

# Urban Green Area Index of Foz do Iguaçu Municipality, Location of the World Natural Heritage Site Iguaçu Falls, Paraná State, Brazil

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**Abstract:** Several ecosystem services are provided by vegetation in urban environments, such as noise and temperature attenuation, and improvement of air quality. In addition to these services, the contact with nature benefits human health in questions related to longevity, mental health, and others. Considering the paramount importance of forest cover in urban areas, the present study aimed to quantify forest fragments in the urban area of Foz do Iguaçu, a municipality in Paraná State, Southern Brazil, identifying their distribution by city region and determining green area index (GAI). The city of Foz do Iguaçu has a very cosmopolitan population and is the main access route to the Iguaçu Falls, a renowned tourist attraction and World Heritage Site. To estimate the area of the fragments, Google Earth Pro software was used. For population data, the numbers provided by the Brazilian Institute of Geography and Statistics were used. The analysis of fragments' distribution by region was done based on the city division proposed in its Municipal Master Plan. Fifty-five forest fragments were identified, totaling 332 ha (2% of the urban area). An unequal distribution of fragments among regions was observed, which suggests the need to create new green areas, notably, in region 1, which currently does not have such spaces. Regarding GAI, the values calculated for 2010 and 2019 were 13 m<sup>2</sup>/inh and 12.8 m<sup>2</sup>/inh, respectively. These numbers, although they comply with World Health Organization (WHO) recommendations, do not meet the minimum value advised by the Brazilian Society of Urban Forestry (SBAU).

**Key words:** urban forest, quality of life, urban life, green area index

## 1. Introduction

According to Biondi (2015) [1], urban forest is defined as all vegetation cover, whether public or private, present in the urban perimeter of a municipality. Andrade et al. (2012) [2] consider that it is important to know the green area index (GAI) of a city, for it is a quality of life indicator. This index is a very important instrument in urban planning,

generating values that allow assessing the population's quality of life.

In Brazil, the Brazilian Society of Urban Forestry (SBAU) is the main organization dealing with urban arborization issues in cities. It recommends that the GAI value be equal to or greater than 15 m<sup>2</sup> of green area *per capita* [2, 3]. The World Health Organization (WHO) recommends 12 m<sup>2</sup> per inhabitant [4].

Several ecosystem services are provided by vegetation in urban environment, such as decrease in temperature due to evapotranspiration and shade offering, reduction of rainwater impact on the soil, noise attenuation, property appreciation, and

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improvement in the quality of the air due to the filtering of both particulate and gaseous pollutants [1].

In addition to ecosystem services, contact with nature provides benefits to human health related to longevity, mental health, prevention of obesity and cardiovascular diseases, interference in sleep quality and recovery from diseases [5].

Whereas urban forests provide countless benefits to human beings, it is necessary and acceptable to analyze this index, so that it may serve as a subsidy for more adequate planning of municipality expansion in the future [2].

The city of Foz do Iguaçu is known for its cosmopolitan population and for being the main access route to the Iguaçu Falls, a world-renowned tourist attraction and World Heritage Site.

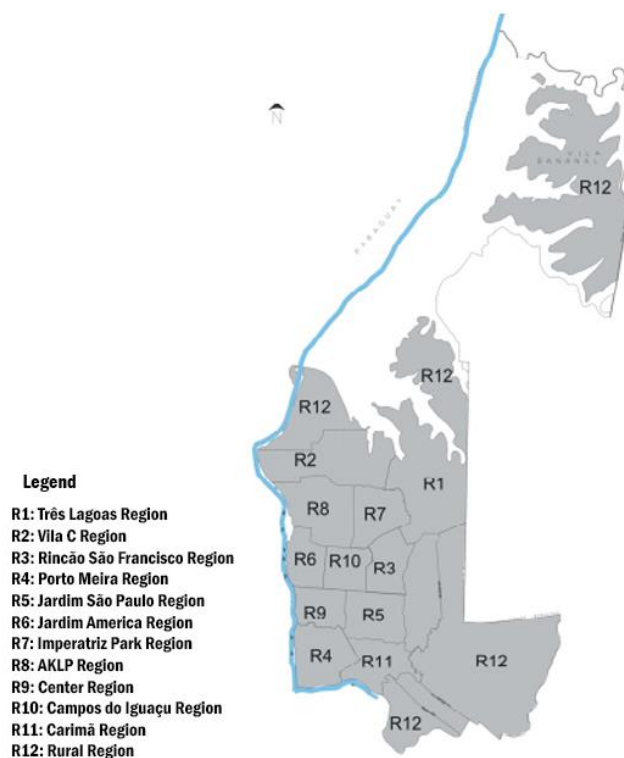
The aim of this work was to quantify the forest fragments in the urban area of Foz do Iguaçu as well as their distribution by city region; to determine the green area index in Foz do Iguaçu urban perimeter and to compare the results with the values recommended by SBAU and WHO. With the results, it was expected to

know if the city meets the minimum values advocated by these institutions, offering subsidies for actions aimed at the conservation and expansion of green areas, recognized as necessary for the well-being of the population. Additionally, it was intended to point out regions in the city in which the allocation of areas for the creation of forest fragments is suggested, in order to offer green areas to local residents.

## 2. Material and Methods

With the aid of the Google Earth Pro polygon tool, polygons of interest representing the city's forest fragments were created, using images from 2010 and 2019. With the creation of the polygons, it was possible to determine the area of each fragment. Field verification was carried out by visiting all fragments *in loco*.

To identify the distribution of fragments by city region, the city division established in the Master Plan for Integrated Sustainable Development (PDDIS, (2016) [6] was used. According to this document, the municipality is divided into 12 regions (Fig. 1).



**Fig. 1** Division of Foz do Iguaçu municipality in regions. (Source: Master Plan for Integrated Sustainable Development.)

### 3. Results and Discussion

Fifty-five forest fragments were identified. The sum of all areas was slightly over 332 hectares; this value corresponds to 2% of the study area.

Regarding the distribution of forest fragments by the regions of the municipality, it was observed that region 2 presented the highest concentration of these areas (13 fragments, making a total of 23.86 ha), followed by region 8 (11 fragments, totaling 63.17 ha). Region 6 concentrates the largest forest area (105.43 ha), although the number of forest fragments is only 6, lower than that observed in regions 2 and 8. In region 1, there is no fragment. In the other regions, the number of fragments varied between 1 (minimum) and 10 (maximum), totaling 37.6 ha and 40.72 ha, respectively. These results indicate an unequal distribution of green areas among the regions of the municipality.

Considering the data presented, the municipality has 13 m<sup>2</sup> and 12.8 m<sup>2</sup> of vegetation *per capita* for the years 2010 and 2019, respectively. When compared to the minimum indicated by SBAU, which is 15 m<sup>2</sup>, and by WHO, 12 m<sup>2</sup> *per capita*, Foz do Iguaçu meets the minimum only according to WHO, for both years mentioned.

With the values obtained for the indexes, it can be inferred that there is a need to allocate new areas for forest restoration in the municipality. These areas must contemplate regions that currently lack forest fragments.

### 4. Conclusion

It is flagrant that there is an unequal distribution of forest fragments in the city of Foz do Iguaçu. Therefore, there is a need to select spaces where forest restoration

can be carried out, creating new green areas. These new areas are needed notably in region 1, which currently does not have any green areas.

Foz do Iguaçu does not meet the minimum level of green area *per capita* recommended by SBAU, the main organization in charge of dealing with issues regarding urban arborization in Brazil. However, considering the value of 12 m<sup>2</sup>/inh recommended by WHO, the city responds positively according to the results obtained in this research for the two years studied.

### References

- [1] D. Biondi, *Floresta Urbana*, Curitiba, 2015, pp. 1-102.
- [2] L. S. Andrade, E. N. Silva, A. Ribeiro, S. P. Paro and M. O. Paula, Avaliação de fragmentos florestais em uma região do quadrilátero ferrífero: município de Mariana e Ouro Preto. Enciclopédia biosfera, centro científico conhecer, *Goiânia* 8 (2012) (14) 1052, accessed on 30 Jun 2020, available online at: <https://www.conhecer.org.br/enciclop/2012a/ambientais/avaliacao%20de%20fragmentos.pdf>.
- [3] Sociedade Brasileira De Arborização Urbana (SBAU), accessed on 8 July, 2020, available online at: <https://www.sbau.org.br/>.
- [4] World Health Organization (WHO), accessed on 8 July, 2020, available online at: <https://www.who.int/eportuguese/onlinelibraries/en/>.
- [5] L. F. Amato-Lourenço, T. C. L. Moreira, B. L. Arantes, D. F. Filva Filho and T. Mauad, *Metrópoles, cobertura vegetal, áreas verdes. Estudos Avançados*, São Paulo, 2016, accessed on 30 Jun 2020, available online at: <https://www.scielo.br/pdf/ea/v30n86/0103-4014-ea-30-86-00113.pdf>.
- [6] PDDIS/FOZ, Plano diretor de desenvolvimento integrado sustentável — Foz do Iguaçu, 2016, accessed on 08 Jul 2020, available online at: <http://www.pmfi.pr.gov.br/conteudo/%3bjsessionid%3d53101ac9d62c3bb457190b4a6b81?idmenu=650>.