
Mapping the historical evolution of land use and occupation in the municipality of João Pessoa-PB, from 1985 to 2022

Mapeo de la evolución histórica del uso y ocupación del suelo en el municipio de João Pessoa-PB, de 1985 a 2022

Mapeamento da evolução histórica do uso e ocupação do solo no município de João Pessoa, Paraíba de 1985 a 2022

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Abstract

Mapping land use and occupation is a procedure that makes it possible to analyze how a given area is being occupied and how this reflects on society. With this in mind, this work was developed with the aim of mapping land occupation in the city of João Pessoa-PB, which is one of the fastest growing cities in Brazil. This article was developed by processing images obtained from the INPE system and from Landsat 5 and 8. The period from 1985 to 2022 shows changes in use in urban and agricultural areas, with an increase in urban centers. The suppression of vegetation and soil sealing are the most recurrent problems in this process of urban expansion.

Keywords: use and occupation; agricultural mosaic; urbanization; space-time variation; INPE.

Resumen

El mapeo del Uso y Ocupación del suelo constituye un procedimiento que permite analizar cómo se está ocupando una determinada área y cuál es el reflejo de esto en la sociedad. En este sentido, este trabajo fue desarrollado con el objetivo de mapear la ocupación del suelo de la ciudad de João Pessoa-PB, que se configura como una de las ciudades de mayor crecimiento en Brasil. Así, este artículo fue desarrollado a partir del procesamiento de imágenes obtenidas del sistema INPE y de los satélites Landsat 5 y 8. El período de 1985 a 2022 presenta modificaciones en el uso en áreas urbanas y agrícolas, donde se observa el aumento de los núcleos urbanos. La supresión de la vegetación y la impermeabilización del suelo constituyen los problemas más recurrentes de este proceso de expansión urbana.

Palabras clave: uso y ocupación; mosaico agrícola; urbanización; variación espacio-tiempo; INPE.

Resumo

O mapeamento do Uso e Ocupação do solo constitui um procedimento que permite analisar como determinada área está sendo ocupada e qual o reflexo disso na sociedade. Nesse sentido, este trabalho foi desenvolvido com objetivo de mapear a ocupação do solo da cidade de João Pessoa-PB, onde configura uma das cidades que mais crescem no Brasil. Assim, este artigo foi desenvolvido a partir do processamento de imagens obtidas do sistema INPE e do Landsat 5 e 8. O período de 1985 a 2022 apresenta modificações no uso em áreas urbanas e agrícolas, onde se observa o aumento dos núcleos urbanos. A supressão da vegetação e a impermeabilização do solo constituem os problemas mais recorrentes desse processo de expansão urbana.

Palavras-chave: uso e ocupação; mosaico agrícola; urbanização; variação espaço-temporal; INPE.

Introdução

Land use is directly related to the social and historical processes of the space in question. Land use for urbanization, for example, completely changes the behavior of natural characteristics, and results in impermeability, soil compaction and hydrological responses (Fontes, 2003). Geographic space develops on the ground, with cities and a large portion of human subsistence activities dependent on the use of this resource. The loss of this surface, caused by pollution and erosion, are some of the consequences of its misuse by those who manage it (Guerra, 1993). Given the complex relationship between man and nature, in recent years there has been a growing search for studies that aim to understand the dynamics resulting from

human occupation of the natural environment (Campos, 2008). Soil, as an open system, plays a fundamental role in this interaction, receiving and emitting energy through processes such as the absorption and release of nutrients, water and heat. In addition, soil also plays a crucial role in the exchange of gases with the atmosphere. However, human interference can disrupt this system, impairing energy exchanges between different parts of the soil profile and other external systems, such as the atmosphere.

The city of João Pessoa, capital of the state of Paraíba, has experienced significant population growth, which, according to the latest IBGE census (2022), represents an increase of more than 15.26% compared to the 2010 census data. This data shows that the city went from 723,515 inhabitants in 2010 to 833,932 inhabitants in 2022, making it the capital with the highest growth in number of residents in the entire Northeast (IBGE, 2022).

Demographic growth brings with it a series of extremely important aspects. The expansion of the urban fabric occurs in parallel with the expansion of the needs of new inhabitants and the transformations in spaces previously dedicated to historical activities in the region, such as subsistence agriculture and livestock farming. This increase in urban centers, with evidence in areas in Latin America, represents an expansive and rapid growth, mainly in the second half of the 20th century, evidenced by the mass rural exodus, which made planning difficult and increased the disorderly occupation of areas considered to be protected or at risk, such as riparian forests and hills. This appropriation generates numerous environmental challenges for the city, such as changes in the rainwater drainage system and the increase in the erosion process, considered to be the result of waterproofing or compaction (Ferreira et al, 2005).

In this sense, the process of mapping land use and occupation becomes essential for urban planning by administrators, in order to ensure the best use and management of spaces. Taking this into account, the development of geotechnologies

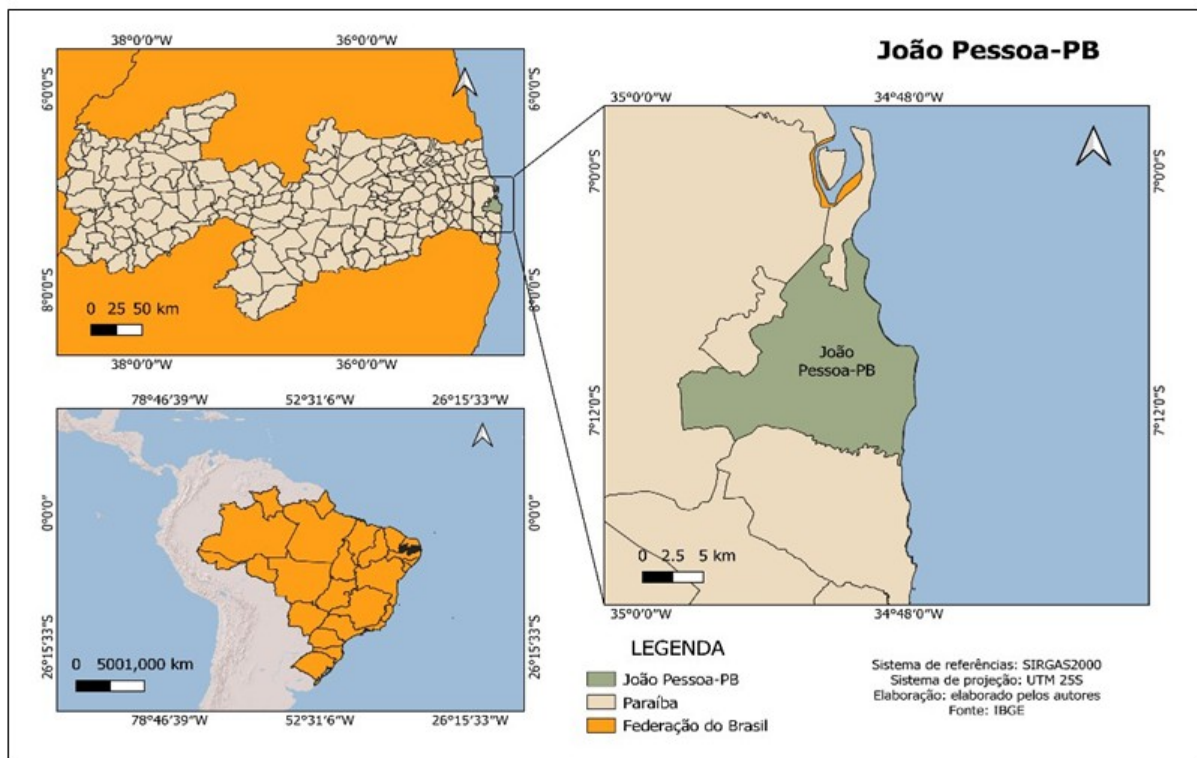
improves the understanding of the different uses that are being developed in the territory. Thus, this research aims to carry out a comparative analysis based on the mapping of land use and occupation in João Pessoa, in the years 1985 and 2022.

This study is important because it allows us to visualize and understand such transformations and how they reflected on the environmental and social dynamics of the city.

Materiais e métodos

The municipality of João Pessoa, in Paraíba, is located in the Northeast region of Brazil, at coordinates $7^{\circ} 6' 55''$ S and $34^{\circ} 51' 40''$ W. It has a total area of 210.044 km², according to data from IBGE (2022), map 1.

Map 1- João Pessoa-Paraiba-Brazil



Source: Prepared by Silva(2024)

The methodological procedures used in this research were defined based on the delimitation of the study area, which was chosen based on its changes in land use and occupation throughout history. Thus, the procedures carried out were bibliographic research, field visits, and analysis and mapping from satellite images.

The satellite images used to generate the land use and occupation maps were obtained through the INPE (National Institute for Space Research) website, where images from LANDSAT 5 and LANDSAT 8 were selected, with a spatial resolution of 30 meters, dated 1985 and 2022, in line with the classification methodology developed by the MapBiomas platform.

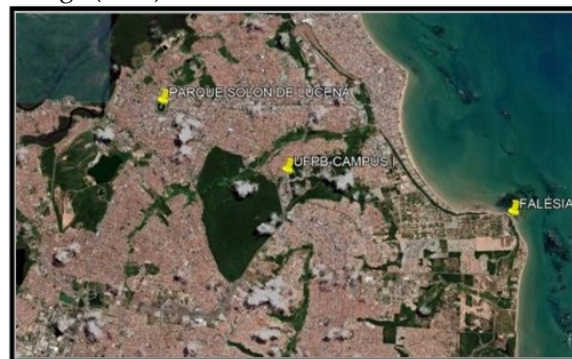
After processing the images, which were acquired in geotiff model with UTM projection and WGS-84 Datum and handled using GIS QGIS 3.36, a total of 11 classes were obtained in the first map and 12 classes in the second. With the preliminary products completed, it became necessary to carry out field visits to validate the preparation of the map. Letter image 1

Image card 1- Expansion of the urban area of the city of João Pessoa-Paraíba-Brazil

Image (1985)



Image (2022)



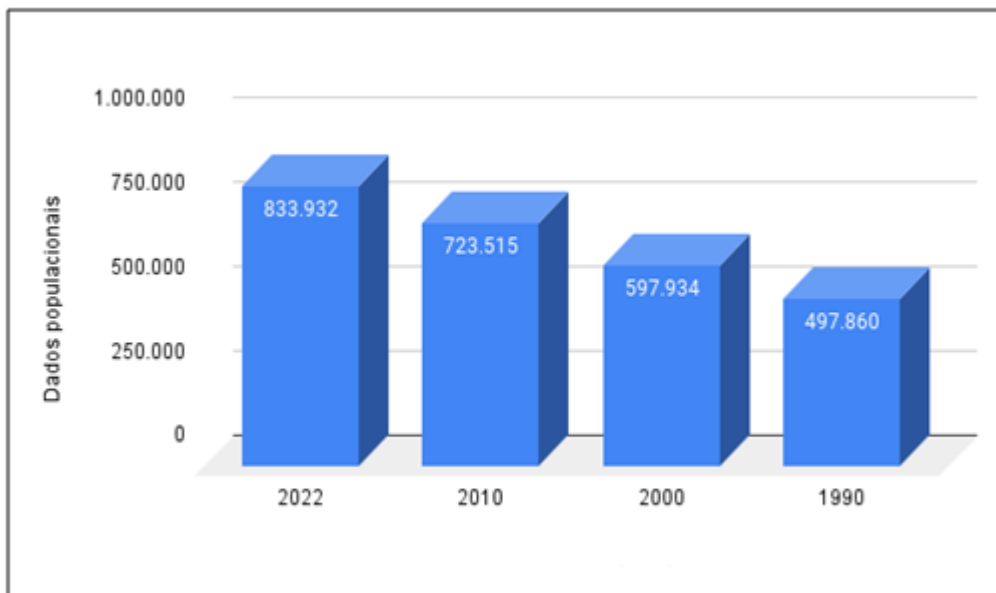
Source: Landsat image (1995-2022) available in Google Earth Pro (2024).

Results and discussion

The occupation of the southern part of the city with the construction of the Mangabeira housing complex in mid-1983 (João Pessoa, 2023) symbolizes the occupation of new areas far from the center, built to meet the housing needs of groups who migrated from the countryside to the city, driven by the flow of rural exodus. Thus, the variation in space and time from 1985 to 2022 shows several changes in the use of land in previously undeveloped areas.

Population growth is one of the main causes of the expansion of the urban fabric in João Pessoa, since a large part of the new buildings and expansions in the city reflect the need to provide infrastructure and services to serve the new residents. In Graph 1, which shows the increase in the urban population from 1990 to 2022 based on data from the IBGE, it is possible to observe a significant increase. During this period, the city's population registered a growth of 67.5%, highlighting the significant demand for housing, services and urban facilities.

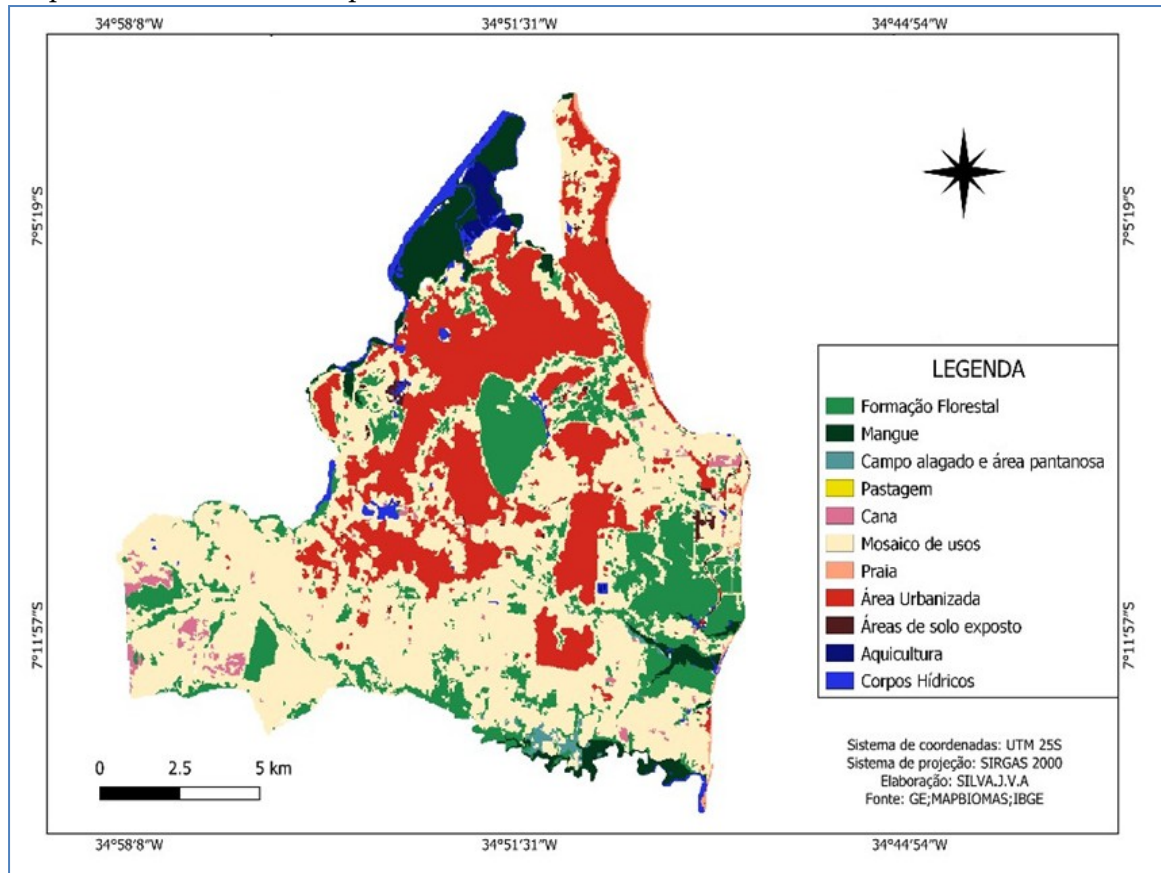
Graph 1 - Comparison of population data between the demographic censuses from 1990 to 2022



Source: Prepared by Silva, data from Ibge (2024)

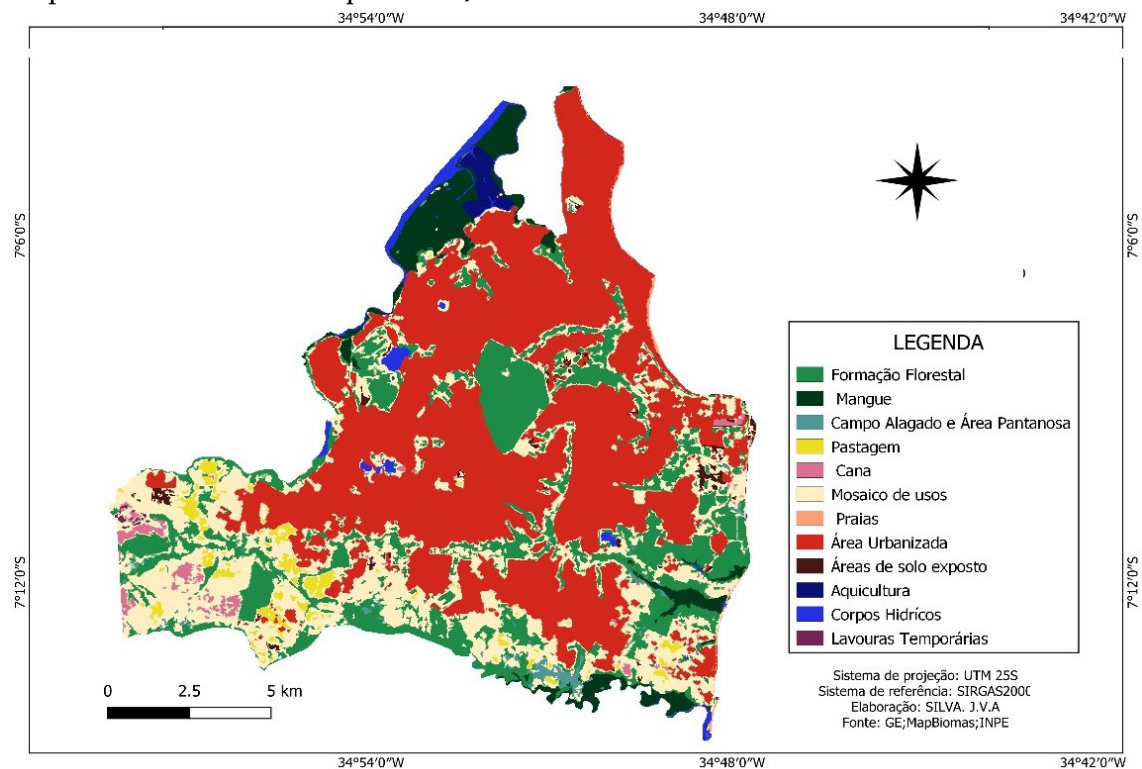
The urban network, made up of roads, houses and other social facilities, was expanded and began to occupy areas of vegetation, which led to deforestation, and areas, called agricultural mosaics, which were intended for the development of agriculture. Thus, it is possible to observe the maps of land use and occupation in João Pessoa and their variation between the years 1985 and 2022. (Maps 1 and 2).

Map 2- Land use and occupation of João Pessoa-Paraíba -1985



Source: Silva (2024)

Map 3 - Land use and occupation of João Pessoa-Paraíba – 2022

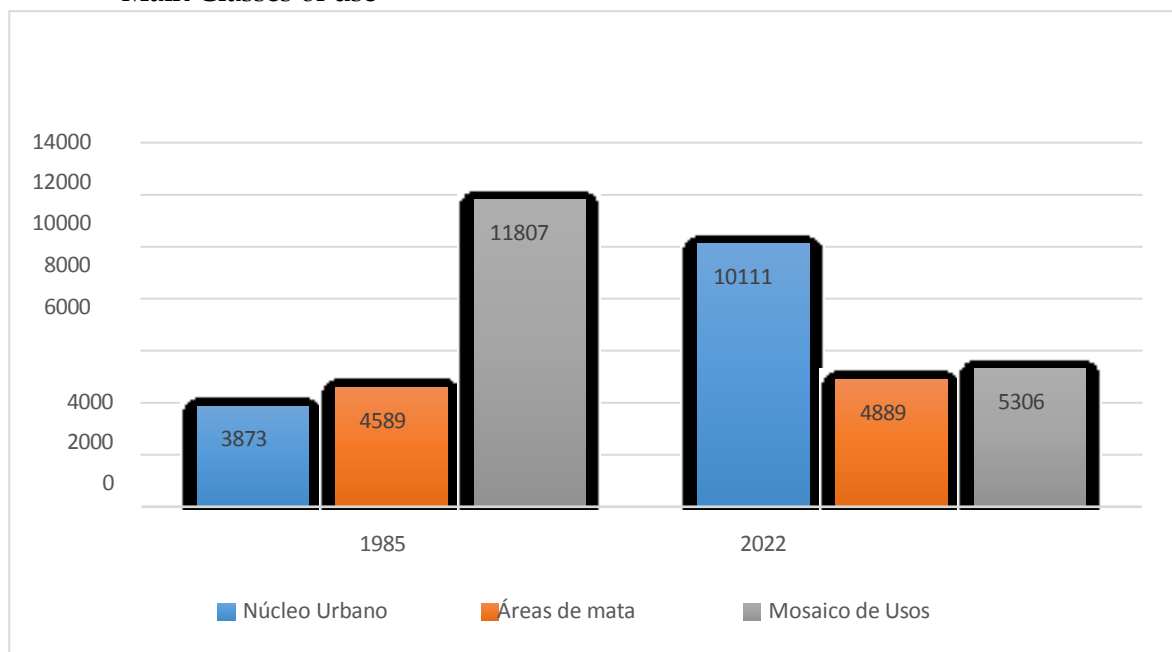


Source: Silva (2024)

As highlighted by Rafael (2009), between 1980 and 2000, urban expansion was concentrated mainly in the northern coastal region of the municipality, encompassing neighborhoods such as Bessa and Jardim Oceania, as well as in the southern center, which includes the neighborhoods of Bancários, Valentina, Água Fria, Ernesto Geisel, Mangabeira and José Américo. Recently, there has been a trend towards replacing the horizontal construction pattern (houses) with a vertical pattern (buildings), especially in the coastal region and in the southern zone, due to excessive land appreciation.

The biggest changes between 1985 and 2022 are reflected in the scenario of increased urbanization, which includes all urban features such as roads, streets, avenues, houses and infrastructure. In statistical data, according to the report published by the MapBiomas website in its collection 8, the urban area of the city of João Pessoa-PB went from 3,873Ha to 10,111Ha in area, which represents a growth of 261.06%, as shown in graph 1.

Graph 1: Comparison of the main layers that had changes in the comparison: Size H of the Main Classes of use



Source: Land Use Map (2022)

To illustrate the changes, we selected data from the MapBiomas website, where we identified three main classes, with the forest area comprising forest

formation and mangroves, as shown in graph 1. In these data, the advance of urban expansion to the detriment of the mosaic of uses class is visible. According to the definition of the IBGE (2023), the mosaic of uses encompasses areas of mixed use, such as agriculture, pasture, forestry and forest remnants, as well as areas with natural or anthropogenic disturbances that make their characterization difficult. The behavioral dynamics of the mosaic of uses class reflect a city that is still undergoing urban development; however, old customs still persist. In the city's history, for many centuries, the main economic activities were the production of sugarcane and pasture for poultry and goats. With urban expansion, these activities were incorporated into the panorama of the so-called rural perimeter of the city (IBGE, 2022). The mosaic of uses includes not only pasture or agricultural areas, but also areas of secondary vegetation, which Moreira (2008) considers to be areas relatively degraded by man, areas that have undergone or are undergoing deforestation or burning. It is worth noting that, during the quantitative survey of the data, it was recorded that, in the second Use and Occupation map, another class of use was included. This analytical category is called Temporary Crops, which is theorized as an area of rotational and seasonal planting, comprising areas of mixed planting of crops for subsistence consumption. According to the IBGE (2022), the main agricultural products produced within the municipal perimeter are concentrated in subsistence production to meet the demands of population consumption in urban open-air markets, such as the production of cassava, sweet potatoes and vegetables. In this sense, the Temporary Crop areas are located far from the urbanized central regions, the same applying to the Pasture category, which also showed an increase in the analyzed period. It is pertinent to highlight that in several areas on the occupation map and empirical analyses, it is notable to see the presence of lagoons. Vital (2015) emphasizes that a large part of the lagoons in the city are the result of the process of dissolution of limestone present in the lower geological layers. This process creates caves and depressions that, in turn, end up becoming the city's

lagoons due to the deposition of rainwater. It is worth mentioning that during the analysis and processing of the data, we observed a relatively simplified change in the Forest Formation categories. This increase can be attributed to the environmental conservation measures implemented by the city of João Pessoa in recent years (João Pessoa, 2023). However, according to MapBiomias (2022), with the improvement of images and the development of new observation technologies, areas previously classified in other categories were renamed. These reclassifications follow the standards established by the geotechnology tool and reflect the modernization in the approach to analyzing the areas.

Anthropic influence, especially urbanization, can alter the natural interaction process of the environment. These new altered areas behave independently of their natural landscapes, having adverse responses to environmental causality.

Throughout the study, it was possible to perceive changes in land use in the city of João Pessoa, notably the change from the mosaic of uses as the predominant class in 1985 to the urban core in 2022, exemplifying the relationship of exchange of uses for land.

Final considerations

In view of the above, the data collected in the research clearly demonstrated the urban development in the city of João Pessoa-PB during the period analyzed. This horizontal and vertical expansion in the city's urban fabric generates numerous results within the logic of cause and effect. These results, combined with poor planning and territorial management caused by unbridled urbanization, impact the systemic responses of the city's physical environments.

The intense human occupation of the soil and the consequent removal of natural cover profoundly alter the organic structure of ecosystems, affecting their responses to extreme events, such as torrential rains. Urban expansion and the

construction of new residential areas have led to soil compaction, pollution and erosion of landscapes. These changes also impact the sensory perception of residents in relation to the environment, highlighting the formation of heat islands. The lack of humidity, essential for thermal regulation, intensifies this phenomenon in densely urbanized areas with cleared vegetation.

Territorial management is extremely important for the environmental conservation of an area. Based on this statement, the study attempted to spatialize the process and development of land use and occupation in João Pessoa-PB to the detriment of the area's natural landscapes and their causes, which can contribute to a future review of land use and occupation laws.

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Contribuição dos autores

Autor 1; Elaboração, metodologia, discussão dos resultados, fundamentação teórica, revisão textual, análise final dos resultados.

Autor 2: Revisão textual, discussão dos resultados.

Autor 3: Revisão textual, discussão dos resultados.

Autor 4: Revisão textual, supervisão.

Autor 5: Revisão Textual, supervisão, orientação.