromising the wetland areas, which are essential for biodiversity and water regulation. Vegetable cultivation activities and the construction of residential developments along watercourses have exacerbated environmental degradation and the alteration of hydrological cycles (Silva; Oliveira, 2023).

The Buritys stream has its source in the northern region of Itumbiara and houses areas with native vegetation, phytophysiology of footpaths and areas subject to reforestation along the marginal strips of paved roads. The irregular occupations identified along the watercourse include the cultivation of vegetables and the construction of residences. A section of the canal, located between Presidente Tancredo Neves Avenue and Osvaldo Volgarini Street, has a high degree of siltation, as a result of the channeling works carried out about two years ago. In addition, there are regularized lots less than 30 meters from the watercourse, which shows the lack of concern with environmental preservation and the management of water resources during the process of allotment of the area.

The source of the Pombas stream is located in the vicinity of GO-419, outside the urban perimeter of Itumbiara, but a significant stretch of its course crosses the urban area until the confluence with the Buritys stream, covering about 900 meters until it flows into

the Paranaíba River. A large part of the population of Itumbiara knows only the channeled section of the Pombas stream, which is completely transformed by the road network and the allotments. However, areas of wetlands located upstream of the channel still preserve significant native vegetation, although they have been impacted due to irregular occupations, such as farms and the cultivation of vegetables, which results in the suppression of vegetation and water pollution.

**Chart 2:** Result of the diagnosis of urban PPAs in Itumbiara-GO

Watercourse	Location of the main APPs (springs, veredes) in the urban perimeter	Approximate Area	Diagnosis	Classification	Observations
Córrego Água Suja	Between Remy Martins and Ladário Cardoso de Paula neighborhoods	38 hect	A; 1; 2; 3; 4; 6; 9; 10; 11; 12	Bad	Remove invaders; constitute an Ecological Park; fence and affix signs; build a guardhouse, bathrooms and a small trail.
	Dona Marolina Neighborhood (behind 5th BPM)	30 hec	A; 1; 2; 3; 4; 5; 6; 9; 10; 11; 12	Bad	
	Green Dream Neighborhood	98 hectares	B; D; 5; 11	Very good	Reforest areas without vegetation; constitute the area as a Forest or Park
	Between Jd. Leonora and Nova Itumbiara neighborhoods	98	B; 1; 2; 6; 11;	Good	Remove invaders and illegal activities; fence, affix signs, reforest areas with low vegetation cover and constitute a Municipal Park
	Ferreira da Costa Neighborhood	98	A; 1; 2; 4; 6; 7; 11	Regular	Remove invaders; reforestation to contain erosion and silting processes; fence and affix signs; to constitute as a park or legally formalize the APP
Ribeirão Trindade	Zenon Borges Neighborhood	24	C; 4; 5; 9; 11	Bad	
	Between Dom Bosco and Alto Trindade	35	A; 1; 4; 11	Good	Surround; affix signs and constitute it as a

					Forest or Municipal Park
	Governor Mauro Borges Teixeira Park	29	B; D; 3; 11	Very good	Monitor; interrupt the activity of cultivation of annual crops; reforest; build structure, trails for receiving visitors
	Near the State University of Goiás	87,5	B; 6; 9; 11	Good	Reforest; identify polluting source
	Maria Luiza Neighborhood (behind Shimohira condominium)	9	The; 1	Very good	There is a condominium upstream that entered part of the APP of the spring. Needs monitoring to maintain quality
Córrego Buritys	Between Santa Rita and Jd. Flamboyant neighborhoods	29,8	A, 3; 4; 9; 10; 11; 12	Regular	
	Between Av. Valter Barra and 76th Street (behind CRAS)	2,11	A; 1; 2; 4; 6; 9	Good	You need to monitor the area, fence, post signs and remove invaders so as not to worsen the quality of the APP
	Between 76th Street and Av. Benedito Rosa de Medeiros (Road Sector)	2,77	A; 1; 4; 6	Good	You need to monitor the area, fence it, post signs so as not to worsen the quality of the APP
	Between 72nd Street and Osvaldo Volgarini (Road Sector)	0,82	C; 1; 4; 6; 7; 8; 11	Bad	
	Between R. Osvaldo Volgarini and Av. Pres. Tancredo de Almeida Neves (Road Sector)	0,59	1; 6; 7; 8	Bad	
Córrego das Pombas	Between Av. Herculino de Araújo and R. Cromínia (São João Sector)	5,2	B; 1; 2; 3; 4; 6; 10; 11; 12	Bad	
	Next. To 205th Street and GO-409	3	C; 1; 3; 6; 10; 11; 12	Bad	
	Between Bem-te-vi Street and Rolinha Street (N. Senhora da Saúde neighborhood)	9,3	C; 1; 2; 3; 4; 5; 6; 9; 10; 11; 12	Bad	

The detailed analysis reveals that the most prominent irregular occupations in Itumbiara-GO are located in the peripheral regions of the city. These areas are often marked by significant housing deficit, reflecting the lack of effective public policies to meet

the growing housing demand. In addition, there is a higher concentration of people in situations of social vulnerability in these regions, which contributes to the spread of irregular occupations in spaces intended for environmental preservation and other areas protected by law.

The disorderly expansion of the city has exacerbated these problems, resulting in the illegal occupation of land intended for environmental conservation, such as permanent preservation areas (APPs). This phenomenon not only compromises the environmental integrity of these places, but also amplifies the socioeconomic challenges faced by the vulnerable population (Provin, 2017). Understanding these patterns of irregular occupation is essential for the development of more effective urban policies, which not only combat the housing deficit, but also promote social inclusion and environmental sustainability in the peripheral areas of Itumbiara.

The results of the diagnosis provided a comprehensive overview of the conservation status of the PPAs in the watersheds studied, highlighting the main environmental pressures and impacts resulting from disorderly urbanization. Some of the consequences of the irregular occupation of these physical spaces, protected by law, include the worsening of the environmental degradation processes of the APPs, the pollution of springs and watercourses, the loss of biodiversity, the suppression of native vegetation, the impermeabilization of the soil, the reduction of the volume of water infiltration, increasing surface runoff and consequently contributing to the increase in floods and the occurrence of floods.

Irregular occupations and agricultural activities within the APP cause degradation of the area, such as: grounding of the footpath; loss of native vegetation; irregular disposal of solid waste; possibilities of using pesticides within the APP to grow vegetables; discharge of untreated domestic sewage directly into the area, which alters the quality of the water, polluting the springs.

Given this scenario, it is evident that the disorderly expansion of Itumbiara reflects the lack of effective public policies that integrate urban and environmental planning with sustainable development. The irregular occupation of APPs not only compromises environmental integrity, but also intensifies the socioeconomic challenges faced by the local population. Therefore, it is imperative that coordinated actions be implemented to promote the recovery and conservation of these areas, ensuring the protection of water

resources and the social inclusion of vulnerable communities (Provin, 2017; Lima et al., 2021).

## **FINAL CONSIDERATIONS**

The study highlights the urgent need for planned and coordinated interventions for the sustainable management of permanent preservation areas in Itumbiara-GO. The classification of the conservation status of APPs and the identification of environmental pressures are fundamental steps for the elaboration of public policies that reconcile environmental preservation with sustainable urban development.

The predominant conservation status of these areas varies between regular and poor. This condition is attributed to the absence of effective environmental public policies aimed at protecting these territories. The lack of adequate intervention results in the progressive degradation of APPs, compromising their ecological functionality. The irregular occupation of urban APPs in Itumbiara-GO is a direct consequence of disorderly urban expansion, exacerbated by the ineffectiveness of public policies for social housing. This occupation has significant impacts on the environmental quality of the micro-basins of urban streams, harming the integrity of aquatic and terrestrial ecosystems.

The proper use of APPs in urban space is crucial for the preservation of water, landscape, soil, fauna and flora resources. In addition, the effective management of these areas contributes to the significant improvement of the quality of life of the inhabitants. Implementing management strategies that incorporate urban parks and other forms of environmental protection can promote substantial ecological and social benefits by mitigating the negative impacts of disorderly urbanization.

The evaluation of urban APPs in Itumbiara-GO reveals the urgent need for effective public policies for the protection and management of these areas. The integration of environmental preservation and sustainable urban development strategies is essential to ensure the conservation of natural resources and the improvement of the population's quality of life. Future studies should focus on the implementation and monitoring of these policies, as well as on the environmental education of the community to promote a harmonious coexistence between urban development and environmental preservation.

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