



**Espaços verdes públicos e justiça ambiental:
correlações em Ribeirão Preto – SP**

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Espaços verdes públicos e justiça ambiental: correlações em Ribeirão Preto – SP

RESUMO

Objetivo - o objetivo do trabalho é analisar desigualdades espaciais e correlações entre fatores sociais e ambientais no Município de Ribeirão Preto (SP), tendo os espaços verdes públicos como elemento central e articulador.

Metodologia - a pesquisa utilizou geoprocessamento e análises estatísticas para correlacionar a distância dos espaços verdes públicos com fatores ambientais (áreas de inundação e temperatura de superfície) e suas respectivas variabilidades com fatores sociais (de renda e raça) para cada setor censitário analisado.

Originalidade/relevância - o aprofundamento teórico-metodológico dessas análises tem importância significativa para identificar especificidades socioespaciais e embasar políticas públicas urbanas mais justas, equitativas e territorialmente redistributivas, em consonância com o direito à cidade e os princípios da justiça socioambiental.

Resultados - os resultados apontam que as áreas com maior risco de inundação estão mais próximas de populações de baixa renda e mais afastadas da população branca; as temperaturas tendem a diminuir com o aumento da renda; menores distâncias entre espaços verdes estão associadas a temperaturas mais baixas e menor risco de inundação, destacando o potencial dessas infraestruturas verdes na promoção da justiça ambiental. A qualificação dos espaços verdes públicos deve ser considerada para trazer benefícios para a população.

Contribuições teóricas/metodológicas - a pesquisa avança na investigação de ferramentas de geoprocessamento e de análises estatísticas para realizar correlações de fatores sociais e ambientais que destacam territórios mais vulnerabilizados.

Contribuições sociais e ambientais - o trabalho lança luz sobre vulnerabilidades urbanas e ambientais em territórios precarizados e busca contribuir para o debate e políticas de reversão de processos de exclusão e vulnerabilidades.

PALAVRAS-CHAVE: justiça ambiental; espaços verdes públicos; vulnerabilidade urbana.

Public Green Spaces and Environmental Justice: Correlations in Ribeirão Preto – SP

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ABSTRACT

Objective – This study aims to analyze spatial inequalities and correlations between social and environmental factors in the municipality of Ribeirão Preto (SP), using public green spaces as a central and articulating element.

Methodology – The research employed geoprocessing and statistical analyses to correlate the distance to public green spaces with environmental factors (flood-prone areas and surface temperature) and their respective variabilities with social factors (income and race) for each census tract analyzed.

Originality/Relevance – The theoretical–methodological development of these analyses is significantly important for identifying socio-spatial specificities and supporting more just, equitable, and territorially redistributive urban public policies, in line with the right to the city and the principles of socio-environmental justice.

Results – The findings show that areas with higher flood risk are closer to low-income populations and farther from the white population; temperatures tend to decrease as income increases; Shorter distances to green spaces are associated with lower temperatures and reduced flood risk, highlighting the potential of these green infrastructures in promoting environmental justice. The improvement of public green spaces should be considered to bring benefits to the population.

Theoretical/Methodological Contributions – The research advances the investigation of geoprocessing tools and statistical analyses to correlate social and environmental factors that highlight more vulnerable territories.

Social and Environmental Contributions – This study sheds light on urban and environmental vulnerabilities in precarious territories and seeks to contribute to debates and policies aimed at reversing processes of exclusion and vulnerability.

KEYWORDS: environmental justice; public green spaces; urban vulnerability.

Espacios Verdes Públicos y Justicia Ambiental: Correlaciones en Ribeirão Preto – SP

RESUMEN

Objetivo – El objetivo del estudio es analizar las desigualdades espaciales y las correlaciones entre factores sociales y ambientales en el municipio de Ribeirão Preto (SP), teniendo los espacios verdes públicos como elemento central y articulador.

Metodología – La investigación empleó geoprocesamiento y análisis estadísticos para correlacionar la distancia a los espacios verdes públicos con factores ambientales (áreas de inundación y temperatura de superficie) y sus respectivas variabilidades con factores sociales (ingresos y raza) para cada sector censal analizado.

Originalidad/Relevancia – El desarrollo teórico-metodológico de estos análisis es de gran importancia para identificar especificidades socioespaciales y fundamentar políticas públicas urbanas más justas, equitativas y territorialmente redistributivas, en consonancia con el derecho a la ciudad y los principios de la justicia socioambiental.

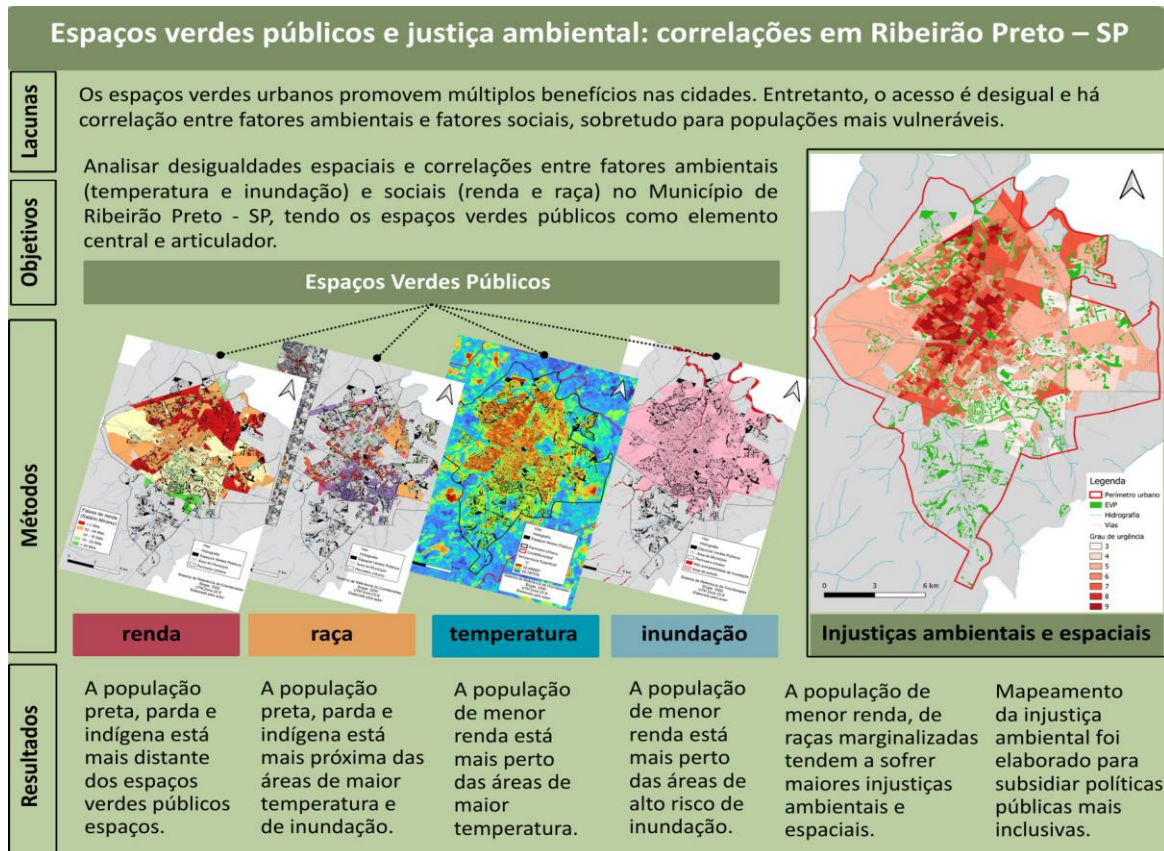
Resultados – Los resultados muestran que las áreas con mayor riesgo de inundación están más próximas a poblaciones de bajos ingresos y más alejadas de la población blanca. Las temperaturas tienden a disminuir a medida que aumentan los ingresos. Menores distancias entre espacios verdes se asocian con temperaturas más bajas y menor riesgo de inundación, destacando el potencial de estas infraestructuras verdes para promover la justicia ambiental. La mejora de los espacios verdes públicos debe considerarse para generar beneficios para la población.

Contribuciones Teóricas/Metodológicas – La investigación avanza en la exploración de herramientas de geoprocesamiento y análisis estadísticos para realizar correlaciones entre factores sociales y ambientales que ponen de relieve territorios más vulnerables.

Contribuciones Sociales y Ambientales – El estudio arroja luz sobre vulnerabilidades urbanas y ambientales en territorios precarizados y busca contribuir al debate y a las políticas destinadas a revertir procesos de exclusión y vulnerabilidad.

PALABRAS CLAVE: justicia ambiental. Espacios verdes públicos; vulnerabilidad urbana.

GRAPHICAL SUMMARY



1 INTRODUCTION

This work is part of the debate on public green spaces in cities and their interfaces with issues such as the climate crisis, ethnic-racial and class inequalities, which make certain territories and populations more vulnerable to these impacts. The study sheds light on urban and environmental vulnerabilities in precarious territories and seeks to contribute to the debate on reversing processes of exclusion and vulnerability.

The processes of city production are socially constructed, resulting from labor applied to nature, and generate disputes and inequalities (Carlos, Souza, Sposito, 2011). These inequalities, in turn, are expressed in the unequal provision of goods, services, technologies, and infrastructure in urban spaces (Ribeiro, 2017), requiring more equitable approaches to urbanization.

One of the areas where unequal provision occurs in cities is public green spaces. There is a vast body of literature on the multiple benefits of urban green spaces. They can create thermally comfortable environments and help mitigate the effects of heat islands (Doick & Hutchings, 2013; Yu et al., 2017). They are also associated with reductions in air pollution (Kumar et al., 2019). In their correlation to urban waters, green spaces can contribute to lowering rainwater surface runoff and assist in flood risk management, particularly in expansion areas (Battemarco et al., 2022). The expansion of vegetation and green spaces also produces important effects on the health and well-being of residents living nearby (Navarrete-Hernandez; Laffan, 2019), potentially reducing psychological and cardiovascular diseases (Saldiva, 2018). International agreements and frameworks, such as the New Urban Agenda and the Sustainable Development Goals (SDGs), recognize the importance of cities as key spaces in efforts to mitigate and adapt to climate change and recommend that they foster well-connected and well-distributed networks of public, open, multifunctional, safe, inclusive, accessible, and high-quality green spaces (UN, 2019; 2022).

However, despite the overall benefits of green spaces, there are still social, spatial, and political processes that may prevent or limit part of the population from fully enjoying the potential benefits and services they provide. As Anguelovski et al. (2016) show, the uses of green spaces can create barriers to equal access when they are not planned with the explicit aim of addressing the needs of disadvantaged or marginalized groups.

Studies have identified inequalities in access and disparities in the quality of green spaces across different contexts. Research conducted in cities in England (Ferguson et al., 2018), South Africa (Venter et al., 2020), Chile (Päcke; Aldunce, 2010), as well as Brazilian cities (Guerrero et al., 2021) demonstrates that the correlation between accessibility to public green spaces and the population's income or race is evident. In reviewing a range of scientific publications involving several cities, studies by Zuniga-Teran (2021) and Zuniga-Teran et al. (2025) identify that public green spaces tend to be closer to or more accessible for higher-income populations and farther from or inaccessible to populations that have experienced some form of historical process of exclusion or marginalization.

This fact has served to reinforce historical issues of segregation, which condition marginalized populations to settle in devalued locations, whether these were produced by the urbanization process or rejected due to the environmental characteristics that shape the urban landscape.

In Brazil, the development of cities has historical components that connect state actions with the real estate and business sectors and prioritize individual rights over the social functions of the city (Maricato, 2015). Such processes condition our cities to profound social absences, such as the lack of housing policies for lower-income groups, the presence of slums and urban communities, the absence or incomplete provision of public services, interference with and degradation of water bodies, and land-related issues that have significantly altered important characteristics of the landscape (Sposito; Góes, 2013), thereby compromising the fulfillment of fundamental collective rights. These processes are often driven mainly by market interests, to the detriment of the right to the city, and are assuming new contours related to the commodification and financialization of capital (Klink; Souza, 2017).

The municipality of Ribeirão Preto, located in the northeast of the State of São Paulo and seat of its metropolitan region, brings together a set of factors related to its urbanization process that have resulted in dynamics of socio-spatial segregation, consolidated at different historical moments (Denaldi, 2003).

There is, therefore, a need for an interdisciplinary approach to the problem, aiming to deepen understanding that can serve as a basis for public policy makers, urban planners, and other actors, taking into account local particularities and more inclusive decision-making processes. These initiatives must be supported and grounded in critical analyses and applied studies that contribute to a proactive, fair, and inclusive urban agenda.

2 OBJECTIVES

The objective of this study is to analyze spatial inequalities and correlations between social and environmental factors in the municipality of Ribeirão Preto (SP), with public green spaces as the central and articulating element. We sought to understand the dynamics of urban occupation and the correlations between the location of public green spaces, environmental factors (flooding and temperature), and their respective variations in relation to social factors (income and race).

The study, therefore, deepens analyses that seek to understand how these relationships are important for identifying knowledge gaps and priority areas, in order to reverse processes of exclusion and vulnerability and support fairer, more equitable, and better distributed public policies in urban areas.

3 METHODOLOGY

3.1 Study Area: Municipality of Ribeirão Preto - historical context, urban planning, and spatial injustices

Located in the northeast of the State of São Paulo, 313 km away from the state capital and 696 km from the federal capital, Ribeirão Preto (21°10'40" South and 47°48'36" West) has a total area of 650.916 km², of which 149.42 km² is urbanized. It has 698,642 inhabitants and a population density of 1,073.72 inhabitants per km², making it the 8th most populous municipality in the state and the 29th in the country (IBGE, 2023).

Founded in 1856, Ribeirão Preto had its original center located in the well-known central quadrangle, between the banks of the Ribeirão Preto and Retiro Saudoso streams, an area promoted by the region's agrarian elite. In 1886, the Antônio Prado Colonial Center began to be established on the opposite banks of the rivers that shaped the city, formed by vacant and unproductive lands belonging to former farmers and subdivided into lots for occupation by the immigrant population (Silva, 2008). At this moment, a first socio-spatial division was already established in the city: the space of the proletariat, located to the north, and the space of the upper class, located in the original center of the foundation, which, with urban development, progressively shifted toward the south.

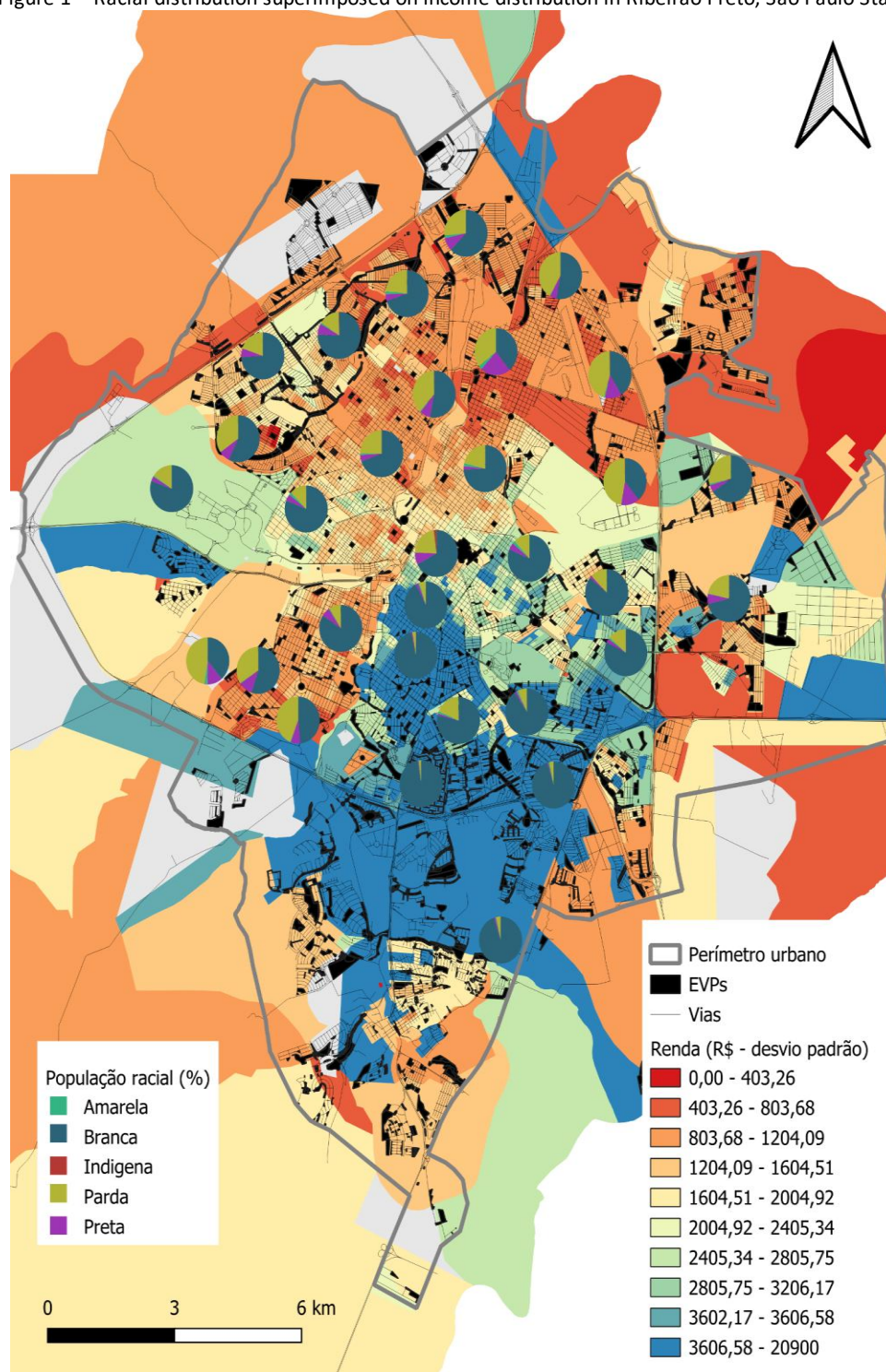
Environmental aspects are also intrinsically linked to the city's early development. This population settled on infertile, low-lying lands near riverbeds, areas prone to flooding. Over time, north–south segregation has been reinforced by the introduction of new urban facilities, with legislation also contributing to widening inequalities. Melo (2017) points out that socio-spatial segregation in the municipality of Ribeirão Preto was reinforced, induced, and consolidated through the actions of the municipal government via laws, decrees, urban plans and projects, and investments in infrastructure and urban facilities.

Currently, the presence of social housing in the northern sector, contrasted with the large concentration of high-income gated communities in the southern sector of the municipality, is a striking feature of the urban landscape of Ribeirão Preto. Studies by Melo (2017) and Zamboni et al. (2019) highlight that in the southern sector a “predominant mode of operation” prevails, marked by the articulation between real estate developers and landowners, supported by public agents, accentuating processes of socio-spatial segregation and urban sprawl.

In addition to the territorial segregation of the population according to class, racial segregation is another factor present in Ribeirão Preto, since income and race are closely linked due to the legacy of historical processes that shaped the country's formation. In the city, the black population is more concentrated in the northern sector, in low-income areas with less access to urban amenities, while the higher-income sectors of the city are also those with the highest percentage of the white population.

Figure 1 illustrates these socio-spatial contrasts and inequalities. The colors of each census tract vary according to income (bluer for higher incomes and redder for lower incomes). The pie charts present racial demographics and overlap some of the census tracts. This allows us to observe a higher concentration of bluish tones in the southern sector, while the northern sector contains a greater number of reddish sectors. In terms of racial distribution, the charts show sectors in the southern region with more than 90% of their population being white, while in the northern region there is greater diversity in the racial composition of the population. Even though the white population is predominant in some sectors of this region, it is here that the lowest percentage of this population is found and also where, in some cases, the black population (blacks and browns) is larger than the white population.

Figure 1 – Racial distribution superimposed on income distribution in Ribeirão Preto, São Paulo State



Source: Brazilian Institute of Geography and Statistics (IBGE), 2010. Prepared by the author, 2024.

All these issues are also linked to the distribution of public green spaces in Ribeirão Preto. According to Gomes (2009), the city's parks are unevenly distributed, following the same north–south opposition and implemented through negotiations between the government and the real estate sector, also as a way of producing more valuable land. Ribeirão Preto has 11 parks, with 5 located in the south, 2 in the east, 2 in the west, and 2 in the north. Considering

the information presented, it can be observed that socio-spatial segregation in the municipality of Ribeirão Preto occurred through a continuous process, bringing together various mechanisms and agents acting jointly in order to achieve market objectives. As a result, nature becomes a commodity, where space is, in a sense, public, but access to its use and benefits becomes a privilege for those who can afford to live nearby.

Thus, the social factors described above are compounded by certain environmental aspects, which are increasingly aggravated by climate issues and extreme events (Hageer, 2025). In the context of the climate crisis, the impacts become significant factors in the production of socio-spatial inequalities. Technical Note No. 1/2023/SADJ-VI/SAM/CC/PR from the Civil House (Brazil, 2023) highlights that “rapid and often disorderly urbanization, as well as socio-territorial segregation, have led the most disadvantaged populations to occupy inadequate locations, subject to flooding, landslides, and other correlated threats. These areas are generally inhabited by low-income communities that have few resources to adapt or recover from the impacts of these events, making them more vulnerable to such processes.” The same report lists Ribeirão Preto among the 1,942 Brazilian municipalities at risk of climate disasters, with emphasis on the risks of torrential rains and flooding. In addition, in 2024, Ribeirão Preto was one of the most affected municipalities by heat waves and peri-urban fires.

This form of territorial planning has promoted environmental injustices, which, in the studies by Herculano (2008), Acseirad et al. (2009), Ribeiro (2017), and Hoover et al. (2021), are understood as processes through which unequal societies assign the greatest burden of environmental damage resulting from development to low-income social groups, racially discriminated groups, marginalized and most vulnerable populations.

3.2 Methodological procedures and methods of analyzing the results

The sectors classified as “urban” by the 2010 IBGE census, located within the urban perimeter defined by the Municipal Master Plan, constituted the limits of the study area. Of the 1,004 census tracts in Ribeirão Preto defined by the IBGE, 943 were included in the analysis. Some were excluded in order to avoid confounding effects in the statistical analyses, as they correspond to specific urbanization processes, such as Bonfim Paulista District.

Public green spaces (PGS) were defined on the basis of the public green spaces shapefile provided by the Ribeirão Preto Municipal Government (RIBEIRÃO PRETO, 2022), which identifies all squares, parks, roadside flower beds, and tree-lined roundabouts or areas designated as public green spaces.

The environmental factors selected were “land surface temperature” and “proximity to areas at high risk of flooding”. These were chosen because flooding and rising temperatures have been frequent issues in the municipality and, in the context of climate change, extreme heat waves and more intense rainfall over shorter time spans are becoming increasingly common. In this way, these two variables function as means to visualize environmental impacts in the municipality. In addition, public green spaces are closely linked to these two factors, both due to the role of vegetation in reducing temperatures and the ability of permeable green areas to enhance soil infiltration and mitigate flooding and waterlogging.

The definition of land surface temperature was based on satellite imagery freely obtained from the U.S. Geological Survey website, using images from the LANDSAT 8 satellite. For flood-related variables, the data were acquired through direct contact with the municipal government, which provided georeferenced vector shapefiles from a study carried out by the Institute for Technological Research (IPT, 2023).

To examine the social differentiation of these environmental variables, two representative social factors were established: 1) income, which is assumed to confer greater advantages as it increases; 2) race, in order to assess whether (and how) inequality exists in access to environmental benefits among populations of different ethnicities. Both categories were stratified into levels, allowing for differentiation within groups. The income factor was divided into five brackets (based on the minimum wage 'MW' in effect at the time of the 2010 Census). The race factor was divided into the five IBGE classifications (Yellow, White, Indigenous, Brown, and Black). All members of these groups were subjected to the same analyses regarding the environmental variables defined, considering the following outcomes: proximity to public green spaces, proximity to high-risk flood areas, and surface temperature.

To determine the values of the environmental variables for the social factor of race, the 100 census tracts with the highest percentage of each racial group were selected. Thus, the same number of census tracts was used for each racial category, allowing for a balanced comparison in terms of sample observation.

To obtain income data, the database from the 2010 Demographic Census of the Brazilian Institute of Geography and Statistics (IBGE, 2010) was used, based on values from V005—“average monthly nominal income of heads of permanent private households (with and without income)” —available in the Census’s basic data file. For race data, the “Color or Race, Age, and Gender” file from the same Census was employed.

The study made use of geoprocessing through the QGIS GIS software to carry out the analysis, into which georeferenced datasets were imported for data collection and processing. The georeferenced files included: municipal census tracts containing race and income information; vector datasets of public green spaces; vector datasets of floodplains; and raster satellite images containing land surface temperature data.

To establish correlations and assign values from the environmental data to the population, a centroid was generated for each vector file, serving as the reference point for defining the value of each factor under analysis.

Through geoprocessing, a table was generated containing information on income, race, distance to the nearest public green space, distance to the nearest flood area, and land surface temperature for each census tract, enabling the statistical correlation analysis with the social data.

Spearman’s correlation coefficient was computed between the environmental variables (distance to public green spaces, land surface temperature, and distance to high-risk flood areas) in order to determine how these phenomena are associated within the municipality’s territory.

Next, an ANOVA test was conducted using a significance level of 5% ($\alpha = 0.05$) to statistically verify whether social factors act as determinants in access to these benefits. The homogeneity of variances was evaluated using Levene’s test, which indicated significant

differences between the groups ($p < 0.001$). Given this result, the Games-Howell post-hoc test was employed, a procedure robust to heteroscedasticity and suitable for situations in which equality of variances cannot be assumed. From this, it was possible to assess how income and race shape the way the population relates to its proximity to Public Green Spaces (PGS), land surface temperature, and proximity to areas at high risk of flooding, as well as to identify which groups differ from one another.

4 RESULTS AND DISCUSSION

4.1 Correlations between public green spaces, environmental factors (temperature and flooding), and variations in relation to the social factors of income and race.

The correlations between public green spaces and temperature and flooding in the municipality of Ribeirão Preto demonstrated that these spaces have great potential to mitigate the climate effects caused by extreme weather events (Table 1).

The result of the strong negative correlation between temperature and distance from flooding (areas near high-risk flood zones tend to be warmer) indicates that the city's high-temperature areas coincide with those at greatest risk of flooding, highlighting the existence of priority areas for addressing these adverse weather conditions (Tables 1 and 2 and Figures 2 and 3).

Table 1 - Correlations between PGS distances and the environmental factors of temperature and flood risk.

Variable	Index	Distance between PGSs	Temperature	Distance from areas at high risk of flooding
Distance between PGSs	Spearman's Rho	—	0.247	-0.244
	p-value	—	<.001	<.001
Temperature	Spearman's Rho	0.247	—	-0.330
	p-value	<.001	—	<.001
Distance from areas at high risk of flooding	Spearman's Rho	-0.244	-0.330	—
	p-value	<.001	<.001	—

Prepared by the author, 2024.

Areas at high flood risk are found closer to populations earning up to four minimum wages and farther from the white population. The shorter the distance between green spaces, the lower the temperature. Areas at high flood risk are also located farther from public green spaces.

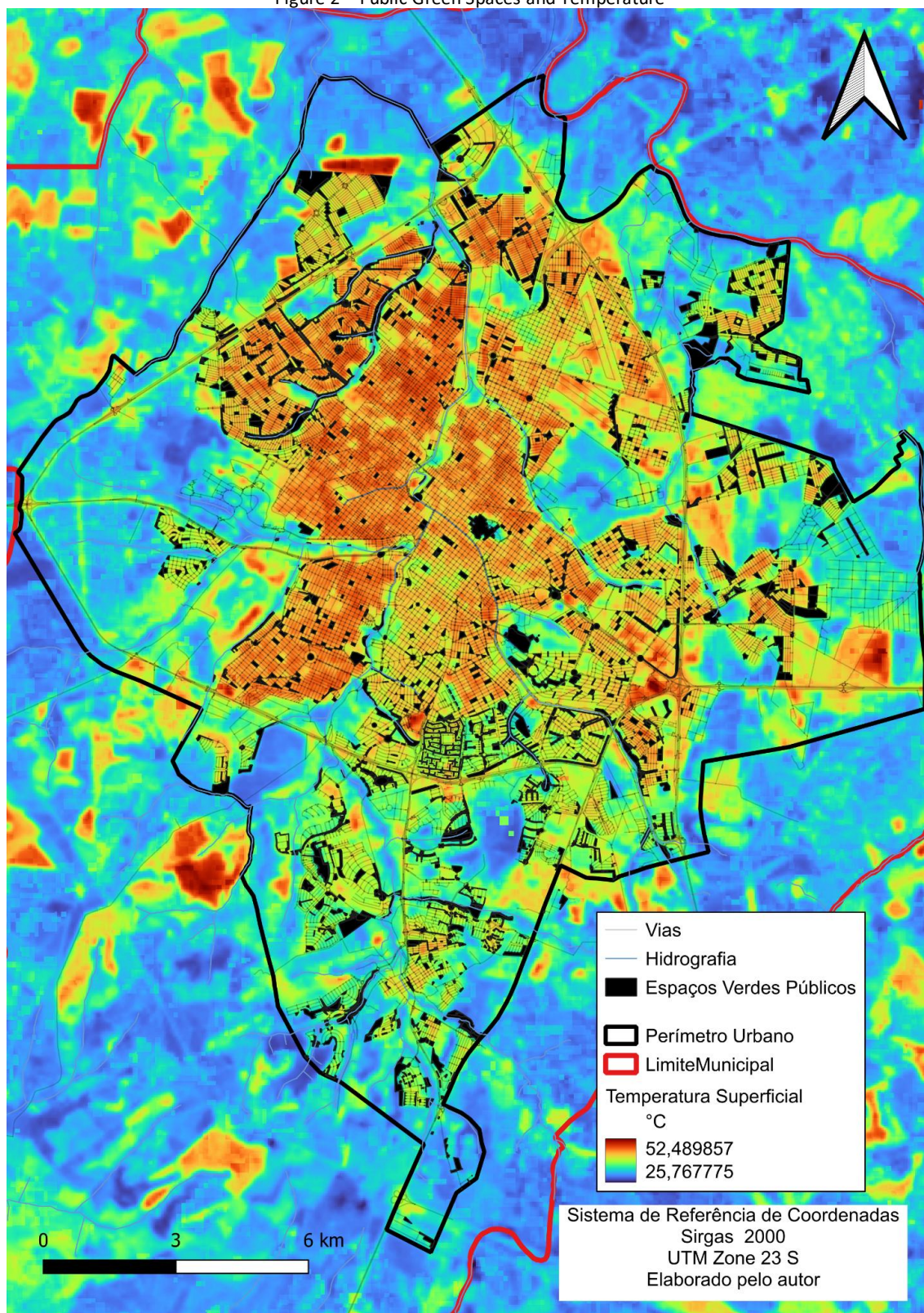
Temperature and flooding are likewise negatively correlated, indicating that areas with greater flood risk are also vulnerable to higher temperatures.

Table 2 - Average values and standard deviations of the variables in relation to social factors.

Titles		Proximity to Public Green Spaces (meters)		Temperature (°C)		Proximity to High Flood Risk Areas (meters)	
		average	standard deviation	average	standard deviation	average	standard deviation
Income	<2 MW	126.3	109.6	43.4	3.18	1.852	1.329
	2-4 MW	187.0	164.1	44.0	2.94	2.014	1.766
	4-10 MW	159.0	163.8	42.1	3.18	2.819	1.712
	10-20 MW	137.7	111.8	40.2	2.64	2.964	1.800
	>20 MW	84.7	107.7	38.4	2.01	3.120	1.266
Race	Yellow	203.3	191.4	42.8	3.16	1.822	130
	White	125.3	97.53	41.1	2.76	3.018	164
	Indigenous	153.9	123.22	43.4	2.96	1.935	160
	Brown	123.4	127.43	42.7	3.61	2.231	138
	Black	145.5	130.74	43.6	3.30	1.755	133

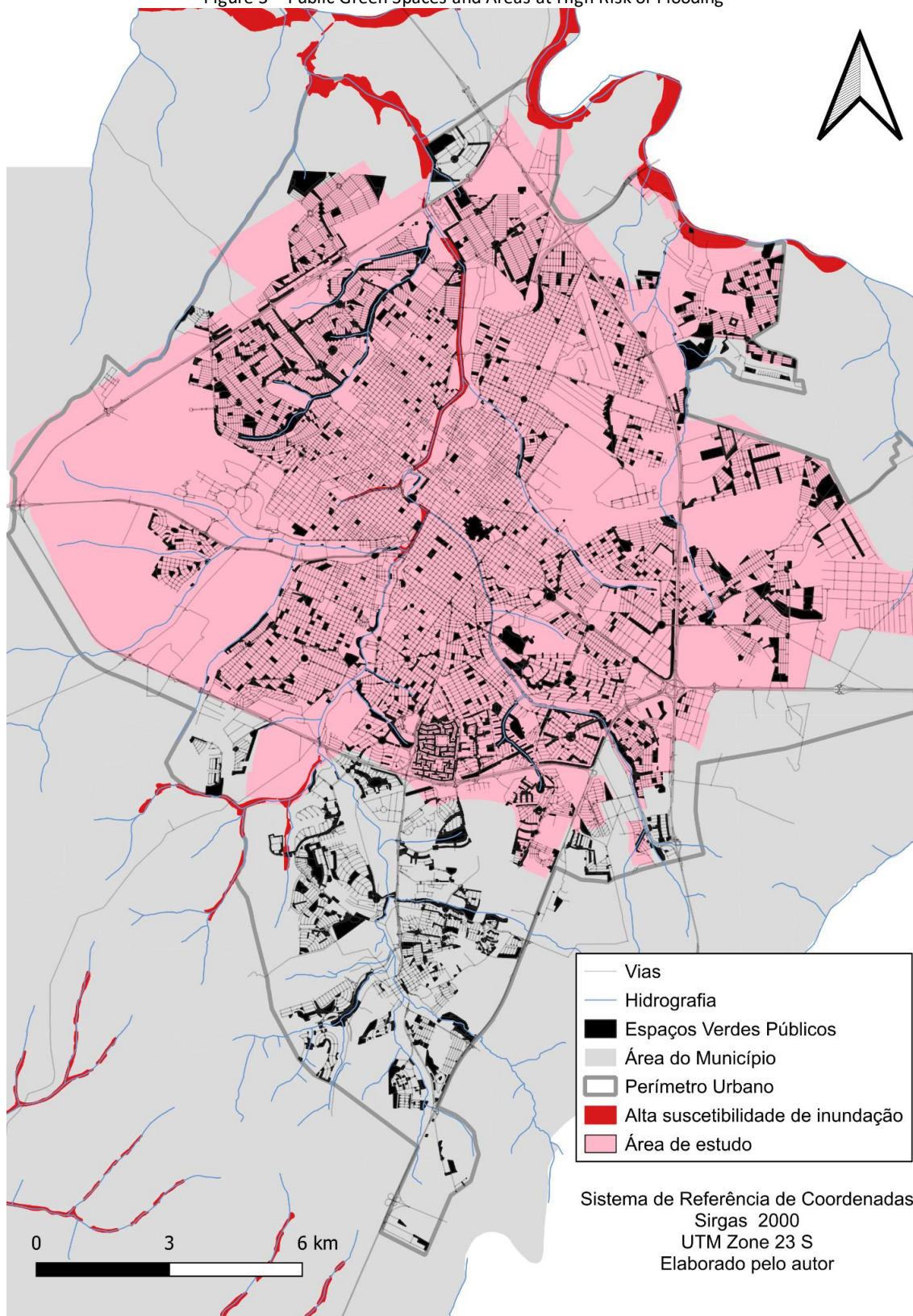
Prepared by the author, 2024.

Figure 2 – Public Green Spaces and Temperature



Source: IBGE (2010); Ribeirão Preto City Hall; U.S. Geological Survey. Prepared by the author.

Figure 3 – Public Green Spaces and Areas at High Risk of Flooding



Source: IBGE (2010); Ribeirão Preto City Hall; Institute for Technological Research. Prepared by the author.

The results also indicate that public green spaces, when combined with other forms of green infrastructure, may contribute to reducing local heat islands and that their implementation could represent an alternative solution to flooding issues by improving drainage in micro-watersheds, since such drainage is often insufficient in flood-prone areas (Van Der Jagt et al., 2019).

Furthermore, the occurrence of higher temperatures in areas with a high risk of flooding reinforces this argument, suggesting that the implementation of public green spaces in nearby areas can help mitigate both problems.

Temperature showed significant differences among income brackets, tending to decrease as income increases. With regard to race, temperature also differs statistically for the white population, whose average is 41.1 °C, while for other racial groups the average ranges from 42.7 to 43.6 °C.

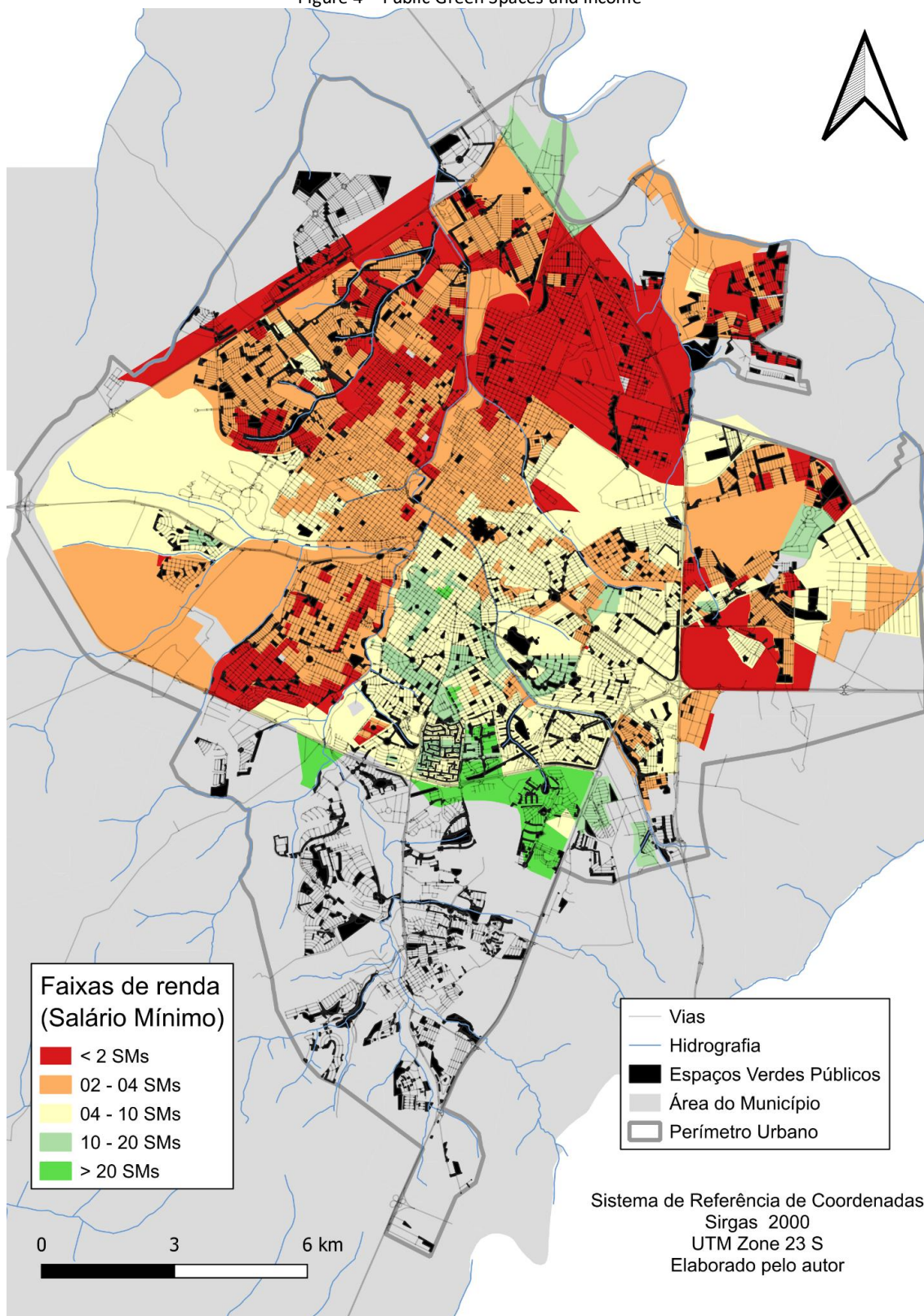
The findings regarding income and race in relation to access to the benefits of public green spaces are considerably more disparate than the differences associated with proximity to these spaces. In other words, even though there is no significant difference in access to these facilities, the benefits affect different populations in distinct ways, reinforcing the debate on the importance of the quality of these spaces (Figures 4 and 5).

Lima; Oliveira; Quaresma (2025, p.274) corroborate studies that analyze the influence of urban vegetation on the mitigation of urban heat islands and carbon sequestration in the municipality of Ribeirão Preto (SP), showing that areas with greater vegetation cover, especially those with tree cover, tend to present lower surface temperatures and higher levels of stored carbon. The authors highlight some areas in the city where carbon sequestration is highest, namely: the Ribeirão Preto Ecological Station, the University of São Paulo (USP) campus, portions of the eastern region where Prefeito Luiz Roberto Jábali Municipal Park is located, and other patches of vegetation and riparian forests with high vigor.

Regarding the income factor, for each income bracket starting at 2 MW, the distance from Public Green Spaces decreases, on average, by 34 meters, and temperature tends to decrease, on average, by 1.8 °C. As for flooding, the distance increases significantly from 4 MW onward. In other words, the average distance from public green spaces decreases as income increases.

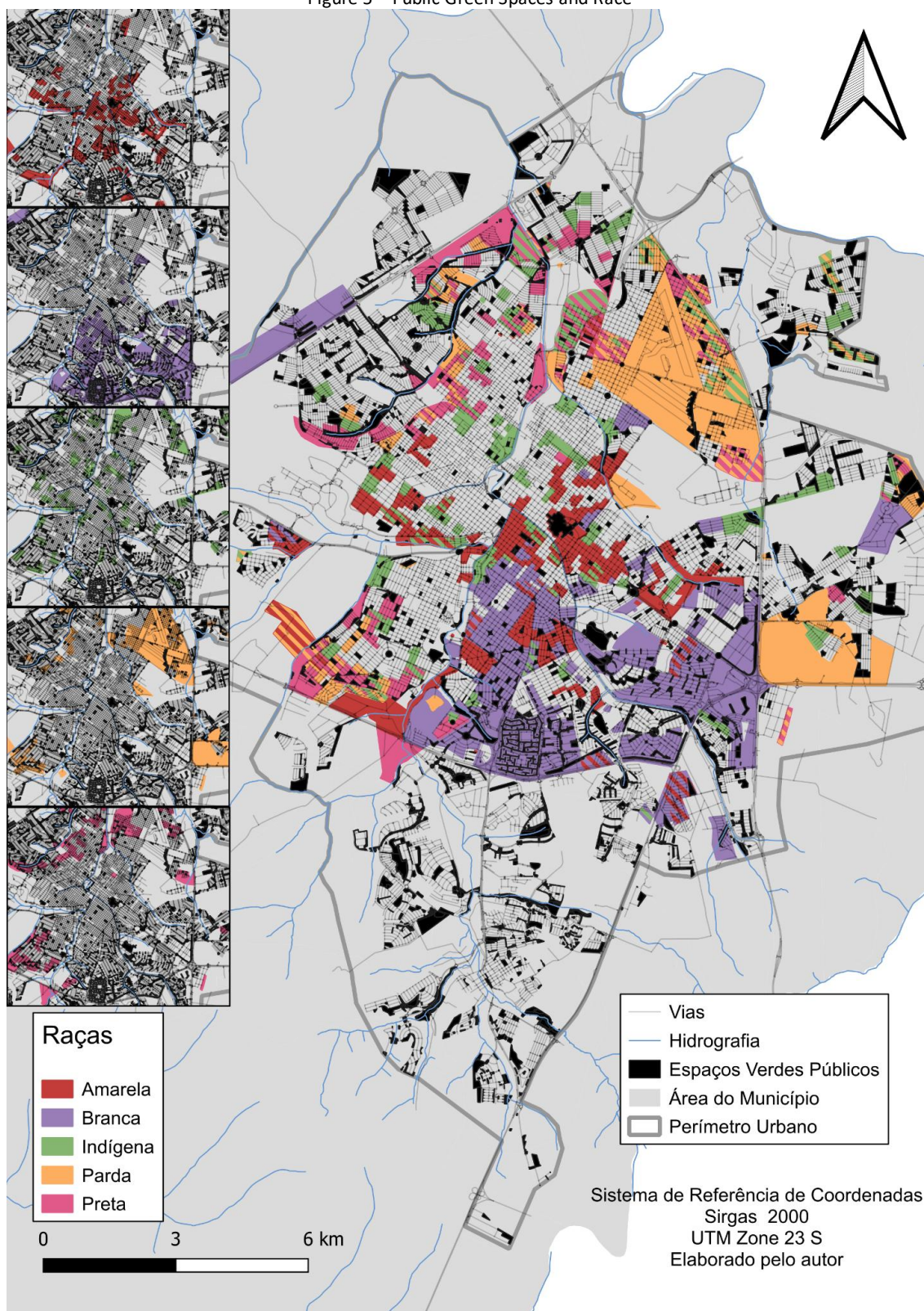
The results align with findings reported in the literature. In Santiago, the capital of Chile, the unequal distribution of green spaces is associated with the population's income: the higher the local income level, the greater the total area of green spaces (Päcke & Aldunce, 2010); this pattern is also observed in São Carlos, state of São Paulo – a city approximately 100 km from Ribeirão Preto – where the average income of residents in areas with higher tree cover exceeds the municipality's overall average (Guerrero et al., 2021; Peres & Schenk, 2021). In Belém, State of Pará, there is a strong correlation between race and flooding, a result that is also found in Ribeirão Preto, where the non-white population lives closer to flood-prone areas than the white population (Miranda, 2021).

Figure 4 – Public Green Spaces and Income



Source: IBGE (2010); Ribeirão Preto City Hall. Prepared by the author.

Figure 5 – Public Green Spaces and Race



Source: IBGE (2010); Ribeirão Preto City Hall. Prepared by the author.

With regard to race, the white population differs from the others, living in cooler environments and at greater distances from flood risk. Areas with a higher concentration of yellow residents also tend to be farther from PGSs, but the effects of temperature and flooding do not seem to affect this population differently from other racial groups, except for the white population.

The white population does not differ statistically from other races — with the exception of the yellow population — in terms of proximity to PGS. However, it is the only group that stands out in benefiting from lower temperatures and greater distance from flood-risk areas. This indicates that PGS located in areas with a higher proportion of white residents are enhancing the quality of urban space and providing benefits that are not observed in areas where other ethnic groups are concentrated.

Rigolon (2016) highlights inequalities between urban parks in neighborhoods with ethnic majorities and minorities in the U.S., where minority communities may be close to green spaces but do not experience the same levels of benefits, maintenance, and safety as parks found in predominantly white communities.

4.2. Mapping of Environmental Injustice in the Municipality of Ribeirão Preto

In order to identify which areas are subject to the most critical conditions regarding the environmental factors analyzed, and where greater efforts can be directed to mitigate environmental injustice in the municipality, a scoring system was developed to classify and categorize census tracts on a scale ranging from highest to lowest priority.

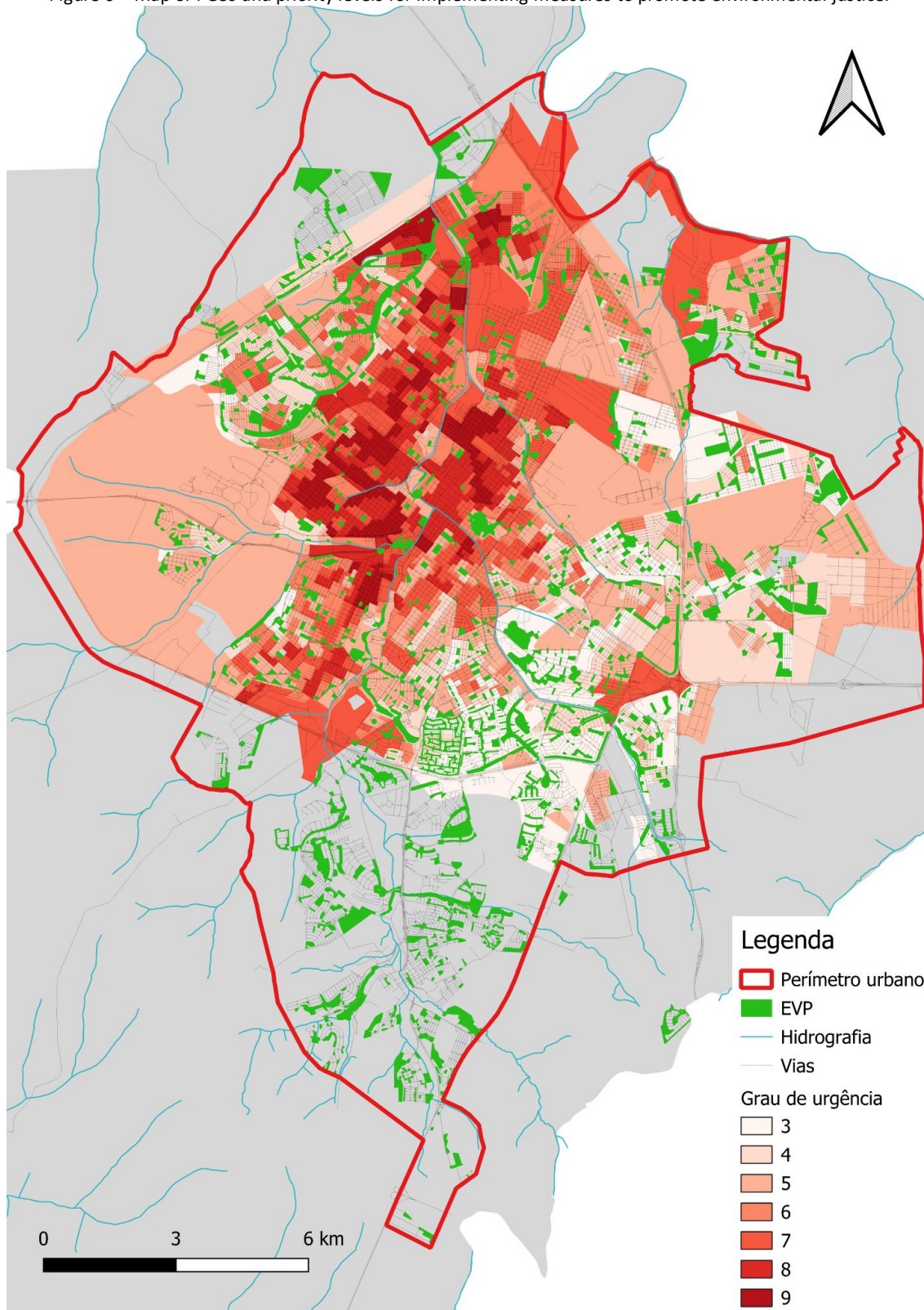
Each factor analyzed (distance from PGS, land surface temperature, and distance from flood zones) was divided into three levels, with each census tract assigned a score from 1 point (least urgent) to 3 points (most urgent), resulting in a maximum of 9 and a minimum of 3 points (Figure 6).

The values were distributed using an “equal weighting” approach across three levels, so that, for each variable, 33.33% of the sectors were classified among the lowest values, 33.33% among the highest values, and 33.33% in the intermediate range. Thus, it was possible to identify those sectors in the most critical condition in relation to the analyzed parameters.

The north and west sectors were identified as the highest priority areas for interventions aimed at revitalizing vulnerable zones, promoting improved environmental quality for the population and reducing existing disparities among the city’s sectors.

This analysis, therefore, proved significant for interpreting and promoting spatial justice in the city, as a research outcome that highlights inequalities in environmental quality across the municipality’s territory. It is not possible to understand the impacts of extreme weather events on the municipality’s population without considering the configuration of urban space and the territorial nature of these events, since injustice is a mappable phenomenon that corresponds to the distribution of urban infrastructure, public facilities, and the region’s demographic profile.

Figure 6 – Map of PGSSs and priority levels for implementing measures to promote environmental justice.



Prepared by the author, 2024.

The idea that increasing tree cover can offer solutions that promote environmental justice, and that each case must be assessed individually, considering the specific characteristics of these spaces, is also supported by Schwarz et al. (2015). Gomes (2003), in analyzing three medium-sized Brazilian cities, one of which is Ribeirão Preto, argues that greater tree cover in public spaces would improve environmental quality and, consequently, the health of the population, since many of these areas currently function as urban voids.

The difficulty of planning urban environments with green spaces accessible to different segments of the population has been identified as a factor behind the failure to consider social inequalities in the planning, implementation, and management of green spaces and, taking into account the context of the Global South, the adoption of planning models inherited from colonial periods (Calderón-Argelich, 2023; Lindley, 2018). As discussed by Neidig (2022), if urban greening projects are not carefully implemented – that is, taking social factors into account – the outcome may be an increase in inequalities and environmental injustices through processes such as gentrification and green privilege, alongside real estate speculation and the appropriation of urban green spaces.

In order to overcome the structures that underpin social inequalities in contemporary urbanization, Argelich (2023) identifies inclusive urban planning as an emerging approach, complementing the multifunctional perspective that advocates for sustainable and resilient cities. Thus, the adoption of urban planning tools that promote an equitable, democratic, and inclusive urban environment is essential for dismantling the historical processes that have produced this framework of inequality.

Godoy; Benini; Silva (2025, p.12) emphasize that the implementation of urban planning committed to climate justice can be organized around three interdependent pillars: prioritizing investments in resilient infrastructure in areas of greatest socio-environmental vulnerability; ensuring the effective participation of local communities in planning and decision-making processes; and the equitable redistribution of public resources.

Studies by De Sá Brito, Mendonça, and Rolnik (2023) propose guidelines for anti-racist urban legislation, based on a racialized analysis of segregation. They aim, in this way, to show that incorporating a racial perspective opens up new avenues that have not yet been explored in Brazil's agenda for the right to the city.

The contemporary challenge is, therefore, to promote green spaces more equitably in urban centers without producing harmful effects for residents in surrounding areas and to ensure that these residents are able to remain there after the implementation of green infrastructure.

The city government's method of classifying public green spaces reflects an ineffective approach to understanding the municipality's actual environmental quality, as it obscures the diverse realities of urban space through the homogenization of public green space categories.

The representation of the situation at a human scale highlights differences in spatial quality and infrastructure across the various environments observed and shows how these dynamics unfold in the municipality's reality. Different laws and public facilities shape the physical reality of urban development, which aligns with social reality while also influencing it.

Ribeirão Preto, a city that stands out economically and presents positive social indicators in comparison to the broader Brazilian context, is nonetheless marked by its own contradictions, giving rise to inequalities that must be confronted and overcome.

The study brings to light some of these contradictions, highlighting the socio-spatial perspective of the distribution of environmental injustices in the municipality and identifying the populations and areas most affected in order to mitigate undesirable socio-environmental effects.

5 FINAL REMARKS

This study sought to analyze spatial inequalities and the correlations between social and environmental factors in the municipality of Ribeirão Preto, São Paulo, using Public Green Spaces (PGS) as a central and unifying element. The methodology adopted proved effective in offering an overview of environmental and spatial injustice in the municipality. There are limitations that could be addressed in future studies, such as updating the 2010 Census data, the sectoral scale, and the use of centroids as a spatial reference. Nevertheless, the authors consider that the methodology can be replicated and adapted to other Brazilian municipalities and encourage the further development of complementary and more complex approaches focused on in-depth case studies or more localized contexts.

The spatial and environmental justice approach supported this study in understanding how certain communities and urban groups may be affected by inequalities inherent in the city's production process. It also contributed to establishing correlations between different areas of the city, so that less unequal public policies can be developed, expanding opportunities and access to goods, services, geographic space, and nature.

The history of urbanization in Ribeirão Preto is marked by processes that shape both the urban landscape and the demographic profile of each neighborhood, resulting in racially segregated communities. These processes have been taking place since the city's founding and continue to evolve, materializing in the form of laws, decrees, partnerships, infrastructure, and similar mechanisms, driven by different actors such as government agencies, construction companies and developers, and landowners, and guided by the real estate market.

This differentiation is also reflected in the distribution of public green spaces, contributing to environmental inequality in the city and, consequently, to environmental injustice. As a result, lower-income populations from marginalized racial groups tend to experience greater environmental impacts and the effects of climate change.

Given Ribeirão Preto's history of urbanization, most of the population has settled in the northern part of the municipality, while the white, higher-income population has become concentrated in the southern part. This contrast produces a scenario of spatial injustice, concentrating the problems of urbanization in specific areas of the city. It is not possible to plan for the promotion of environmental justice in the municipality of Ribeirão Preto without understanding its spatial dynamics; therefore, spatial justice and environmental justice, in this case, are interdependent.

Public green spaces have shown strong potential to alleviate adverse weather conditions, being associated with areas of lower temperature and largely absent from areas at high risk of flooding; however, on their own, they are not capable of preventing real estate

dynamics such as land value appreciation, gentrification, and the displacement of the local population.

Urban planners and other agents involved in city development must consider the creation of public green spaces in alignment with principles of inclusion and social justice. New forms of planning and urban planning tools must be implemented with this perspective, in an effort to prevent these dynamics of injustice from continuing to be reproduced.

Therefore, it can be concluded that, to promote spatial and environmental justice in the municipality of Ribeirão Preto, increasing the equitable distribution of public green spaces across the urban area may represent an important initiative; however, it is also necessary to consider improving the distribution and quality of existing green spaces, so that they can provide the benefits and services demanded by the population in an integrated way, aligned with local needs for mitigating adverse climatic and social effects. This and other actions aimed at promoting environmental justice in Ribeirão Preto must take into account the territorial nature of socio-environmental problems, which in this case are more pronounced in the north and west sectors. Further analysis of these issues is of great importance for identifying territorial gaps and informing fairer, more equitable, and territorially redistributive urban public policies, in line with the right to the city and the challenges that climate change poses to cities.

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DECLARAÇÕES

CONTRIBUIÇÃO DE CADA AUTOR

Breno Alves Guldani: responsável pela concepção e design do estudo; curadoria de dados; análise formal; aquisição de financiamento; investigação; metodologia; redação inicial; revisão crítica e edição final.

Renata Bovo Peres: responsável pela concepção e design do estudo; revisão crítica; edição final e supervisão.

DECLARAÇÃO DE CONFLITOS DE INTERESSE

Nós, Breno Alves Guldani e Renata Bovo Peres, declaramos que o manuscrito intitulado "Espaços verdes públicos e justiça ambiental: correlações em Ribeirão Preto – SP":

1. **Vínculos Financeiros:** Não possui vínculos financeiros que possam influenciar os resultados ou interpretação do trabalho. (Este trabalho foi financiado pela Capes - Coordenação de Aperfeiçoamento de Pessoal de Nível Superior).
 2. **Relações Profissionais:** Não possui relações profissionais que possam impactar na análise, interpretação ou apresentação dos resultados.
 3. **Conflitos Pessoais:** Não possui conflitos de interesse pessoais relacionados ao conteúdo do manuscrito.
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