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Papers

Historical Cartography as a Tool for Analyzing Landscape Transformations of the Paquequer River in the Genesis Area of Teresópolis, Rio de Janeiro – Brazil

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Abstract

When addressing landscape dynamics, the theoretical-conceptual intersection between cartography and geoecology converges in the interpretation and representation of spatial and environmental transformations, comprehensively elucidating the interactions between natural systems and human interventions in the territory. This study investigates the landscape transformations of the Paquequer River, located in the central area of Teresópolis (Rio de Janeiro, Brazil), using historical cartography as the main analytical tool and adopting geoecology as the theoretical framework, which serves as a geographic approach for analyzing landscape dynamics. In this regard, the central aim is to identify and understand the changes in the course of the Paquequer River and their correlations with the urban development of Teresópolis. The article addresses the evolution of the river and its influence on the urban development of Teresópolis from the 19th century to the present day. Gathering historical documents, such as maps, photographs, and municipal records, was essential for contextualizing the region's geographical and cultural changes. The historical maps were compared with contemporary cartographic data using georeferencing and vectorization techniques, allowing for an analysis of the modifications in the river's course, particularly concerning its sinuosity index. The analysis revealed a decrease in the river's sinuosity over time, suggesting a process of channel straightening. The study concludes that the Paquequer River in the genesis area of the municipality of Teresópolis is a crucial structuring element in the city's development and that integrating historical and geographical approaches is essential for effectively preserving and managing urban landscapes. The methodology employed provided a detailed understanding of landscape transformations, offering valuable insights for urban planning and environmental management.

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INTRODUCTION

The city of Teresópolis, located in Serra Fluminese, a mountainous microregion of the state of Rio de Janeiro, Brazil, presents a historical and geographical formation intrinsically linked to the Paquequer River, an essential element in the municipality's initial spatial configuration (IBGE, 2024).

Teresópolis's origins date back to the first half of the 19th century when in 1788 Baltazar da Silva Lisboa made the first official descriptions of the region. Later, in 1821, George March, a Portuguese man of English roots, acquired a vast tract of land and established a demonstration farm named Santo Antônio do Paquequer, where the Alto neighborhood is currently located. This initial settlement expanded along the path that connected the capital, Rio de Janeiro, home to the Royal Family, to the Minas Gerais province, southeastern Brazil, favoring agriculture, livestock, and tourism (Santos, 2023).

The urban development of Teresópolis, driven by the Paquequer River, illustrates how waterways play a fundamental role in the occupation and spatial organization of cities. The history of Teresópolis highlights the importance of the relationships between natural geography and human dynamics in the formation of urban landscapes in the Serra Fluminense region. This relationship should be explored through historical cartography, which offers a scientific and operational framework for understanding the evolution of the landscape over time.

Historical cartography is a field of study dedicated to historical maps analysis and interpretation, which is essential for understanding the geographical knowledge of certain eras. Not only do these cartographic documents illustrate the representation of physical space but they also reveal the processes and techniques used in their creation, therefore being valuable repositories of knowledge. Through them, it is possible to carry out a diachronic analysis, both qualitative and quantitative, of the geographical space evolution over time. Historical maps offer a window into the past, allowing for extracting geographical, cultural, and toponymic information. They are fundamental for studies on the evolution of urban areas, land occupation, and landscape transformations. These documents enable an in-depth understanding of the historical-geographical relationships and the different representations of the landscape in various historical periods, providing a detailed view of physical, social, and cultural changes over time (Menezes *et al*., 2022).

At present, historical cartography has established itself as an essential operational basis with various geographical applications. In this sense, it is crucial for understanding urban expansion and changes in the landscape, as it allows the study of geographical elements and features modified by human activity and enables the analysis of environmental transformations, such as landfills, the straightening of watercourses, and the dismantling of hills (Menezes *et al*., 2022; Lima *et al*., 2020). Thus, historical maps are indispensable for recovering geographical information from past eras, as they offer records of certain places' cultural, structural, and functional aspects. The analysis of these historical cartographic representations allows us to not only understand the territorial configuration but also the social and economic dynamics that have shaped the landscape over time (Menezes *et al*., 2022).

This paper presents an analysis of the Paquequer River, the primary watercourse in the genesis area of the city of Teresópolis, in the state of Rio de Janeiro, Brazil, based on a comparison of information extracted from historical cartographic documents of the 19th and 20th centuries with the most recent cartographic base, to identify the changes that occurred in the Paquequer River and their relation to the city's urban expansion.

A methodological approach that integrates old photographs and historical maps was adopted to understand the relationship between nature and culture and its impacts on the landscape transformation of the Paquequer River. The comparative analysis of these materials, organized chronologically, allows for natural and cultural landmarks identification and, therefore, the observation of the changes in the landscape over time. This historical contextualization through municipal documents and records reveals the cultural, economic, and political influences that have shaped urban development. This synthesis of visual and documentary data allows for the dynamics of natural elements modification to be interpreted, illustrating the complex interaction between society and first nature in the evolution of the Paquequer River landscape.

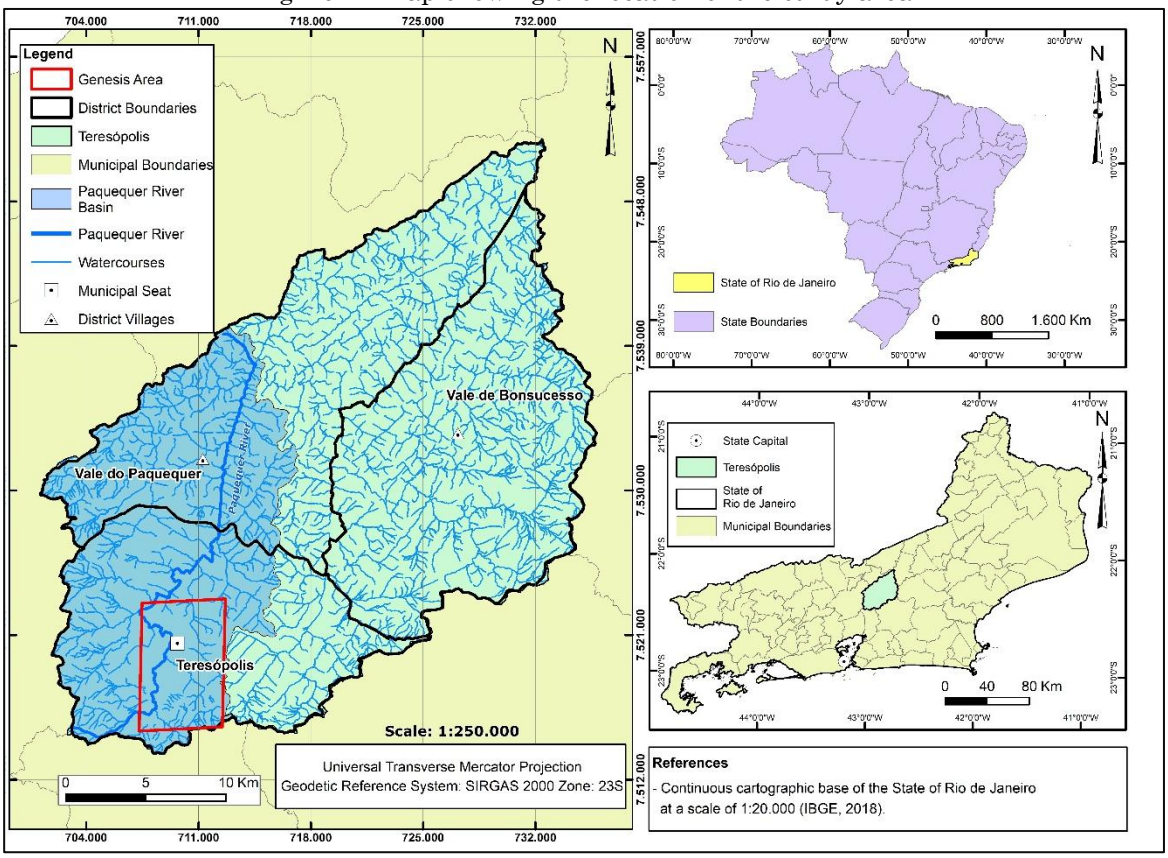
AREA OF STUDY

The municipality of Teresópolis is located in the Serrana micro-region of the state of Rio de Janeiro, Brazil. It has an area of 773,338 km² and a resident population of 165,123 inhabitants, according to the 2022 demographic census (IBGE, 2022). This data can be viewed in a more didactic way on the portal (IBGE, 2024). At present, the municipality is subdivided into three districts: Teresópolis (1st District), Vale do Paquequer (2nd District), and Vale de Bonsucesso (3rd District).

Between the 1840s and 1870s, the then-recent settlement of Teresópolis underwent significant changes in its urban structure. The land was gradually occupied, following the natural course of the Paquequer River, without initial direct interventions. The street names referred to Brazilian rivers from different regions. For example, the main avenue "Amazonas" (the Brazilian name for the Amazon River), was crossed by streets named after rivers of other watersheds and tributaries. However, over time, the city's expansion along the Paquequer River became orthogonal, marking a milestone in the settlement process and the landscape modification (Santos, 2023).

Therefore, Teresópolis's origin and initial spatial configuration were strongly determined by the Paquequer River (Figure 1). The natural course of this river established the boundaries of the first allotments, along with political and social issues. Thus, the city's genesis is inextricably linked to the morphology and dynamics of the local river, which has shaped the urban structure from its earliest days.

Figure 1 - Map showing the location of the study area



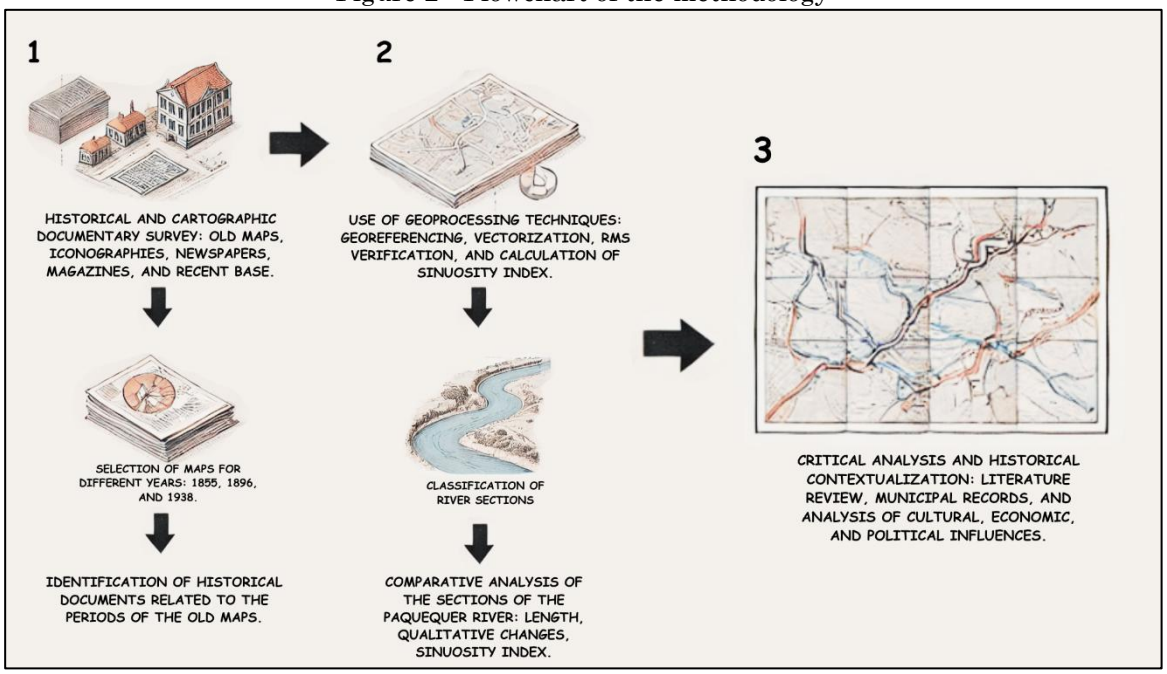
Source: The authors (2024).

In summary, studying the transformations that have occurred from the initial period to the present day proves itself crucial not only to understand the modifications in the course of the Paquequer River but also to serve as a base for broader analyses of the impact of these changes on the dynamics of the local drainage network. This knowledge is fundamental for urban planning and risk mitigation, especially regarding floods that affect the city (Silveira; De Souza, 2012; Trevisol; Maceira, 2015).

METHODOLOGY

This study adopted an interdisciplinary approach, combining historical cartography and iconographic analysis to analyze the transformations of the Paquequer River in the center of Teresópolis. This process was carried out in three stages (Figure 2): 1) gathering and analyzing old documents and maps from the years 1855, 1896, and 1938 to identify the representations of the river over time; 2) georeferencing and spatial analysis to compare the historical and current configurations of the river; and 3) critical interpretation of socio-environmental transformations associated with these changes.

Figure 2 - Flowchart of the methodology



Source: The authors (2024).

Gathering of Cartographic and Documentary Historical Documents

Initially, cartographic and iconographic historical documents, such as photographs and maps, as well as newspaper publications and articles from that time, were concurrently gathered. These documents were obtained from municipal archives, libraries, and private collections to elaborate a comprehensive information base that would allow for the analysis of the transformations that occurred over time in the course of the Paquequer River. Three main historical cartographic documents were discovered: the Therezopolis Map of 1855 (Ferrez, 1970), on a scale of 1:11,000, the Therezopolis City Map of 1896 (Vieira, 1938), on an approximate scale of 1:13,000; and the Teresópolis Map of 1938 (Cavalcante, 1938), on a scale of 1:10,000.

The maps analyzed follow a chronological sequence, starting with the one from 1855, obtained from Vieira's book (1938), whose authorship is anonymous; however, the document mentions Polycarpo Magalhães Álvares d'Azevedo, a relevant figure in the first allotment of land in Teresópolis, as responsible for the perpetual land tenure. The 1896 map, extracted from Ferrez's book (1970), had its approximate scale based on the metrics of the original map and adjusted after georeferencing (Santos, 2017). The 1938 map, prepared by the city hall per National Decree-Law No. 311 of March 2nd, 1938, is a copy of W. Cavalcante, and

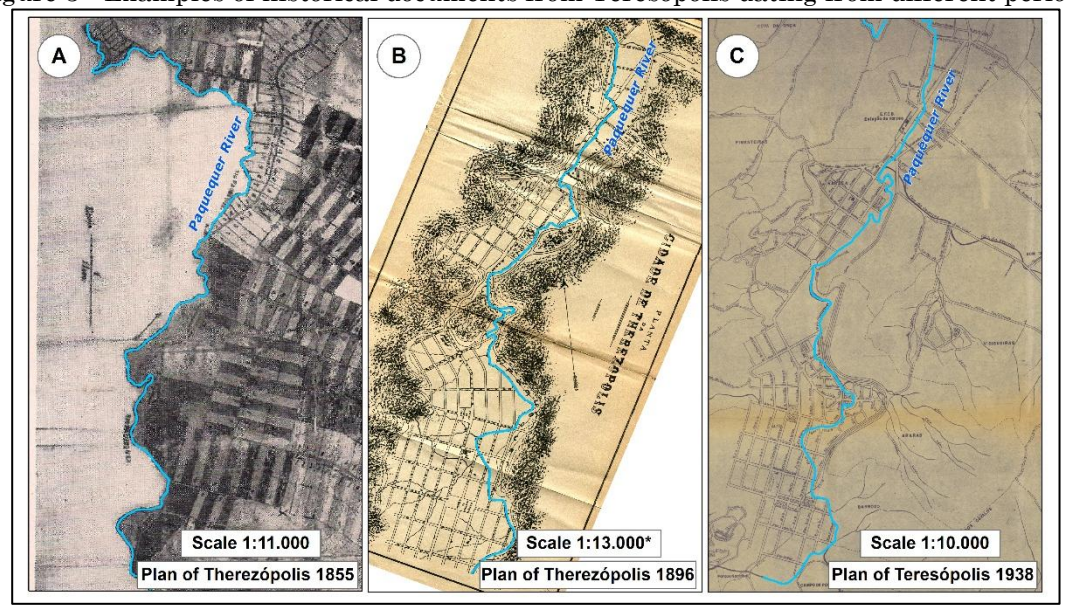
the scales of the maps of 1855 and 1938 are indicated on the maps themselves.

Georeferencing and Vectorization of Historical Documents

The historical maps were georeferenced through the ArcGIS PRO 3.4 software, licensed by the Universidade Federal do Rio de Janeiro (Federal University of Rio de Janeiro). For this, the continuous cartographic base of Rio de Janeiro, at a scale of 1:25,000, from the Instituto Brasileiro de Geografia e Estatística (IBGE, in Portuguese), the federal agency responsible for gathering statistical and geographical information in Brazil, was used, in addition to satellite images available on Google Earth. This ensured greater accuracy in the overlay and analysis of landscape transformations. After their scanning, precise geographical coordinates were assigned to the cartographic elements, allowing comparison with current data. The root mean square error (RMS) analysis indicated that using 6 control points provided the best results. The RMS values obtained were: 1.47 for the 1855 map, 2.60 for the 1896 map, and 2.65 for the 1938 map.

After georeferencing, the features of interest in the historical documents were vectorized. This process consisted of transforming the cartographic elements, such as the Paquequer River outline, from a raster to a vector format, simplifying the spatial and temporal analysis of the changes that occurred through time (Figure 3).

Figure 3 - Examples of historical documents from Teresópolis dating from different periods



Source: A - Ferrez (1970); B - Vieira (1938); C - Cavalcante (1938). Adapted by the authors (2024).

The location of the historical photographs used in this study was established through a meticulous interpretative analysis, focused primarily on the topographic morphological features that appear in the background of the images, as they often are stable over time and, therefore, reliable for spatial inferences. Additionally, recognizable urban structures identification, such as long-standing buildings and public roads, was a complementary reference in the correlation process with historical cartography. This method allowed for a precise triangulation between iconographic records and cartographic documents, enabling a coherent temporal reconstruction of landscape transformations.

Comparative Analysis and Historical Contextualization

With the vectorized and georeferenced data, a comparative analysis was carried out between the different outlines of the Paquequer River, considering metrics such as length, qualitative changes, and sinuosity index. This analysis allowed the identification of changes in the course of the Paquequer River and their correlation with the urban development of Teresópolis.

It is necessary to mention that, despite the existence of Municipal Law No. 0814, of 05/30/1974, which prescribes the codification, toponymy, and delimitation of neighborhoods and public areas in the urban and suburban areas of the city of Teresópolis, the descriptive

memorials of the city's neighborhoods have not yet been made available. Therefore, the neighborhood delimitations used in the final map that compares the traces were based on data from the 2022 Census, organized by IBGE, and carried out through interpretation and geoprocessing processes. This approach allows for the most approximate and up-to-date representation of neighborhood boundaries for the intended analysis.

The historical contextualization has been enriched by municipal documents and records that provide information on the cultural, economic, and political influences that shaped the city's development. This stage involved the review of secondary literature, including theses, dissertations, and scientific articles, to understand the historical and geographical context of the observed transformations.

One of the main metrics analyzed in this study was the Sinuosity Index, essential for characterizing and understanding the degree of change in the Paquequer River. The Sinuosity Index is calculated by dividing the channel's length in a given section by the length of this same section measured along the valley (Eq. 1) (Christofoletti, 1981, p. 150).

$$\text{Sinuosity Index} = L / t \quad \text{(Eq. 1)}$$

Where L is the length of the main channel and t is the vector distance between the start and end points of the stretch. Measurements of the Sinuosity Index were calculated through ArcGIS PRO 3.4, which allowed accurate comparisons between different historical periods. The indices found for the three main channels were classified according to the typology proposed by Leopold and Wolman (1957). In this classification, sinuosity values smaller than 1.5 indicate rectilinear channels, while values equal to or greater than 1.5 correspond to meandering channels. This distinction is critical to understanding fluvial dynamics and changes in channel morphology as responses to natural and anthropogenic factors.

The analysis of the sinuosity was crucial for contextualizing the changes in the course of the Paquequer River in correlation with urban development and the evolution of the landscape of Teresópolis. By comparing the historical maps and the recent base of the IBGE (scale 1:25,000), it was possible to observe the changes in the outline of the river over 1855, 1896, 1938, and 2018. This analysis helped to identify sections of the river that have undergone straightening or other significant modifications. Based on the sinuosity indices, the river's sections were classified into rectilinear or meandering. This classification allowed the understanding of the different fluvial dynamics present in each stretch and its correlation with historical urbanization events and environmental changes.

Through diachronic analysis, it was possible to correlate the changes in sinuosity with human activities such as urban sprawl and transport infrastructure. This allowed a deeper understanding of how human interventions influenced the morphology of the river. The classification of river channels proposed by Leopold and Wolman (1957) distinguishes rivers into three main categories: straight, meandering, and intertwined channels. The application of this classification in this study revealed how different types of channels respond to environmental and anthropogenic changes, offering insights valuable for the management and conservation of water resources in the region of Teresópolis.

RESULTS

History and Administrative Formation of Teresópolis

The fascination with Teresópolis dates back to the first official description of the region made in 1788 by Baltazar da Silva Lisboa, who described the Serra and the Imbuí Waterfall. Its origin, in turn, dates back to the early years of the nineteenth century, when George March, a Portuguese of English origins, acquired a large amount of land and transformed it into a farm called Santo Antônio do Paquequer, where the neighborhood Alto is located today (Câmara Municipal de Teresópolis, 2024).

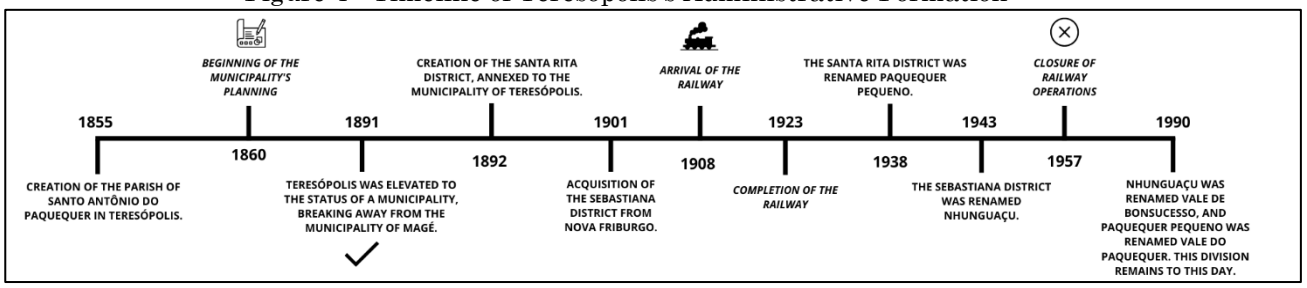
The village's growth occurred initially in the north-south direction. It served as a resting point for merchants from Minas Gerais who went to Porto da Estrela port in Magé, a municipality in Rio de Janeiro. In 1855, it became the parish of Santo Antônio do Paquequer. It was only in 1891 that it reached the category of municipality, receiving the name it maintains to this day, although with spelling modifications: before Therezópolis, now Teresópolis. Although its planning began in 1860, the construction of the railway, which significantly boosted the development of the municipality, only started in Teresópolis in 1908 and was completed in 1923, when the Várzea station was inaugurated (Almeida, 2018).

Santos (2023) presents an overview of the evolution of Teresópolis, highlighting the relationship between population growth,

infrastructure, and economic development of the city. Initially, Teresópolis had a modest population growth, driven mainly by agriculture and summer tourism. The railway's establishment in the early twentieth century, however, was a key milestone in the transformation of the city. The new access road facilitated the arrival of people and goods, leading to significant population growth.

The synthesis of the administrative evolution of the municipality of Teresópolis, with its respective territorial and institutional changes over time, is summarized in Figure 4 (Féo, 2016; Santos, 2023):

Figure 4 - Timeline of Teresópolis's Administrative Formation



Source: The authors (2024).

The census data presented by Santos (2023, p. 119) clearly demonstrate this growth: between 1890 and 1920, the population of Teresópolis more than tripled. Therefore, the railway catalyzed the city's urban development, connecting it more efficiently to Rio de Janeiro and boosting its economy.

Additionally, the municipality of Teresópolis has a Municipal Director Plan, established by Complementary Law No. 079/2006. Notably, this director plan establishes goals that support the enhancement of the landscape and ordering urban space. It also shows concern for ensuring the adequate location of the population, without harming the natural landscape. However, it is important to note that the law does not define clearly what figures as a "landscape", although its value is highlighted. This ambiguity in its definition is an area of significant interest for future research as understanding what constitutes the landscape is fundamental to analyzing its influence on environmental management, territorial planning, and society's interaction with the environment.

Analysis of the transformation of the Paquequer river landscape

The different perspectives on the concept of landscape offer varied possibilities for its use in legislation and planning processes. According to Miklós *et al.* (2019), it is necessary to define first what should be managed and planned. Secondly, one must understand the landscape's "offer". Thus, it becomes clear that the interests of the various activities that permeate socioeconomic life occupy the same spaces, resulting in conflicts of interest. These conflicts are particularly evident when factors such as conservation are considered, reinforcing the need for a strategic and integrated approach to the landscape. However, the question arises: How should this be done?

According to the new theories and interpretations on this theme, a comprehensive landscape research strategy is necessary (Bertrand; Bertrand, 2007; Gambino; Peano, 2016; Miklós *et al.*, 2019; Passos, 2016; 2022; Semenov, 2017). This strategy must consider its three essential dimensions: social, economic, and environmental. In addition, it must explore the connections between these dimensions to ground and democratize territorial planning and ordering.

Under the same prism, Reis *et al.* (2021) conducted a literature review on landscape incorporation as a right, an object of interest, and a theme in legal and social discussions. It also addresses the growing association of landscape with themes such as democracy, participation, and its legal recognition not only in Brazil but also internationally (Ribeiro, 2013). The perception that the right to landscape is essential for sustainable planning, management, and development, considering past, present, and future, stands out in this discussion, especially after the European Landscape Convention in 2000. In addition, the concept of the right to landscape is seen as a cultural right, beyond mere aesthetic appreciation, and is related to the human rights expansion.

However, the mobilizations around the disputes for landscape are fostering the demand for the recognition of the right to landscape. Depending on the context and how the term is appropriated, the right to landscape may involve the right to see the landscape, to be in it, or to

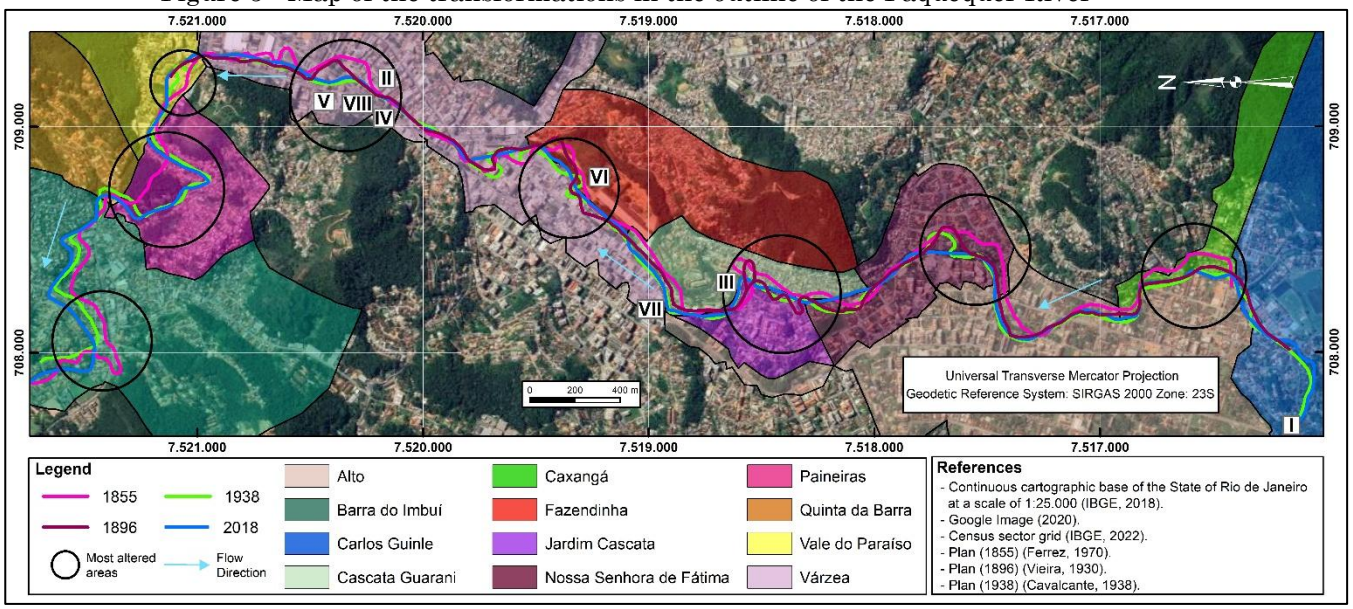
be part of it, highlighting the notion of landscape citizenship (Reis *et al.*, 2021; Ribeiro, 2020).

The landscape is understood as a common good, a fundamental element of the production and reproduction of human values, and its regulation through the creation of laws is becoming relevant as the landscape is consolidated as a right and an object of interest and disputes in society (Ribeiro, 2020). Due to its social and historical formation, and as a continuous process, it is considered of primary public interest and can be used for public policies in sustainable development (Gonçalves, 2015). The increased use of the term "landscape" in the 2000s should also be highlighted since it reflects the growing exposure of the concept in academia and in actions of different scales, as well as the influence of the Instituto do Patrimônio Histórico e Artístico Nacional (IPHAN), the federal agency in charge of registering and preserving the country's tangible and intangible historical, artistic and cultural heritage, in promoting the ideas of landscape and cultural landscape (Reis *et al.*, 2021).

Therefore, understanding the dynamics of the landscape and its transformations over time is fundamental for elaborating effective public policies and preserving historical and cultural heritage. In this context, historical cartography emerges as an indispensable tool, allowing the reconstruction of past landscapes and the analysis of changes that have occurred in a given territory.

Figure 5 compares the outlines of the Paquequer River in different historical moments extracted from historical maps (Ferrez, 1970; Vieira, 1938; Cavalcante, 1938). Through this cartographic representation, it is possible to observe the changes in the watercourse and its adjacent areas over time. The black circles delimit the most altered areas, evidencing the intensification of human occupation and anthropic interventions in the natural environment.

Figure 5 - Map of the transformations in the outline of the Paquequer River



Source: The authors (2024).

The map reveals that the Paquequer River has undergone significant transformations over the last decades, result of urbanization and population growth in Teresópolis. The straightening of the river, the construction of bridges, the detours, the construction of the railway, and the occupation of the river banks (Figure 6) are examples of interventions that have altered the river's natural course and impacted the local landscape. These changes, in turn, impacted biodiversity due to the removal of riparian forest areas and also influenced the hydric and sedimentary dynamics of the region (Vieira; Cunha, 2008).

Figure 6 - Evolution of the Paquequer River landscape

Source: Reminiscências de Teresópolis (2024). Elaborated by the authors (2024).

The analysis of this sequence of historical images of the Paquequer River, which covers approximately 60 years (1908 to 1968), reveals significant transformations in the urban landscape and the relationship between the city and the watercourse.

1908-1930: The Railway and the First Occupation

- Presence of the railway: The first images demonstrate the railway's importance for the region's development, as it prompted the construction of bridges and the integration of rail transport into the landscape.
- Natural landscape: The river has a more natural course, with wooded banks and less human intervention.
- Beginning of occupation: The start of the occupation of river banks can be observed, especially in the vicinity of the railway station.

1950-1961: Urban Growth and First Interventions

- Urban growth: From the 1950s, the city's growth accelerated with the expansion of the urban network and the occupation of areas near the river.
- Soil waterproofing: The images show stretches of the genesis area that are densely waterproofed already, indicating the vulnerability of the urban area to flooding events, typical of the region, and the need for flood control measures.
- Interventions in the river: The construction of bridges and the channelization of some river sections demonstrate the first attempts to control the watercourse and adapt it to the needs of the expanding city.

1961-n.d.: Consolidation of the urbanization

- Consolidation of urbanization: The most recent images show the consolidation of urban occupation on the river banks, such as the construction of buildings and leisure areas.

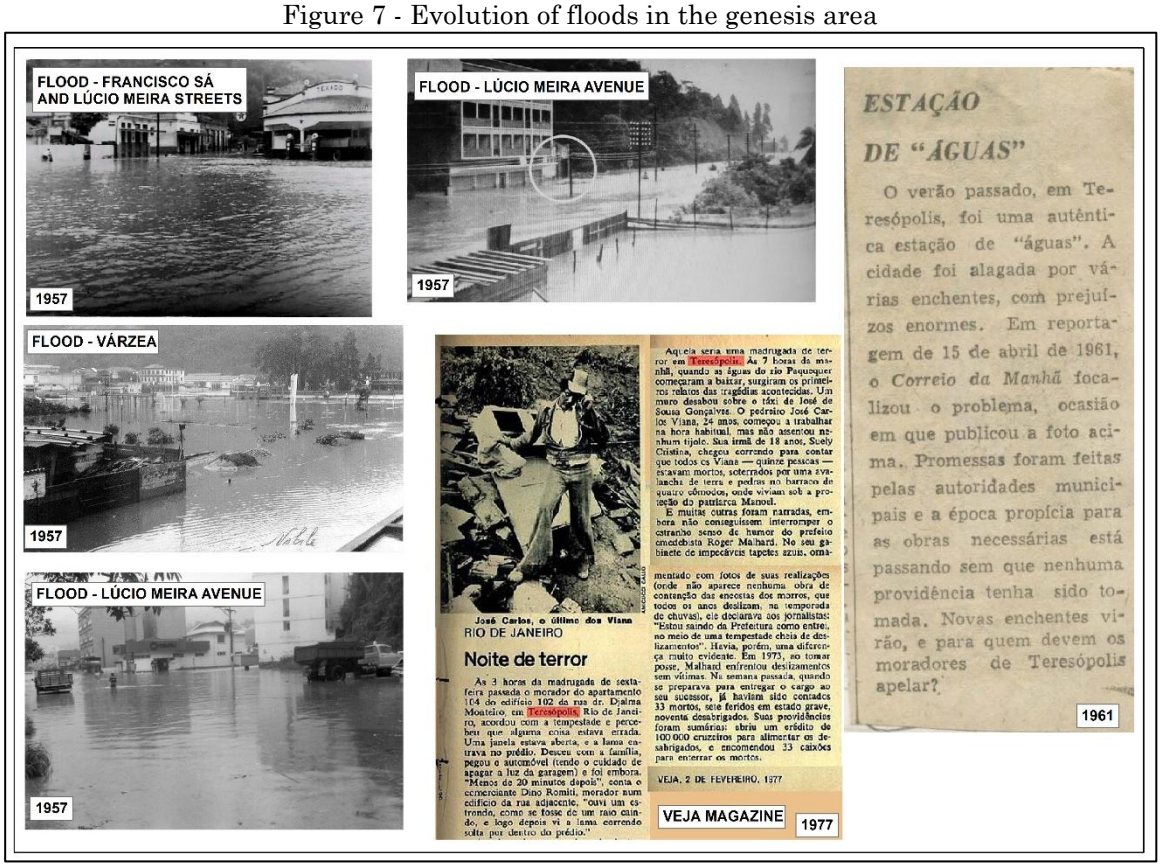
- Changes in the course of the river: The river presents a more standardized course, with the construction of retaining walls and the creation of artificial channels.
- Use conflicts: The coexistence of residential, commercial, and leisure areas in the river vicinity highlights the land-use conflicts and the need for more integrated urban planning. The river was used for recreational boating as shown in the 1968 image.

N.D: The Lago Encantado

- Intense transformations: The Lago Encantado was formed by the winding curve of the Paquequer River, located between the Alto and Várzea neighborhoods, in the vicinity of the old railroad tunnel. The lake and the railway line composed a characteristic landscape of the region. However, with the decommissioning of the railway in 1957, the lake had the same fate, gradually disappearing and leaving few traces of its existence.

The urban fluvial dynamics, deeply influenced by human activities, have been the subject of increasing scientific interest. Interventions such as deforestation and impermeable areas expansion, in addition to engineering works that alter the channel's morphology, have caused significant changes in the hydrological and geomorphological regimes of urban watercourses (Vieira; Cunha, 2008). In Teresópolis, processes such as straightening, widening, and narrowing of channels, intensified by siltation and the occupation of floodplains, jeopardize the rivers' conduction capacity and increase the vulnerability to flood events (Figure 7).

Figure 7 - Evolution of floods in the genesis area



Source: Reminiscências de Teresópolis (2024). Elaborated by the authors (2024).

An emblematic example is the case of the Várzea neighborhood, whose name, which means "floodplain" or "meadow", already suggests its location in an alluvial plain naturally subjected to flooding. The 1957 photographs depict one of these occurrences. They show that changes in the layout of the Paquequer River, associated with the urbanization process, intensified the frequency and magnitude of these floods. The soil waterproofing, which reduces the infiltration capacity of rainwater, and the change in the watercourse, a result of interventions in the river, contributed significantly to the aggravation of this problem. This has been a recurring problem in the genesis area of the

municipality - the disposal of countless objects, the silting of the river, and its straightening and confinement have only worsened it over the years. But what have been the quantitative changes in the outline of the Paquequer River over the years?

The calculations of the Paquequer River sinuosity, considering only the genesis area, showed significant variations over time. To ensure the homogeneity of the data, the 1896 records were excluded from the analysis, since they do not cover the entire area's extent (Table 1).

Table 1 – Calculation of the sinuosity in the genesis area

Year	Length of the River (m)	Length of the line (m)	Sinuosity
1855	8982.07	5270.51	1.7
1938	8914.12	5270.51	1.69
2018	8371.82	5270.51	1.58

Source: The authors (2024).

Analysis of the data reveals a general trend of decreasing sinuosity over time. In 1855, the river had the greatest sinuosity, which indicates a more meandering channel. On the other hand, the sinuosity in 2018 is the smallest, suggesting a more rectilinear though still meandering channel. This particular reduction may be related to several factors, such as erosive processes and sediment deposition, but mainly to human interventions in the channel, which alter the river's water and sedimentological regime (Vieria; Cunha, 2008).

The delimitation of the 1896 outline as the maximum limit allowed consistent comparisons between all analyzed periods (Table 2).

Table 2 – Calculation of sinuosity in the genesis area cutout

Year	Length of the River (m)	Length of the line (m)	Sinuosity
1855	6808.06	4758.23	1.43
1896	6709.65	4758.23	1.41
1938	6569.97	4758.23	1.38
2018	5956.37	4758.23	1.25

Source: The authors (2024).

The analysis presented in Tables 1 and 2 reveals a decreasing trend in sinuosity over the studied period. The most evident decrease occurred between 1938 and 2018, indicating a straightening process of the river section. To deepen this analysis, the study focused on a spatial cutout of the Paquequer River, where qualitative changes in the layout were identified, demonstrated by the black circles in Figure 3. The results obtained for these more altered areas suggest that the straightening process was more intense in these places. However, it is essential to highlight that the characterization of the sinuosity for this spatial cutout does not represent the condition of the Paquequer River in all its extension, since the length of the river and the position of the straight line were adjusted for the analysis. In other words, the area studied was delimitated so that the comparison between the traces had the same start and end point.

CONCLUSIONS

The study of the landscape transformations of the Paquequer River, located in the central area of Teresópolis, highlights the importance of historical cartography and iconography as analytical tools to understand urban evolution and landscape transformations over time. This research revealed a significant decrease in the river's sinuosity, result of a continuous channel straightening process. It also highlighted the structural role of the Paquequer River in the urban development of Teresópolis. The integration of historical georeferenced maps with contemporary cartographic data provided a detailed analysis of the modifications in the river's course, allowing for correlations between human interventions and changes in fluvial morphology. This information is crucial for urban planning and environmental management of the city, especially in the context of the frequent floods that affect the region.

Identifying and interpreting these changes is essential for understanding the landscape as a structuring element of urban space. The reduction in the sinuosity of the Paquequer River, evidenced by comparative analyses, suggests a direct impact of human actions on the river's morphology, highlighting the interdependence between urban development and natural dynamics. Through historical cartography, it was possible to not only map these transformations but also to contextualize them within the historical, economic, and social processes that drove the growth of Teresópolis.

Future research should focus on the development and application of predictive flood models that consider the historical changes in the course of the Paquequer River. These models can integrate historical and current data to predict risk areas and assist in implementing effective preventive measures. In addition, the use of historical cartography as a basis for sustainable urban planning is essential. Past transformations analysis can guide the development of policies that preserve the historical-cultural heritage while mitigating environmental impacts. It is also recommended that cartographic accuracy studies be carried out on the historical maps to verify their accuracy and potential for use in current planning. This calculation will allow for the reliable use of historical maps in restoration and urban planning projects.

The methodology used in this study demonstrated the relevance of historical cartography in the analysis of landscape transformations, offering insights into the effective management of water resources and sustainable urban development. Furthering research in this area, with the incorporation of advanced geoprocessing techniques and predictive modeling, will contribute significantly to urban resilience and the preservation of the environmental and cultural heritage of Teresópolis.

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Pietro Meirelles Brites: Conceptualization, Methodology, Investigation, Formal analysis and Writing - Original Draft.

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