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CHANGES IN LAND USE AND COVER FROM 2013 TO 2023 IN THE MUNICIPALITY OF CASTANHAL- PA

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Abstract: This study analyzes changes in land use and occupation in the municipality of Castanhal, Pará, between 2013 and 2023, with a focus on deforestation and its impacts. The research uses geospatial data and satellite images to identify and map the main transformations in urban, rural and forest areas over the period. With the help of Geographic Information System (GIS) tools, thematic maps and a comparative graph were created to visualize changes in land use, allowing trends such as the advance of urbanization and agriculture to the detriment of native vegetation areas to be identified. The study also presents a flowchart describing the main stages of the land occupation process and its environmental effects, such as the loss of biodiversity and alterations to the hydrological cycle. Data analysis indicates that urban and agricultural expansion has been the main driver of deforestation in the region, resulting in significant environmental and social impacts. Finally, the implications of these transformations for local sustainable development are discussed and policy recommendations are presented to mitigate the negative impacts of deforestation, promoting a more balanced use of the land.

Keywords: Deforestation, Urbanization, Environmental Impacts, Castanhal

INTRODUCTION

Changes in land use and land cover are highly relevant topics in discussions on sustainable development, especially in regions such as the Amazon, where pressures on natural resources are intense. The municipality of Castanhal, located in the state of Pará, has faced significant transformations in its territory in recent decades, driven mainly by urbanization and agricultural expansion. As Silva and Oliveira (2019) state, “uncontrolled urbanization is one of the greatest threats to biodiversity and the sustainability of ecosystems, espe-

cially in tropical regions”. These changes raise concerns about the environmental impacts resulting from deforestation and the degradation of local ecosystems.

This work aims to analyze the dynamics of land use and occupation in Castanhal over the last ten years, specifically between 2013 and 2023. Data on deforestation, urbanization patterns and their environmental consequences will be examined. Based on a quantitative and qualitative approach, the study will use Geographic Information System (GIS) tools to map the changes that have occurred, as well as drawing up a comparative graph that allows for a better visualization of the transformations in land use. As Campos (2021) notes, “the use of geographic information technologies allows for a more precise analysis of changes in land use, providing fundamental data for environmental management”.

The questions to be investigated include: What were the main areas affected by deforestation in Castanhal? How have urbanization and agricultural expansion impacted local ecosystems? What are the implications of these changes for the environmental sustainability of the region? By analyzing the data, we hope to contribute to understanding the relationship between land use, deforestation and sustainable development, as well as providing recommendations for the proper management of natural resources.

THEORETICAL FRAMEWORK

LAND USE AND LAND COVER: CONCEPTS AND FUNDAMENTALS

Land use and land cover refer to human activities in geographical space, such as agriculture, commerce and residential areas. Land use reflects socio-economic dynamics, while land cover refers to the way these activities and natural elements are distributed and organized on the earth's surface. According to

Santos (2006), these practices are shaped by cultural and economic factors. Villaça (2012) points out that urban planning is crucial to organizing these uses in a sustainable way.

RECENT TRANSFORMATIONS IN LAND USE

In recent decades, Brazilian cities have experienced rapid changes in land use due to urbanization and infrastructure expansion. In medium-sized municipalities like Castanhal, urban growth can lead to problems such as a lack of basic services and environmental degradation (Almeida, 2018). Irregular occupation is a challenge that affects both the environment and the quality of urban life (Monteiro, 2020).

PUBLIC POLICIES AND LAND USE

Public policies such as the City Statute (Law No. 10.257/2001) guide land use, establishing guidelines for sustainable development. The Master Plan is one of the main instruments in this regard, regulating zoning and occupation patterns. In Castanhal, urban growth depends on the implementation of these policies and the articulation between the various actors involved (Silva, 2019).

LAND USE DYNAMICS IN CASTANHAL

In the last 10 years, Castanhal has undergone transformations marked by urban expansion and migration. The city's growth has brought challenges such as the conversion of agricultural areas into urban ones and pressure on natural resources. Its strategic location, close to Belém, contributes to this process of accelerated development.

METHODOLOGY

This work used a qualitative and quantitative approach to analyze changes in land use and occupation in Castanhal over the last 10 years.

The methodology was structured into the following stages:

LOCATION

The municipality of Castanhal is located in the state of Pará, with a territorial area of 1,029.300 km², which corresponds to 0.08% of the total area of Pará. It belongs to the Guamá integration region and according to the regional geographic division drawn up by the IBGE (Brazilian Institute of Geography and Statistics), the municipality is part of the Belém Metropolitan mesoregion and Castanhal microregion and in the Castanhal intermediate geographic region and Castanhal immediate region and is approximately 68 km from the capital of Pará. Its municipal seat has the following geographical coordinates: a latitude of 1° 17' 50" South and a longitude of 47° 55' 20" West.

BIBLIOGRAPHICAL RESEARCH

The first stage consisted of a literature review to provide a theoretical basis for the topic. Academic articles and legislation related to urban planning, land use and occupation were consulted, as well as specific studies on the city of Castanhal. The search for references included databases such as Scielo, Google Scholar and specialized journals.

SECONDARY DATA COLLECTION

Secondary data obtained from official sources, such as the Brazilian Institute of Geography and Statistics (IBGE), the National Institute for Space Research (INPE), and the Castanhal city hall, were used to analyze land use. This data included land use and land cover maps, demographic information and statistics on urban and rural growth in the region.

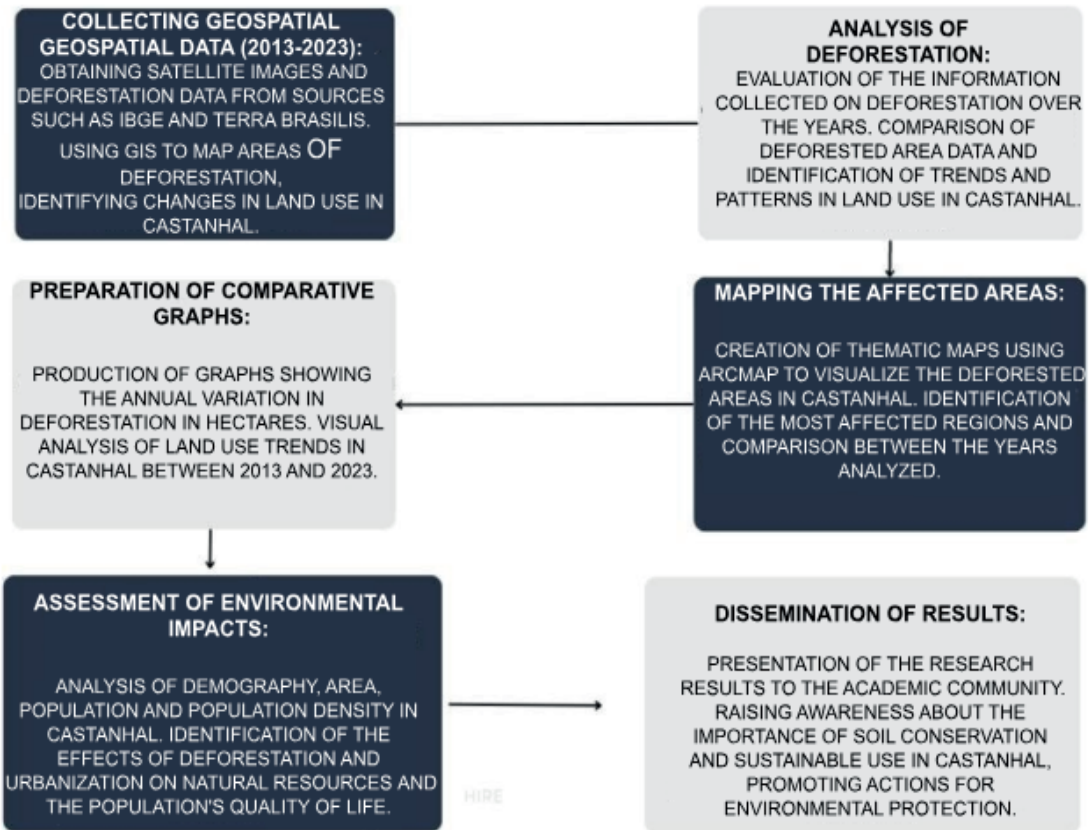


FIGURE 1 - Methodology flowchart

Source - Authors

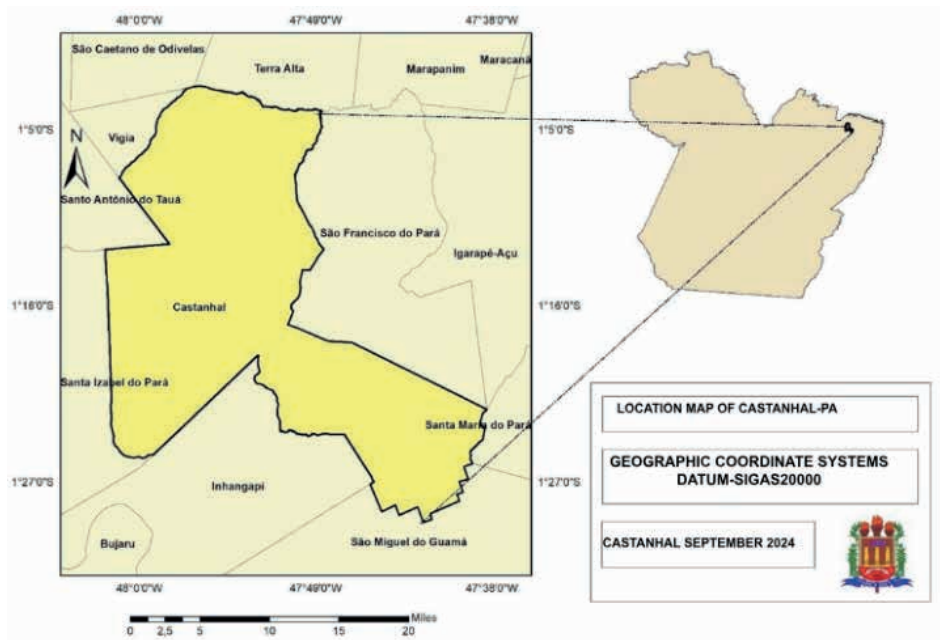


FIGURE 2 - Location map of Castanhal

Source - Authors

SATELLITE IMAGE ANALYSIS

An analysis of high-resolution satellite images was carried out to identify changes in land use over the last decade. The images were obtained from platforms such as Google Earth and the INPE database. The comparison between different periods made it possible to verify urban expansion, the transformation of agricultural areas and the occupation of environmental preservation areas.

DATA ANALYSIS

The data collected was analyzed using a combination of spatial analysis, using software such as QGIS, and content analysis of the interviews. The information obtained enabled thematic maps and graphs to be drawn up illustrating the transformations in land use in Castanhal. The results were interpreted in the light of the theoretical framework and public policies applicable to territorial management.

RESULTS AND DISCUSSIONS

Analyzing the data collected reveals an oscillating trend of deforestation in the municipality of Castanhal between 2013 and 2023. The year 2013 recorded the highest rate of deforestation, with 123.15 hectares. This high figure may be related to the intensification of urbanization and the expansion of new housing and commercial areas. In the following years, there was a significant drop in deforestation in 2014 (19.85 hectares), indicating a possible momentary containment of urban expansion. However, the data shows that, after 2014, deforestation increased again, reaching peaks in 2016 (84.47 hectares) and 2017 (91.49 hectares). These years coincide with a significant expansion of urban and agricultural areas in Castanhal, driven by pressure for new housing developments and infrastructure to accommodate population growth. From 2019 onwards, a further drop is observed, reaching a minimum point of 25.02 hectares, which

may be a reflection of new regulations or the exhaustion of the most accessible areas for expansion. However, in 2020, deforestation increased again, reaching 74.73 hectares, possibly driven by the recovery of the economy and the need for new urban and agricultural spaces. The year 2021 saw another significant peak (95.78 hectares), reaffirming the correlation between urban growth and the loss of natural areas. This data, expressed in the graph, shows the vertical growth caused by the advance of urbanization into rural areas. The maps below illustrate the main deforestation hotspots from 2013 to 2023.

The graph below expresses the data from the maps above more clearly.

The data indicates that the advance of urbanization in Castanhal is directly related to the increase in deforestation during periods of population and economic growth. Territorial expansion, especially in areas of native vegetation and rural areas, has been one of the main causes of environmental degradation. The demand for housing, industrial areas and agricultural spaces has put pressure on land use, leading to the conversion of natural areas into urbanized land. This dynamic is evident in the peaks in deforestation observed in 2013, 2016 and 2021, when urban expansion seems to have accelerated. These moments of increased deforestation coincide with periods of local economic growth, increased housing demand and the lack of a stricter urban control and planning policy.

The following table shows a correlation between population growth and the density of inhabitants per square kilometer (Hab/km²) in Castanhal from 2013 to 2022, and the impact of this on deforestation. During this period, the population increased from 183,917 inhabitants in 2013 to 205,667 in 2021, with the population density also increasing from 178.75 inhabitants per square kilometer to 199.81 inhabitants per square kilometer.

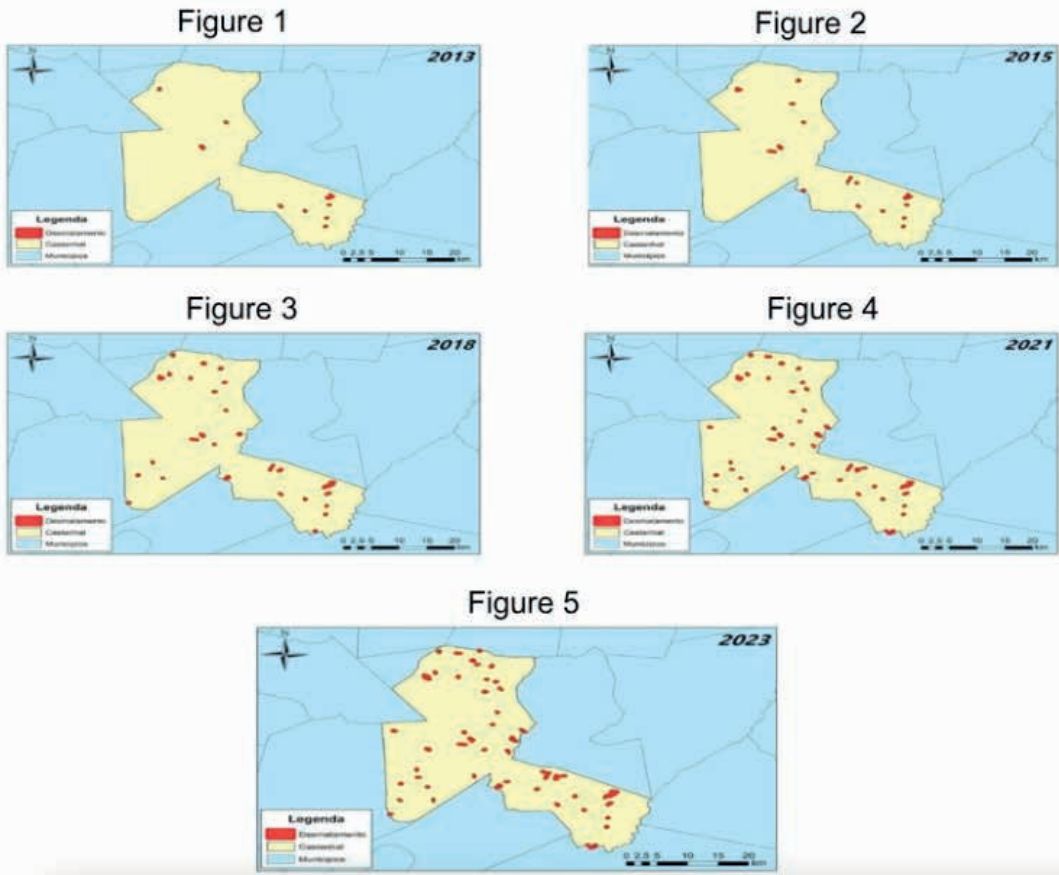
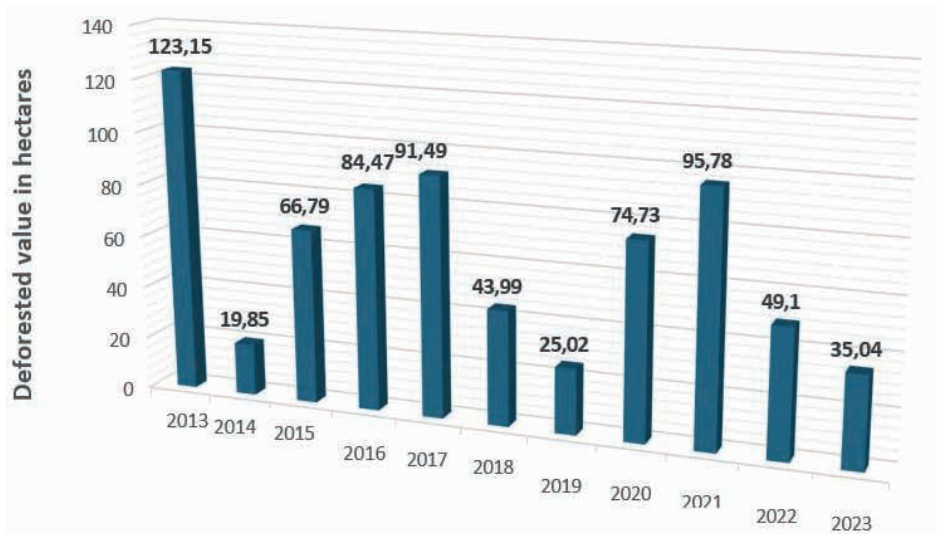


FIGURE 3 - Map of deforestation in the municipality (2013-2023)

Source - Authors



Graph 1 Annual Deforestation in Hectares in Castanhal (2013-2023)

Source - Authors

| Year | Deforestation | Population (Hab) | Area (km ²) | Density (inhab/km ²) |
|------|---------------|------------------|-------------------------|----------------------------------|
| 2013 | 123,15 | 183.917 | 1.028,90 | 178,75 |
| 2014 | 19,85 | 186.895 | 1.024,80 | 182,37 |
| 2015 | 66,79 | 189.784 | 1.024,80 | 185,19 |
| 2016 | 84,47 | 192.571 | 1.028,89 | 187,16 |
| 2017 | 91,49 | 195.253 | 1.028,89 | 189,77 |
| 2018 | 43,99 | 198.294 | 1.030,26 | 192,47 |
| 2019 | 25,02 | 200.793 | 1.029,30 | 195,08 |
| 2020 | 74,73 | 203.251 | 1.029,30 | 197,47 |
| 2021 | 95,78 | 205.667 | 1.029,30 | 199,81 |
| 2022 | 49,1 | 192.256 | 1.029,30 | 186,78 |
| 2023 | - | - | - | - |

Table 1 - Demographics and deforestation

Source - Authors

This population increase generates direct pressure for new urban areas, which contributes significantly to the advance of deforestation, as observed in the years of greatest expansion. Between 2013 and 2021, it can be seen that deforestation peaks, such as in 2013, 2017 and 2021, coincide with periods of higher population growth and increased density, suggesting a direct relationship between the demand for housing and the expansion of urban and agricultural areas. In 2019, population density reached 195.08 inhabitants/km², and deforestation fell to 25.02 hectares, possibly as a result of temporary control policies or the saturation of areas available for expansion without major deforestation. However, the resumption of urban and agricultural growth in the following years, driven by high population demand, again resulted in high rates of deforestation, such as 95.78 hectares in 2021.

Analysis of the table shows that population growth does not necessarily translate into a proportional need for territorial expansion. The municipality's area has remained practically constant over the years, at around 1,029 km², suggesting that the increase in population density is more a question of how already urbanized areas are being used and reorganized, rather than uncontrolled territorial expansion. However, the occupation of new

areas, especially in 2016 and 2021, shows that urban expansion has been carried out without proper containment, reflecting the peaks in deforestation.

The significant drop in deforestation in 2019 (25.02 hectares) and 2023 (35.04 hectares) may signal a slowdown in urban expansion or changes in land cover patterns, but should also be interpreted with caution, as other factors, such as the implementation of environmental regulations or migration to peri-urban areas, may have influenced this temporary reduction. The data indicates that, despite population growth and increased density, deforestation remains a significant concern in Castanhal. Urbanization needs to be better planned to ensure that pressure on natural areas is minimized. Analysis of the table shows that the growth in population density can be an opportunity to invest in urban requalification policies, sustainable densification and preservation of natural areas, without the need to advance into forest and rural areas. The future of sustainability in Castanhal will depend on the municipality's ability to implement policies that not only limit deforestation, but also encourage more efficient use of already occupied land. The table shows that the increase in population density can be managed with policies aimed at opti-

mizing existing urban areas, avoiding encroachment on natural areas and mitigating the environmental impacts of disordered urban expansion.

CONCLUSION

Over the last 10 years, Castanhal has undergone intense transformations in land use and occupation, driven by population growth, urban expansion and proximity to the capital Belém. The analysis carried out reveals a pattern of accelerated urbanization, with an increase in residential and commercial areas, often to the detriment of agricultural and environmental preservation areas.

The lack of proper planning has contributed to the disorderly occupation of land, which has generated significant environmental impacts, such as deforestation and soil sealing,

increasing the risk of flooding and damaging the quality of water resources. In addition, the pressure on green areas and the conversion of land to urban uses highlight the need for more effective public policies to promote sustainable development.

Finally, it is essential that Castanhal adopts urban planning strategies that balance economic growth with the preservation of natural resources and the population's quality of life. The effective implementation of the Master Plan and other policies aimed at territorial management can help to organize this growth, promoting a more rational and balanced use of the land, ensuring that the city's development takes place in a more sustainable way in the coming years.

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