GREEN CITY, HUGE INEQUALITIES: CLIMATE JUSTICE AND ACCESS TO PARKS IN RIO DE JANEIRO

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ABSTRACT

This study examines the spatial distribution of parks in the city of Rio de Janeiro, assessing whether these areas are located in regions of varying socio-environmental vulnerability. Employing a qualitative, associative methodology – including literature review and case study – the research analyses the Social Development Index, ethnic composition, the Normalised Difference Vegetation Index and park locations. Findings reveal a pattern of climate injustice, with green spaces predominantly concentrated in less vulnerable, wealthier areas with lower proportions of Black residents. Although recent initiatives have begun to expand and revitalise parks and protected areas in more vulnerable neighbourhoods, significant disparities persist. The study highlights the need for a participatory process and further research on specific parks, their community engagement, and their integration with local environments.

Key words: socioenvironmental vulnerability, territorial distribution, green spaces

INTRODUCTION

Rio de Janeiro's climate agenda, based on its recent Master Plan (Rio de Janeiro, 2024c), emphasises projects aimed at the expansion of parks. It is supported by a regulatory framework for the implementation of green spaces, especially given the city's vulnerability to climate events such as floods (Manes et al., 2024). The Parques Cariocas project is one such initiative, aiming to revitalise municipal parks in one of the largest urban green space redevelopment programmes worldwide (Rio de Janeiro, 2024b). Additionally, the recently enacted Municipal Law No. 8465/2024 establishes sustainable mechanisms for stormwater management to control floods and inundations, applying the concept of a 'Sponge City' within the municipality (Rio de Janeiro, 2024d).

However, green area distribution remains unequal, predominantly benefiting privileged groups while vulnerable populations lack access (Panagopoulos, 2019). In Rio de Janeiro, green spaces are concentrated in areas with higher Social Development Indexes, particularly in the South Zone (Pistón et al., 2022).

In this context, this study aims to assess whether parks are equitably distributed across Rio, vis-à-vis the socio-environmental vulnerability of its population. For the purposes of this study, the term 'parks' refers specifically to Protected and Conserved Areas (PCAs), as defined by the IUCN, that have been officially designated by the municipal government of Rio de Janeiro as either 'urban parks' or 'natural parks'. These classifications are based on local administrative criteria and reflect areas intended for public use, ecological preservation and recreational functions within the city's administrative regions.

METHOD

We used a phased approach to our research. First, we conducted a literature review of climate injustice in the implementation of parks. Our search included Scopus, Web of Science, SciELO and CAPES Portal (digital publications) databases, and used the following parameters: infrastructure AND green AND ("environmental justice" OR "climate justice"); "parks" AND ("environmental justice" OR "climate justice"); "nature-based solutions" AND ("environmental justice" OR "climate justice"). The same terms were searched in

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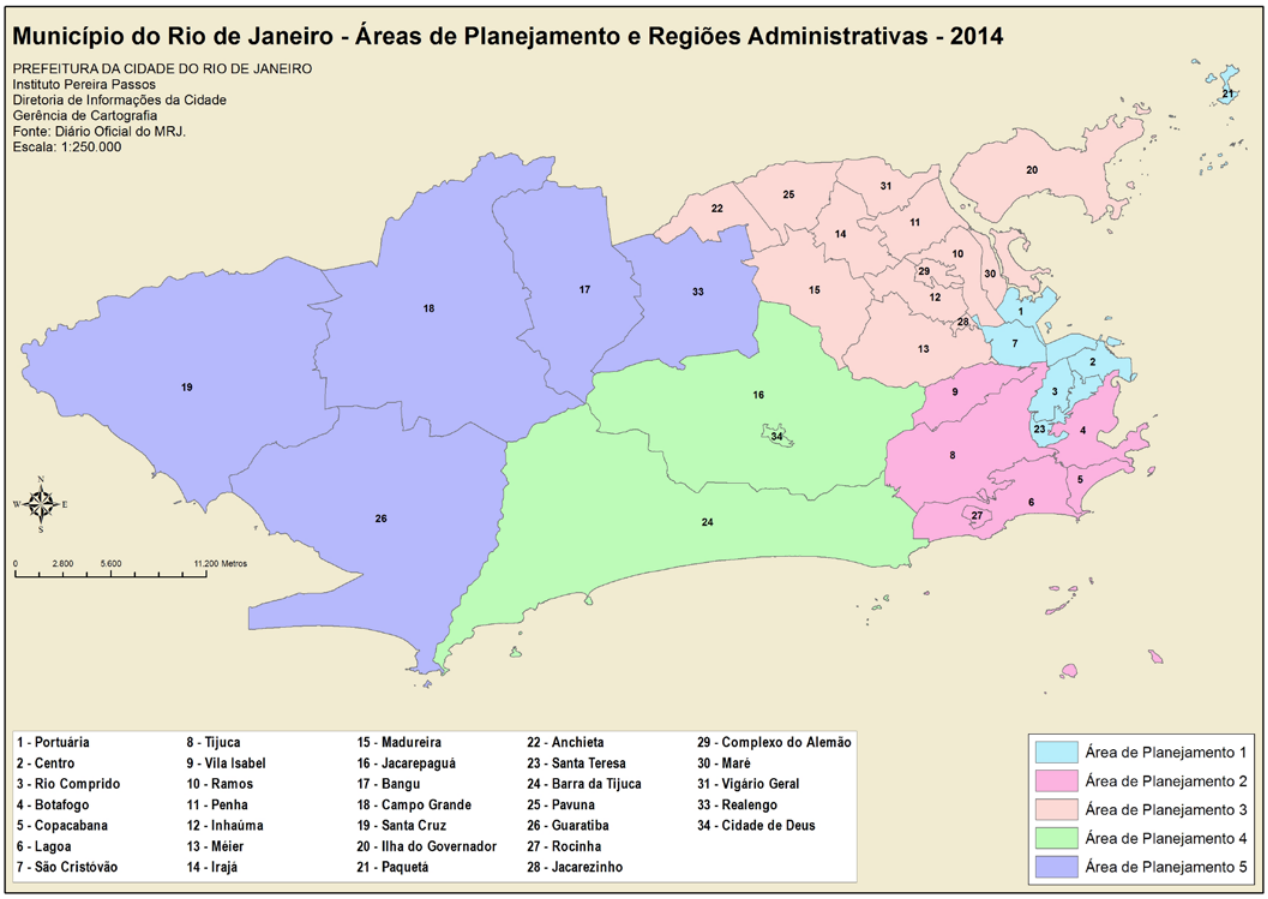

Figure 1. Map of planning areas and administrative regions of Rio de Janeiro. *Source: Rio de Janeiro (2014)*

Portuguese and Spanish. Next, we focused on Rio de Janeiro, identifying socio-environmentally vulnerable areas using ethnicity and the Social Development Index (SDI), both extracted from the Data Rio database. This data was cross-referenced, with the Normalised Difference Vegetation Index (NDVI) to the locations of the city's parks. The methodology applied consisted of assigning specific weights to the mentioned attributes and then calculating a weighted average of the selected attributes to obtain an overall assessment (Sanchéz, 2008). Based on this overall assessment, a summary map was created showing the location of parks and socio-environmental inequality in the city.

RESULTS

Parks and green spaces: globally fragmented spaces

Langhans et al. (2023) highlight that historically marginalised groups, including low-income populations, Indigenous Peoples and Black communities, have significantly less access to nature and its benefits. National data collected by the Brazilian Institute of Geography and Statistics (IBGE) in 2010 and analysed by Souza and Amorim (2013) show regional disparities in tree coverage near buildings and public spaces: the North and Northeast lack surrounding trees by 62.5 per cent and 38.2 per cent, respectively, compared to only 26.2 per cent in the Southeast. Panagopoulos (2019) reviews evidence of persistent inequality in green space distribution between affluent and poorer districts, as well as among the elderly, who tend to live in spaces with fewer green areas. Yan, Jin and Zhang (2024) further note that public facilities such as parks are predominantly located in affluent areas, while industrial zones and high-density housing are concentrated in neighbourhoods inhabited by people of colour and low-income individuals. Consequently, vulnerable populations are more exposed to climate events such as floods (Ximenes & Maglio, 2022), while adaptive solutions such as afforestation and green space expansion tend to be found in areas with more privileged populations, perpetuating climate injustice (Costa & Bôas, 2022).

Rio de Janeiro and the occupation of urban space

Rio de Janeiro, Brazil's second-largest city and a global megalopolis (Fernandez, 2022), has over 6 million residents (IBGE, 2022). Located in Southeast Brazil, it spans 1,200.33 km², with 640.34 km² of urbanised area (IBGE, 2019; 2024). The municipality is divided into 32 administrative regions and five planning areas, based on

Entrance to the Parque Natural da Cidade (Rio de Janeiro), with the Favela Vila Parque da Cidade in the background'. © Alexandre Dantas, 2025

environmental, historical and land-use criteria (Rio de Janeiro, 2024a): Central Zone (AP1), South Zone and Greater Tijuca (AP2), North Zone (AP3), Barra da Tijuca and Jacarepaguá lowlands (AP4), and West Zone, including Guaratiba, Campo Grande and Santa Cruz (AP5). A reference map from City Hall (Rio de Janeiro, 2014) illustrates these divisions (Figure 1).

Urbanisation and nature have long been intertwined in Rio de Janeiro, as noted by travellers and writers since the 18th century (Fernandez, 2022). In the 19th century, extensive vegetation was replaced by coffee plantations, leading to water shortages (Sales et al., 2024). This prompted debates on preserving springs and forest remnants, culminating in the planned reforestation of Tijuca and Paineiras Forests beginning in 1862 (Sales et al., 2024). Influenced by European models, the Tijuca Forest was conceived to reflect ideals of Brazilian prosperity and modernity (Sales et al., 2024).

Concurrently, Rio's political prominence spurred the creation of parks, gardens and squares, following French afforestation standards (Sales et al., 2024). During the 1940s and 1950s, industrialisation, immigration, and architectural transformation led to the development of leisure spaces such as Avenida Presidente Vargas, Praça General Osório, Canal do Jardim de Alah and Praça Saens Peña (Ferreira et al., 2021).

Subsequent decades (1960s–1990s) saw rapid urban expansion, road construction and unregulated housing growth, marked by environmental contradictions and the displacement of low-income populations to hillsides and riverbanks, often through forced evictions linked to land privatisation (Fernandez, 2022). Between 1984 and 2020, the metropolitan urban area nearly doubled, while vegetation cover declined by 13 per cent, particularly in the Pedra Branca and Tijuca Massifs (Miranda et al., 2022). According to Bessa and colleagues (2015), the city's hilly terrain – historically occupied by favelas and low-income populations – reflects a segregationist urban development model. Rocinha favela exemplifies this pattern, with dense, impermeable surfaces and high vulnerability to floods and landslides (Ronchi & Arcidiacono, 2019).

Urbanisation has also disrupted hydrological systems, notably in the Mangue Canal, Acari River Basin, Sepetiba Basin and Jacarepaguá Lagoon Complex (Castro et al., 2023; Costa et al., 2018; De Deus & Oscar Junior, 2020; Guimarães & Miguez, 2020).

Overall, the city's urbanisation reveals a persistent tension between nature and urban growth, with green areas embedded in the urban fabric and vice versa, shaped by unregulated expansion. This dynamic reinforces socio-environmental disparities across the city (Nunes et al., 2020).

Socio-environmental vulnerability and territorial distribution of Rio's parks

Analysing urban land use in Rio de Janeiro allows for a deeper examination of socio-environmental data in relation to the distribution of parks across the city's administrative regions. The collected social and environmental data were translated into maps to visually support the analysis, and the following section explains this mapping process.

The selected social indicators were the SDI and ethnic composition. The SDI indicators are based on eight variables from the 2010 IBGE census, as the 2022 data remains incomplete and unpublished at the regional level (Rio de Janeiro, 2024a). These variables include access to water, sewage, and waste collection; average number of bathrooms per resident; illiteracy rate among 10–14 year olds; and average household income based on minimum wages. SDI values were categorised into three ranges: low (≤ 0.55), medium (0.56–0.65) and high (≥ 0.66). AP5 (West Zone) consistently shows the lowest SDI, while AP2 (South Zone) and AP4 (West Zone) generally present high SDI scores. AP1 (Central Zone) and AP3 (North Zone) predominantly fall within the

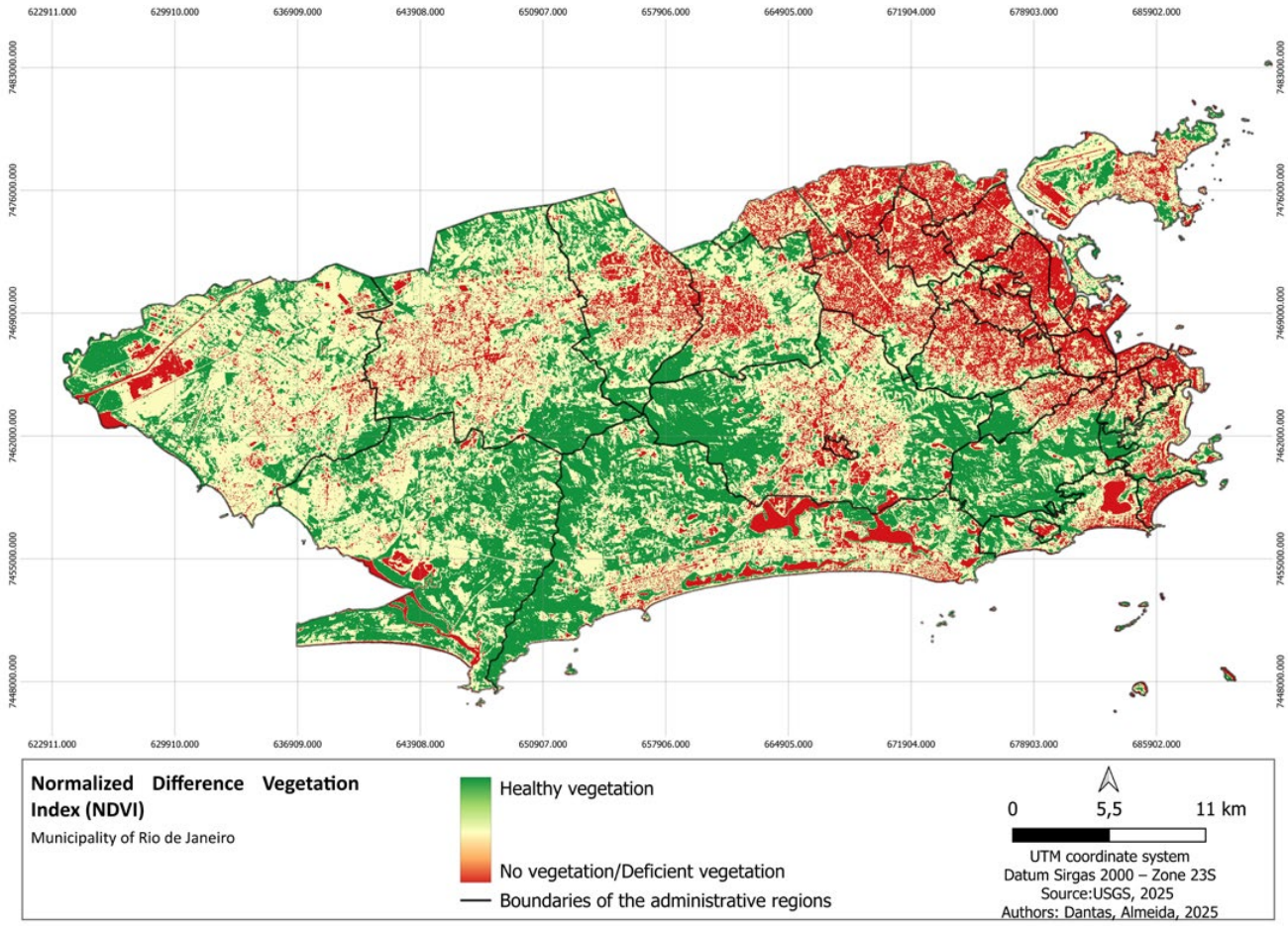

Figure 2. Vegetation map based on NDVI by administrative region. S*ource: prepared by the authors (2025), based on USGS (2025)*

medium SDI range. It is important to note that the vulnerabilities mapped in the 2010 census remain persistent over time. Recent technical notes from Pereira Passos Institute (Cavallieri & Lopes, 2024) and reports from the 'Territórios Sociais program' (Rio de Janeiro & ONU-Habitat, 2025) confirm that the same neighbourhoods identified as socially fragile in 2010 continue to exhibit low SDI values and high levels of deprivation.

Ethnicity data were drawn from the 2022 IBGE census (Rio de Janeiro, 2025a). The analysis was conducted by administrative region, based on the proportion of Black and brown residents relative to the total population. Three categories were defined: high concentration (above 50 per cent), medium (30–49 per cent) and low (below 29 per cent). Notably, areas with the highest proportions of Black and brown populations correspond to those with the lowest SDI, as illustrated in Figure 3. The regions with the highest concentrations were Cidade de Deus (75 per cent), Complexo do Alemão (72 per cent) and Jacarezinho (70 per cent), while the lowest were Copacabana (28 per cent), Botafogo (26 per cent) and Lagoa (21 per cent).

Environmental data analysed across Rio de Janeiro's municipal territory included the spatial distribution of green areas via the NDVI and the location of PCAs. NDVI, derived from satellite-based remote sensing, measures vegetation density and health by comparing red and infrared light absorption. Healthy vegetation absorbs more red light and reflects more infrared, appearing green on the map (Figure 2). In contrast, urbanised zones, water bodies and exposed soil reflect less infrared and appear red. Yellow areas indicate sparse tree cover with limited biodiversity potential.

Vegetation quality analysis reveals that the North Zone is predominantly classified as "no vegetation/deficient vegetation" with limited green areas near the Tijuca Massif and isolated green/yellow zones such as the linear Madureira Park. Healthy vegetation is concentrated in the Maciços regions, primarily within the South Zone (AP2) and Barra da Tijuca/Jacarepaguá (AP4). The West Zone (AP5), the city's largest planning area (an administrative division of the city to structure urban planning and guide public policies), also exhibits extensive areas of low or absent vegetation, particularly in its central region and around Sepetiba Bay.

Table 1. Attribute notes. *Source: prepared by the authors, 2025*

Black population	
High concentration	Note 3
Medium concentration	Note 2
Low concentration	Note 1

SDI	
Low	Note 3
Medium	Note 2
High	Note 1

NDVI	
No vegetation/deficient vegetation	Note 3
Low tree cover/biodiversity	Note 2
Healthy vegetation	Note 1

Table 2. Socio-environmental vulnerability scores by administrative region. *Source: prepared by the authors, 2025*

Administrative region	Ethnicity	SDI	NDVI	Total
I Portuária	3	3	3	***9***
II Centro	2	2	3	***7***
III Rio Comprido	2	2	2	***6***
IV Botafogo	1	1	2	***4***
V Copacabana	1	1	3	***5***
VI Lagoa	1	1	2	***4***
VII São Cristovão	3	2	3	***8***
VIII Tijuca	2	1	1	***4***
IX Vila Isabel	2	2	2	***6***
X Ramos	3	2	3	***8***
XI Penha	3	2	3	***8***
XII Inhaúma	3	2	3	***8***
XIII Meier	2	2	2	***6***
XIV Irajá	3	2	3	***8***
XV Madureira	3	2	3	***8***
XVI Jacarepaguá	3	2	2	***7***
XVII Bangu	3	3	2	***8***
XVIII Campo Grande	3	3	2	***8***
XIX Santa Cruz	3	3	2	***8***
XX Ilha do Governador	2	2	2	***6***
XXI Paquetá	3	2	2	***7***
XXII Anchieta	3	2	2	***7***
XXIII Santa Teresa	3	2	1	***6***
XXIV Barra da Tijuca	2	1	2	***5***
XXV Pavuna	3	3	3	***9***
XXVI Guaratiba	3	3	1	***7***
XXVII Rocinha	3	3	2	***8***
XXVIII Jacarezinho	3	3	3	***9***
XXIX Complexo do Alemão	3	3	3	***9***
XXX Maré	3	3	3	***9***
XXXI Vigário General	3	3	3	***9***
XXXIII Realengo	3	2	2	***8***
XXXIV Cidade de Deus	3	3	3	***9***

The collected socio-environmental data were aggregated using equal weighting for each attribute, following a simple additive formula (Sanchéz, 2008). Three attributes – NDVI, SDI and ethnicity – were evaluated in relation to PCAs' locations. Each was assigned a score from zero to three, reflecting its contribution to socio-environmental vulnerability (Table 1). Final scores were calculated by summing the individual attribute scores, with equal relevance across all indicators. These scores were then distributed across the city's administrative regions to assess spatial variation.

Based on the defined score ranges, attribute weights and selected data, final scores were assigned to each administrative region of Rio de Janeiro. NDVI, being continuous data, is not uniformly distributed across regions. To address this, representative vegetation quality values were extracted from QGIS spreadsheets, accounting for each region's territorial extent. The resulting scores reflect the aggregated socio-environmental conditions per region, combining NDVI, SDI and ethnic composition (Table 2).

Finally, the analysis focused on PCAs, as defined by the IUCN, specifically those designated by the municipal government as 'urban parks' or 'natural parks'. In Rio de Janeiro's planning framework, 'urban parks' are public green areas within the consolidated urban fabric, primarily intended for recreation, leisure and provision of ecosystem services, but they are not legally recognised as conservation units. By contrast, 'natural parks' are formally classified as Conservation Units under the National System of Conservation Units (Law 9.985/2000), with the main purpose of preserving ecosystems, promoting environmental education, and allowing controlled public use (Brazil, 2000; Rio de Janeiro, 2024c). Thus, only natural parks hold the legal status of protected areas, while urban parks remain instruments of urban planning

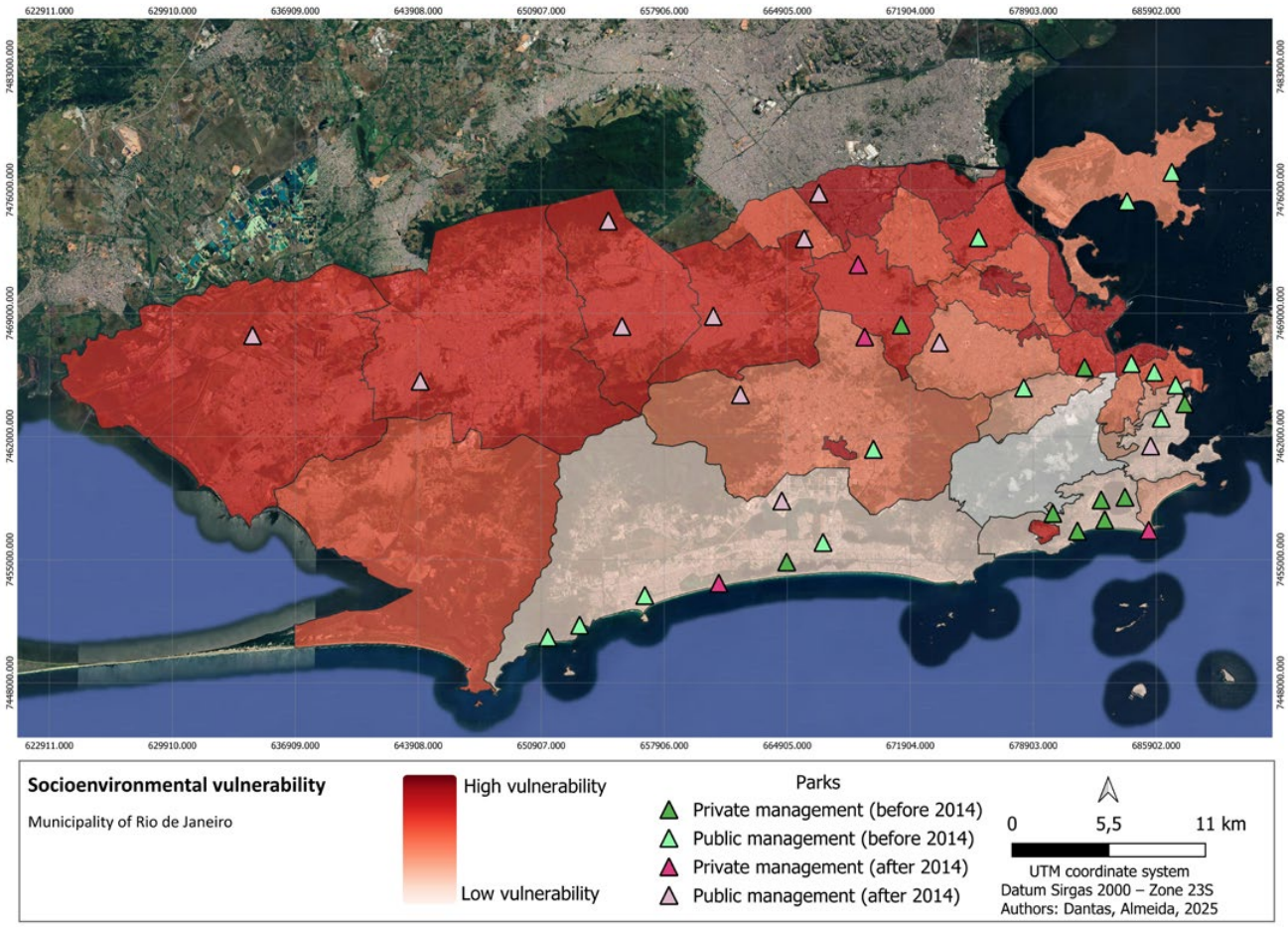

Figure 3. Map of socio-environmental vulnerability and location of parks by administrative region.
Source: prepared by the authors, 2025

and social well-being without equivalent legal safeguards (Cavallieri & Lopes, 2024; Rio de Janeiro, 2025b).

Park locations were identified using municipal records and news sources (Rio de Janeiro, 2024b), as well as official documentation from the Parques Cariocas project, which outlines existing parks, planned delivery of new parks, and public-private concession models (Rio de Janeiro, 2025b). They were categorised into four groups: (i) parks created or last renovated before 2014 and currently undergoing transfer to private management; (ii) those from the same period remaining under public management; (iii) parks created or renovated after 2014 and transferring to private management; and (iv) those post-2014 remaining under public management.

These parks are predominantly concentrated in the South and Central Zones, particularly older parks such as Passeio Público (1779) and Campo de Santana (1880). In contrast, while fewer PCAs are in areas with lower SDI, recent efforts have expanded PCA coverage in AP5 and AP3, with new publicly managed parks such as Parque Oeste and Parque Realengo Susana Naspolini.

Based on the compiled data and park locations, a summary map (Figure 3) was generated using a red gradient to visualise socio-environmental vulnerability. Darker shades represent regions with higher vulnerability, while lighter shades indicate areas with lower vulnerability.

The summary map reveals key patterns in the spatial distribution of parks (PCAs): (i) extensive areas of socio-environmental vulnerability lack any designated parks, notably in Barra de Guaratiba and communities such as Cidade de Deus, Complexo do Alemão, Maré, Jacarezinho and Rocinha; (ii) the oldest and most densely clustered parks are located in areas of lowest vulnerability; (iii) recent efforts have led to the creation and renovation of parks in high-vulnerability zones, suggesting potential progress; and (iv) despite these initiatives, the overall distribution remains disproportionate, especially given the vast territorial extent of the city's most vulnerable regions.

DISCUSSION

The distribution of parks and green spaces in major cities has gained importance amid escalating environmental and social crises, particularly from a climate justice perspective. Green infrastructure, including parks, plays a critical role in mitigating climate change, delivering ecosystem services, enhancing environmental quality, and fostering collective well-being (Graça & Telles, 2020). However, unequal access to these amenities reinforces historical disparities, perpetuating climate injustice that disproportionately affects vulnerable populations (Langhans et al., 2023). In this context, the case of Rio de Janeiro illustrates how uneven access to green spaces intensifies urban socio-environmental inequalities.

Higher-income neighbourhoods with better quality infrastructure generally contain larger parks and greater urban vegetation, while peripheral areas inhabited by socially vulnerable groups face a significant deficit of such spaces. This unequal distribution reinforces the notion of urban climate injustice, as populations lacking access to green areas are disproportionately exposed to adverse climate impacts, including heat island effects, flooding and poor air quality (Costa & Bôas, 2022). The absence of parks also restricts opportunities for leisure, health and community engagement, perpetuating historical exclusions.

Results for Rio de Janeiro confirm this pattern: extensive high-vulnerability areas, such as Barra de Guaratiba, remain without parks, whereas older and larger parks are concentrated in less vulnerable regions, including the South Zone, Barra da Tijuca and the city centre. Although recent initiatives have sought to create and revitalise parks in vulnerable areas, their distribution remains disproportionate to both the territorial extent and the needs of the resident population.

The uneven distribution of green spaces is a central driver of climate injustice in Rio de Janeiro. By denying vulnerable communities the benefits of parks, such as thermal regulation, water absorption, improved air quality and social interaction, public authorities reinforce existing inequalities and limit these populations' capacity to adapt to climate impacts.

Recent initiatives to expand park projects in previously neglected areas, particularly in the North and West Zones, represent important but insufficient progress. While the implementation of new parks and the restoration of degraded areas signal a shift towards recognising the right to access city amenities and nature as universal, the territorial expansion of parks remains limited and fragmented, falling short of current demand.

Ensuring the active participation of vulnerable populations in all stages of park planning, management and maintenance is essential (Fors et al., 2021; Oscilowicz et al., 2023). Social inclusion must be understood not only as an ethical principle but as a prerequisite for the effectiveness and sustainability of green infrastructure policies. Evidence shows that participatory processes foster stronger community ownership, stimulate innovation, and ensure that interventions address local needs (Zuniga-Teran & Gerlak, 2019). In Rio de Janeiro, community engagement in park development is a critical step towards reversing climate injustice and building more equitable and resilient cities, as illustrated by the Parque Realengo initiative (Casa Fluminense, 2024). This local experience resonates with broader international movements, such as the National Park City Journey project. The project demonstrates how collective action and grassroots engagement can transform urban landscapes into healthier, greener and more inclusive environments (National Park City Foundation, n.d.).

CONCLUSIONS

An analysis of the distribution of PCAs classified by the municipality as parks in Rio de Janeiro shows that, despite recent advances in public policies aimed at expanding and revitalising green spaces in vulnerable regions, socio-environmental inequality persists. The data indicate that older and larger PCAs remain concentrated in privileged areas, while vast high-vulnerability regions continue to lack these spaces, which are essential for climate adaptation and collective well-being. This scenario underscores the need for more effective and integrated policies capable of promoting territorial equity and ensuring that the benefits of green infrastructure reach all communities, particularly those historically excluded.

In this context, it is crucial that public authorities prioritise the active participation of vulnerable populations in all stages of parks projects, from design to management and maintenance. Social inclusion and the strengthening of participatory governance are not only ethical imperatives but also necessary conditions for reversing climate injustice and fostering more resilient and equitable cities. Future research and initiatives should monitor the impacts of new PCAs in vulnerable areas, with continuous monitoring and community engagement serving as central pillars for successful implementation.

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