POTENTIAL FOR DEPLOYMENT OF RECREATION GREEN SPACES IN NEIGHBORHOODS AT FORMOSA-GO CITY: AN APPROACH CONSIDERING THE CURRENT LAND USE SCENARIO

Izaias de Souza Silva, Universidade Federal de Goiás, izaias@discente.ufg.br
Jaqueline Pereira Evangelista, Universidade de Brasília, jaqueline.evangellista@aluno.unb.br

Abstract
Urban green spaces to recreation are an important component of urban landscapes and ecosystems and are indispensable to their inhabitants and biodiversity. This study presents an analysis of the potential for implementing urban green spaces to recreation in neighborhoods at Formosa-GO city, Brazil. The analysis are implemented using Orbital Remote Sensing data, high spatial resolution data (4.77m), to identify and map (1:25.0000) areas of consolidated land use, and areas whose land cover conditions are favorable to implementation of new urban green spaces to recreation. The results show neighborhoods with consolidated land use and low potential for implementing new urban green spaces to recreation; and neighborhoods with greater potential for implementing new urban green spaces to recreation, considering the current land cover scenario.

Key words: Urban Green Spaces to Recreation, Sustainable Cities, Climate Adaptation, Public Policy.

1. Introduction

In developing countries, among which Brazil almost stands out, the implementation of public policies with emphasis on the effective creation and maintenance of green spaces with multiple purposes, in fact, still constitutes a great challenge (SANCHES e PELLEGRINO, 2016). The limitations are not restricted to the scope of large centers, but mainly to small and medium-sized cities. This can be evidenced when observes that, even today, the emergence and growth of a significant part of cities occurs without adequate planning, for example, without prioritizing the creation and maintenance of the necessary green spaces. Otwithstanding, most cities suffer from serious environmental, social and economic problems, many of which are irreversible and/or have a very high aggregated value to overcome (IPCC, 2007, 2021, 2022; ISDR, 2009).

In the era of modernization and run from adaptation on climate change, Urban Green Spaces to Recreation are attracting increasing attention in smart city development (ADDAS, 2023). The lack of urban green spaces to recreation can, in fact, have social and physical impacts directly associated with the populations of a city, naturally, demanding more and more intelligent and sustainable cities, in order to experience the long-awaited sustainability (BOUNOUA et al., 2020; CAI et al., 2023). Considering that Urban Green Spaces to recreation

provide multiple environmental services and, equally, promote several benefits to society, benefits that are recognizable and valuable to urban resilience in global climate change scenarios, this study had as its central objective answer the following question:

- *In the current context of land use conditions in the city of Formosa-GO, which are the neighborhoods with the greatest potential for implementing urban green spaces to recreation?*

We emphasize in this study that, even if a city has a few Urban Green Spaces to recreation, with excellent infrastructure and maintenance conditions, their effective democratization is of fundamental importance. Democratization as a process is consolidated not only by promoting access for an increasingly growing population, but also by paying attention to the fact that this same access varies considerably between neighborhoods, depending on socioeconomic characteristics and the urbanization pattern itself (SANCHES e PELLEGRINO, 2016; DAI, 2011).

Paying attention to these aspects, it is understood that Public Policies with an emphasis on the implementation of afforestation and new urban green spaces to recreation, can and need to be directed towards neighborhoods with land uses that are still unconsolidated, neighborhoods considered ' fronts of expansion' in the urban mache location in the city of Formosa-GO, which still has a limited number of urban green spaces to recreation; at the same time, several "empty areas" can be observed with high potential for the implementation of new urban green spaces to recreation. These areas can be synotically identified in the urban area, for example, using Orbital Remote Sensing data (SILVA, 2023).

Within the scope of studies focused on cities and urban sustainability, it is relevant to highlight that, historically; data from Remote Sensing has been widely used, considering different research purposes. In this sense, it includes approaches for the purpose of identification, mapping and analysis of the vegetation structure (different tree strata), Ecology of the Urban Landscape, monitoring the performance of surface heat islands, mapping and monitoring of areas at risk of landslides, cadastral mapping , among many others, thus demonstrating its applicability and contribution to regional and local urban planning, taking into account the different scales (MAHMOODZADEH, 2007; GATRELL e JENSEN, 2008; WENG et al., 2016; YAN et al., 2018).

With the progressive advancement of space technologies and the consequent improvement of Sensor Systems, it is observed that there has been greater availability in terms of data supply from Orbital Remote Sensing, mainly data with high and very high spatial resolution properties (EHLERS et al., 2002), many of these data are freely accessible, citing the example of the CBERS-4A data, with a spatial resolution of 2 m, made available free of charge by the Image Generation Division, within the scope of the National Institute for Space Research (INPE, 2023). It is known that, given its spatial and temporal dimension, there is a large literature that demonstrates how these data are crucial for understanding the phenomena and processes that occur on the surface of the planet, and equally, how they can be used for studies focused on urban planning.

2. Methodology

The study methodology consisted on bibliographic review and Digital Image Processing (DIP) from satellite images, where Planet&NICFI images were used in semidetail mapping (1:25.000) of land cover and use in the city of Formosa-GO. The methodological procedures included the delimitation of the area under study, acquisition, pre-processing, processing and post-processing of data, as well as their respective analysis and understanding. The data processing routines were carried out on the Google Earth Engine platform, as already mentioned, through access to the Planet&NICFI image collection, taking into account images whose percentage of cloud cover is less than 10% in the respective Path /Row, taking September 2023 as the time frame, as it is one of the months with the lowest cloud cover in the area under study.

The subsequent procedures on the Google Earth Engine platform refer to the definition of thematic classes and collection of samples for training the classifier algorithm; the classification; accuracy and export of data related to classification to the Geographic Information System (GIS) environment, "QGIs 3.22 Biatowieza". Regarding the classifier algorithm, based on the machine learning approach, the Classification and Regression Trees (CART) were defined for the present study, a non-parametric classifier that, pixel by pixel, operates using levels of digital numbers of samples established by the user (supervised classification), to generate a decision tree and classify the entire matrix referring to the image. The classification had an overall accuracy of 0.96, and a coefficient Kaapa with 0.95, which means good learning performance.

Once the classification procedure had been carried out and the output of the model had been obtained, i.e. the classified image, it was exported to the GIS environment, as previously described, using the *software QGIs 3.22 Biatowieza*. To this way, the image was vectorized for quality editing and the area of the respective thematic classes was calculated, respectively. It is important to note that, given the purpose of the study, the thematic class "Built-Up Areas" (comprising mainly residential and commercial houses, such as stores, pharmacies, hotels, buildings) e "Others Built-Up Areas" (describing areas with warehouses, waterproofed squares, parking lots, and others) were grouped to form a third thematic class (Consolidated Land Use Areas), which describes areas of the Formosa-GO city which have consolidated land use. In other words, areas where the likelihood of land use change is slightly lower.

Finally, after analyzing the land use conditions in each neighborhood individually, considering Consolidated Land Use Areas, the land cover conditions were analyzed. In this particular case, the Potential for deployment of Recreation Areas considers the proportion (occurrence) of the thematic class mapped as Arboreal Vegetation, Smaller Vegetation and areas with Exposed Soils on landscape scale, in each neighborhood. The greater their occurrence, the greater the potential for implementing green spaces, paying attention to the city's gradual expansion process.

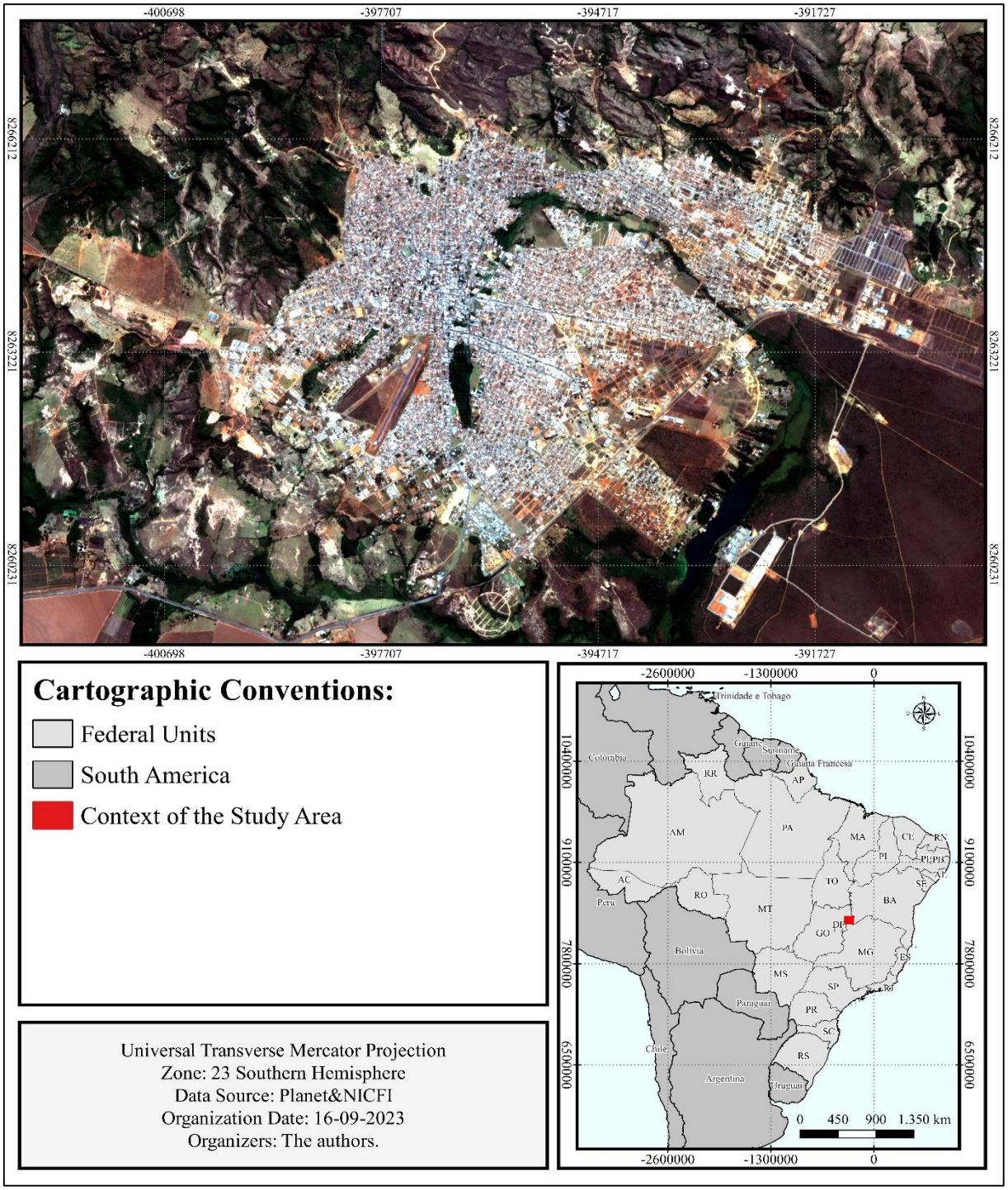

Figure 1 – Situation map of Formosa-GO city in September' 2023. Organization: The authors.

4. Results

From the DIP using Planet&NICFI satellite images, aiming at semi-detail (1:25.000) mapping of land cover and use in the city of Formosa-GO, dating the month of September of the year 2023, Figure 2 shows the ranks of the neighborhoods in the city of Formosa-GO with the highest proportion (m²) of consolidated land use. From this perspective, it can be seen at first glance that the three (3) neighborhoods with the highest proportion of area (m²) of consolidated land use are, on the date: Formosinha, Parque Lago e Conjunto Netinho, respectivamente. On the other hand, the three (3) neighborhoods with the lowest proportion of area (m²) of consolidated land use are: Setor Norte Paraná, Vila Lorena e Abreu, respectivamente. Considering this data, it is important to note the fact that approximately 91% of neighborhoods have a consolidated land use area of less than 1.000.000 (one million) m².

According to Theobald et al., (2020), land use at the scale of the urban landscape is the highest level of human intervention on the surface of planet Earth. From this perspective, looking at Figure 2, it can be understood that in the context of the city of Formosa-GO, specifically in its respective neighborhoods, different components, functions and patterns can be observed in relation to socio-economic activities, therefore, land use, similarly to other urban areas where a complex spatial set of land cover and land use types can commonly be observed. It must be considered that, in the complex network of relationships involving the fixed and flows that characterize and are part of the historical process of building cities (SANTOS, 1988), each neighborhood has its own forms and functions within the urban structure, as well as exerting influences that are unique to it in the broader process of re-producing urban space, especially in rapidly expanding urban spaces.

Paying attention to the neighborhoods with the highest proportion of consolidated land use in the city of Formosa-GO (Figure 1), it is important to note that these are, as can be assumed, mostly central neighborhoods. This fact corroborates the discussion that not only the central sectors but also the peripheral sectors of cities are the ones with the greatest demands and most of the time have favorable conditions for the implementation of new urban green spaces to recreation (SANCHES, 2011). In the particular case of the city of Formosa-GO, the creation of new urban green spaces to recreation in peripheral neighborhoods in relation to the urban core is fundamentally important and necessary to mitigate environmental impacts, especially on urban drainage, as well as to increase ecological connectivity, citing the example of the Parque Ecológico Municipal Mata da Bica, located in the Formosinha neighborhood, central portion from the city.

One more time, it is emphasized that the social role of new urban green spaces to recreation in neighborhoods in the city of Formosa-GO is crucial to improving the quality of life of its population, providing conditions for leisure, recreation and social cohesion both in the central areas and in the more peripheral neighborhoods of the city (JENNINGS e BAMKOLE, 2019).

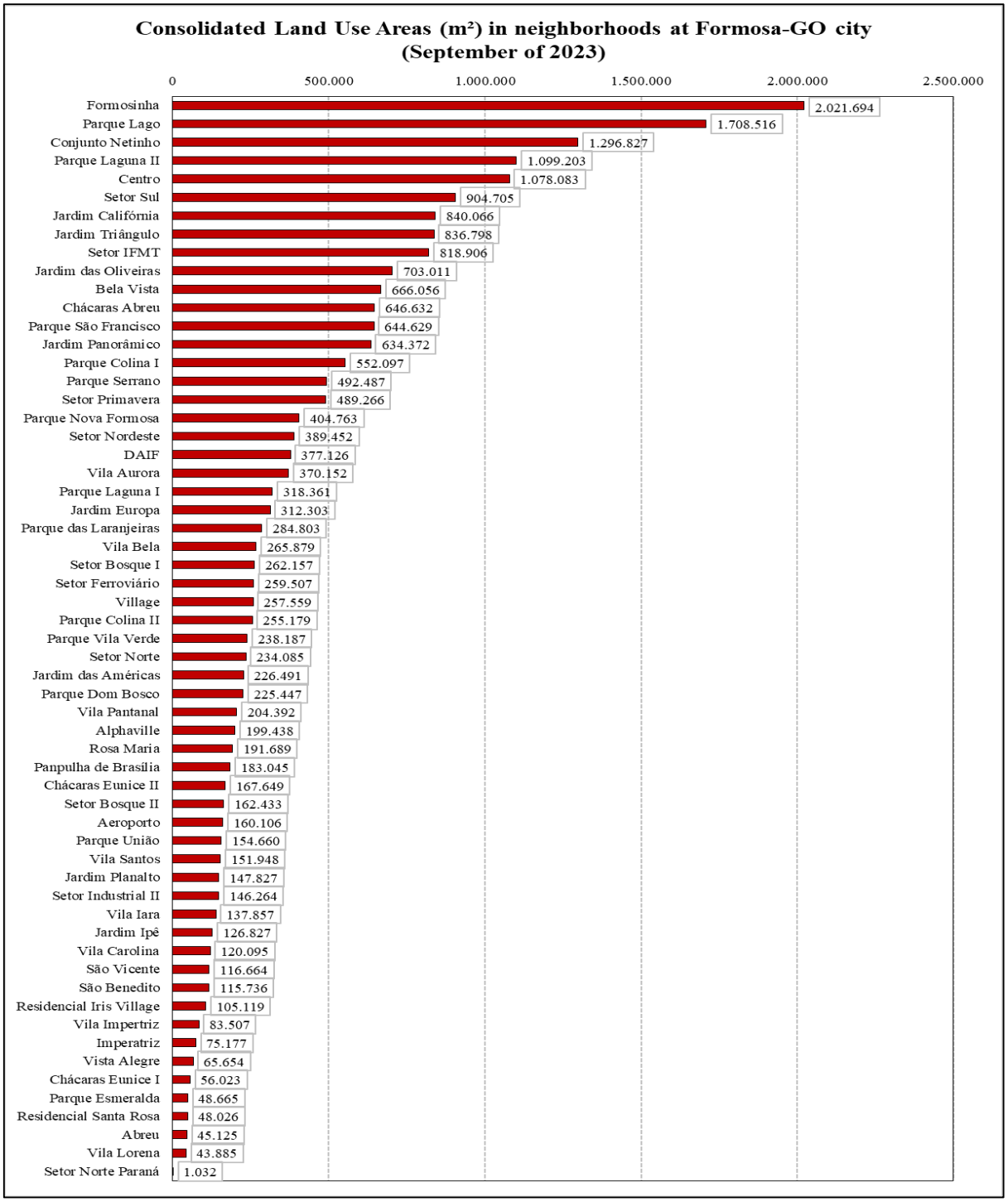

Figure 2 – Consolidated Land Use Areas (m²). Organization: The authors.

Based on the land cover conditions in each neighborhood in the city of Formosa-GO, as mentioned above, the potential for implementing urban green spaces to recreation was assessed and evaluated. In order to demonstrate the importance of semidetail (1:25.000) mapping in understanding the neighborhoods with the greatest potential for urban green spaces to recreation, based on orbital remote sensing data with high spatial resolution, Figure 3 shows the semidetail mapping of the Formosinha neighborhood, whose land use is already predominantly consolidated (Figure 2), a mapping developed and published by Silva (2023). In the western part of the Formosinha neighborhood, it is possible to see the Parque Ecológico Municipal Mata da Bica, the main urban green space to recreation in Formosa-GO city.

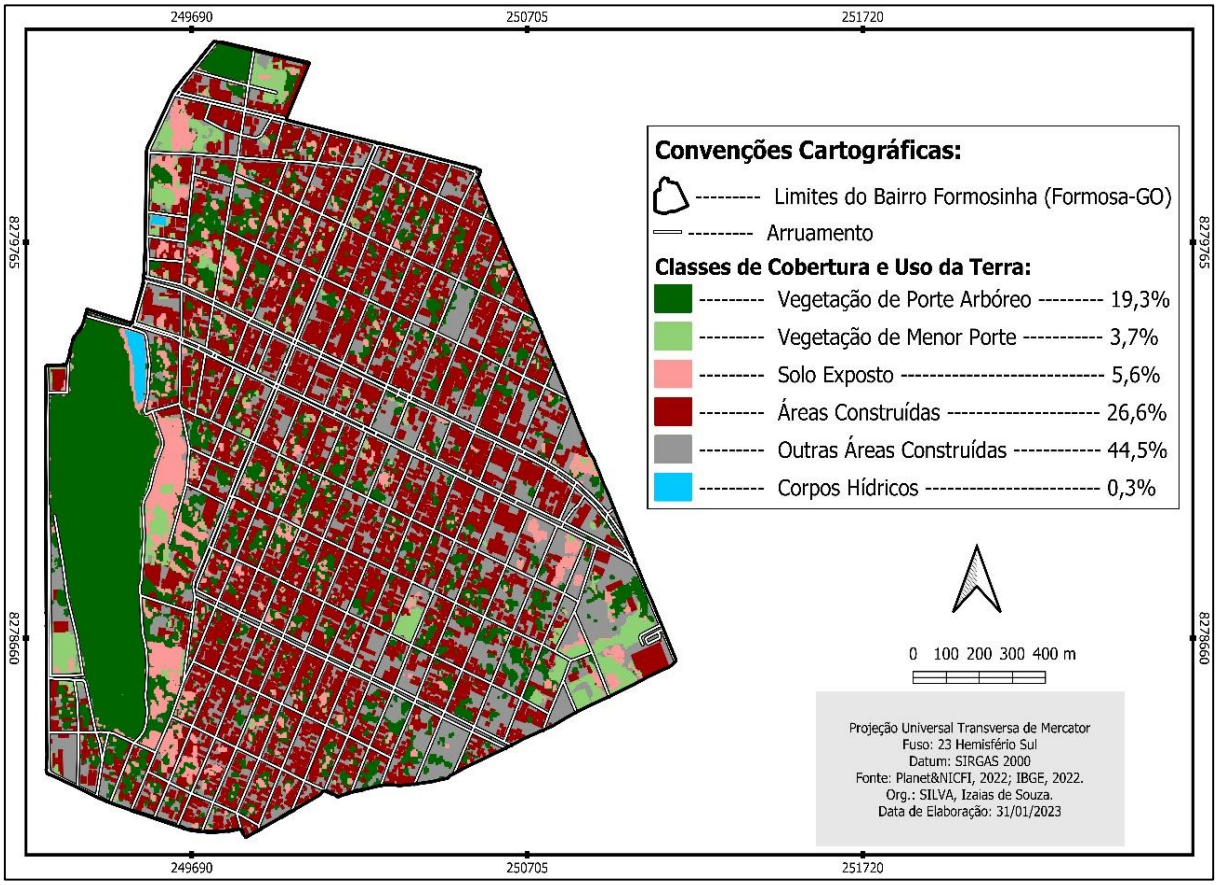

Figure 3 – Land Use and Land Cover at Formosinha neighborhood in October' 2022.
Source: SILVA, I. S. (2023).

Looking at Figure 4, it is possible see the list of neighborhoods in the city of Formosa-GO with the greatest potential for new urban green spaces to recreation, in September 2023.

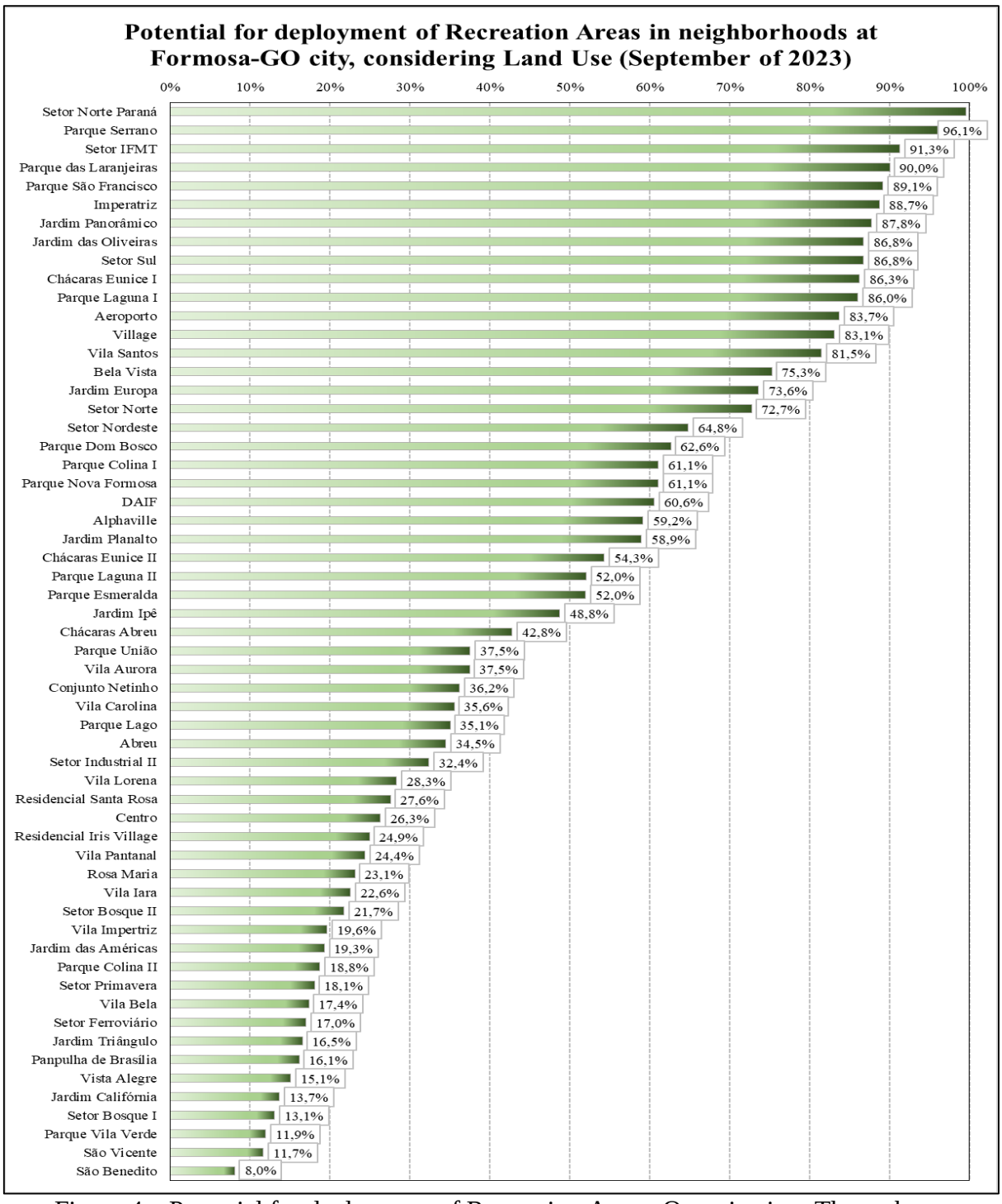

Figure 4 – Potential for deployment of Recreation Areas. Organization: The authors.

As it is possible see on Figure 4, more than 70% of the neighborhoods in the city of Formosa-GO, dating from September 2023, have potential/conditions for deployment of recreation areas, in other words, new urban green spaces to recreation. Considering the fact that most of the time the implementation of urban green spaces to recreation does not keep up with the speed of urban growth in cities (PAULEIT et al., 2005), it is understood that neighborhoods that currently present favorable conditions for the implementation of new urban green spaces to recreation so quickly, in a few decades or years, may no longer present these conditions, thus leading to a gradual reduction in the quality of life of the population of these neighborhoods, given that as land use consolidates, the challenges for implementing these spaces tend to increase systematically, while on the other hand the opportunities tend to run out.

According to the results, it can be seen (Figure 3) that a significant part of the neighborhoods in the city of Formosa-GO, especially the neighborhoods furthest from the city center, still have spaces that can be used for new urban green spaces to recreation. These new urban green spaces to recreation can be adopted to form a green infrastructure system, complete with corridors and poles within the urban area, increasing the opportunities for residents and biodiversity to enjoy the benefits. Population growth, real estate speculation and the accelerated process of urbanization are the main threats to available land with potential for new urban green spaces to recreation. In neighborhoods of expansion where land use is not yet consolidated, for example, forms of land use that generate more direct and instant economic returns for public and private investors mean that those areas favorable to new urban green spaces to recreation give way to other types of investment, constantly and very quickly (M'IKIUGU et al., 2012).

5. Conclusions

From this introductory study, we conclude that the objective of identifying and listing, in the current context of land use in the city of Formosa-GO, which neighbourhoods have the greatest potential for implementing urban green spaces for recreation has been met. The conclusion is that most of the city's neighbourhoods have the conditions for implementing new urban green spaces, especially neighbourhoods further away from the central sector.

Population growth and accelerated urbanization can act as impediments to the creation of new green spaces on land currently identified as having high potential. With accelerated urbanization, the landscape as a whole is becoming more fragmented and ecologically vulnerable. It is hoped that this study can subsidies decision-making by the municipal authorities at Formosa-GO, guiding assertive actions for urban planning.

Orbital remote sensing data with high spatial resolution proved to be efficient in semi-detailed mapping (1:25.000) of land use and land cover at Formosa-GO city. Future studies should investigate, with greater complexity, the social and environmental functions of urban green spaces for recreation in the city of Formosa-GO, spatial relationships of belonging between people and green spaces.

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