Temporal Change in Land Use and Cover in the Municipality of Entre Rios, Bahia (Brazil)

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The objective of this article was to analyze changes in land use and land cover in Entre Rios, Bahia (Brazil), between 2002 and 2022, using data from MapBiomas to contribute to decision-making of environmental interest. The method consisted of a bibliographic review, geoprocessing, and remote sensing techniques using QGIS software and MapBiomas Collection 8, allowing a 20-year temporal analysis. The results of land use and occupation resulted in 5 classes: Group 1 - Forest (variation of 8.7%); Group 2 - Non-forest natural formation (variation of -3.2%); Group 3 - Agriculture (variation of -3.5%); Group 4 - Non-vegetated area (variation of 28.3%) and Group 5 - Water bodies (variation of -5.8%). It is concluded that, from 2002 to 2023, there were relevant changes in land use and occupation for Entre Rios- BA, emphasizing the increase in forestry, agriculture, urbanized areas, mining, and the reduction of water bodies.
Keywords: Land Use. MapBiomas. Geoprocessing. Sustainability.

Anthropogenic changes to the Earth's surface have caused significant transformations in land cover, which have profound implications for ecosystem structure and functioning. Thus, detecting these land use transformations constitutes a significant research challenge [1].

The Brazilian Atlantic Forest is considered one of the great biodiversity hubs on the planet. It has an estimated 20,000 plant species and a high degree of endemic species [2]. In view of this, the Brazilian government established the Pact for the Restoration of the Atlantic Forest in 2009 in an attempt to protect and minimize the anthropogenic impacts on this biome. This document describes some initiatives and actions to assist in efforts to conserve and restore the biome by 2050.

However, according to data from the Annual Report of the SOS Mata Atlântica Foundation and INPE (2022), from January to October 2022, accumulated deforestation was 48,660 hectares [3]. Bahia had the largest number of degraded areas, 15,814 hectares. Also, according to the report, agriculture was the main driver of deforestation, followed by urban expansion.

Given this scenario of increasing anthropogenic changes in the landscape, research considering land use and coverage dynamics can contribute to decision-making regarding urban planning and sustainable development [4].

According to the United Nations (UN, 2023) [5], the Sustainable Development Goals (SDGs) are a global call to action from all spheres of society so that by 2030, all people can live with a higher quality of life in all aspects. Goal 11 highlights "*making cities and human settlements inclusive, safe, resilient, and sustainable*" (UN, 2023).

In this sense, the objective of this article was to analyze the changes in land use and coverage in the municipality of Entre Rios (BA) between 2002 and 2022, using data made available by the Annual Mapping Project of Land Use and Coverage in Brazil - MapBiomas [6].

Materials and Methods

Geospatial data were acquired through the MapBiomas Brasil platform, which processes images from the Landsat satellite provided by Google Earth Engine and provides a historical series of annual maps of land use and land cover in Brazil from 1985 to the present. The initiative uses empirical and statistical methods (e.g., random forest

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and machine learning) to count the recent history of pixels and create the aforementioned maps [1].

In this article, data from collection 8, published in August 2023 and featuring 29 mapped classes, were used to obtain land use and coverage data. This collection reviews data from annual land use and cover maps in Brazil in a historical series from 1985 to 2022 on a scale of 30 m x 30 m [6].

MapBiomas maps the following land use and cover classes: Forest (Forest Formation, Savannah Formation, Mangrove, Wooded Restinga), Non-Forest Natural Formation (Flooded Field and Marshy Area, Grassland Formation, Apicum, Rocky Outcrop, Herbaceous Restinga, Other Non-Forest Formations). Agriculture (Pasture, Agriculture, Forestry, Mosaic of Uses, Beach, Dune and Sand). Non-Vegeted Areas (Urbanized Areas, Mining, Other Non-Vegeted Areas). Water Bodies (River, Lake and Ocean, Aquaculture) [6].

The images of the land use and land cover maps were downloaded in Geotiff format from the Google Earth Engine website (through the link directed by the MapBiomas website), where data from 2002 and 2022 were selected for the municipality of Entre Rios-BA.

As the files were obtained in gray scales, the data was reclassified using QGIS software version 3.10.13 to extract information on land use and land cover classes.

Study Area

The municipality of Entre Rios is located in the North Coast Economic Region of Bahia, approximately 165 km from the capital of Bahia, Salvador. According to data from IBGE (2022) [7], Entre Rios has a population of 38,098 inhabitants and a population density of 32.08 inhabitants /km². The climate of the municipality is Af, that is, humid tropical, according to the Köppen -Geiger classification and its main characteristics are: average temperatures above 18°C; the hottest months are from December to March with maximums of 29.9°C; coldest months are from July to October with minimums of 17.4°C. The average annual precipitation in the municipality is 1339 mm, with the months between March and August having the highest precipitation [8].

In addition, it has a territorial area of 1,187.766 km² [7] that extends from the coast towards the interior of the State. Entre Rios is located in the Costa dos Coqueiros Tourist Zone, with three beaches in its territory: Porto de Sauípe, Massarandupió, and Subaúma [8]. Due to the transformations in the territorial and economic dynamics initiated with the construction of the second section of the BA-099 (Green Line) on the North Coast of Bahia, and to preserve the environmental heritage contained in this region through the proper organization of territorial occupation and the development of activities aimed at tourism consciously and sustainably, the Conservation Unit (UC) of the Sustainable Use Group, Environmental Protection Area (APA) of the North Coast of Bahia was created through decree 1,046 of March 17, 1992 [9].

The APA covers part of the municipalities of "*Jandaíra, Conde, Esplanade, Entre Rios and Mata de São João, whose territorial area is comprised, to the North, by the border between the States of Bahia and Sergipe*" [9]. Approximately 16% of the UC area is contained in the municipality of Entre Rios - BA [10].

The predominant biome in the municipality of Entre Rios is the Atlantic Forest [7]. Regarding the water resources management unit, Entre Rios is located in the Recôncavo Norte and Inhambupe Hydrographic Basin [8].

Results

According to Cruz and colleagues (2021) [11], orbital image data are important sources for mapping land use and land cover, as they contribute to the analysis of natural and anthropogenic elements.

In their study of the spatiotemporal analysis of land use and coverage in Benevides—PA, Macedo, and Farias (2022) [12] reported that remote sensing proved an effective tool for analyzing and monitoring land use.

Thus, the dynamics of land use and coverage were carried out for the municipality of Entre Rios-BA in 2002 and 2022, defining a 20-year time series.

MapBiomas Database

We observed that the level 1 classes of predominant use in the municipality of Entre Rios - BA were: Agriculture with 71.40% (highlighting Pasture, Silviculture); Forest with 25.26% (highlighting the subclass Forest Formation, Savannah Formation, Arboreal Restinga); Non-vegetated area with 1.26% (highlighting Beach, Dune and Sand, Urbanized Area); Non-Forest Natural Formation with 1.91% (Flooded Field and Marshy Area); and Water Body with 0.16% (Figure 1).

In Figure 2, the characteristics of land use for the year 2022 show significant changes over these two decades. Figure 3 highlights the changes for level 1 classes. Thus, it was noted that Agriculture, still in the lead, reduced its percentage to 68.92%; forestry increased to 27.45%; non-vegetated area increased to 1.62%; Non-forest Natural Formation reduced to 1.85%, and Water Body reduced to 0.15%.

Figure 4 allows a more detailed analysis regarding the percentage changes that occurred over the period evaluated (2002-2022) for the more specific level classes.

Thus, although the percentage of Agriculture and Livestock decreased by 2,941 hectares (-3.5%), mainly due to the decrease in pastures (-28.9%), there was an increase of 63.4% in Forestry, with a notable 11,456 hectares more, as well as an increase in agriculture and crops, which together total 45 hectares more. Other relevant data that need to be highlighted are the 62.7% growth in urbanization, which represents an additional 314 hectares; the expansion of mining, which was not identified in the 2002 mapping but was shown on the current map at 26 hectares; and the 5.8% reduction in water bodies, corresponding to 11 hectares, which may indicate environmental impacts, such as silting of rivers and lakes.

According to Souza (2009) [13], the municipality of Entre Rios's hydrographic basins, composed of the main rivers Inhambupe, Subaúma, and Sauípe, are heavily degraded by deforestation and pollution caused by livestock farming, agriculture (especially forestry), and mining activities, in addition to recent real estate and tourism interventions on the coastal strip.

Corroborating the results found, Silva (2022) [14] analyzed the influence of the evolution of land use and occupation on evapotranspiration in hydrographic basins, where it was possible to observe that in the hydrographic basin where the degree of change in land use and occupation was significant, the change in evapotranspiration rates increased, which is an indication of more significant pressure on the basin's water availability.

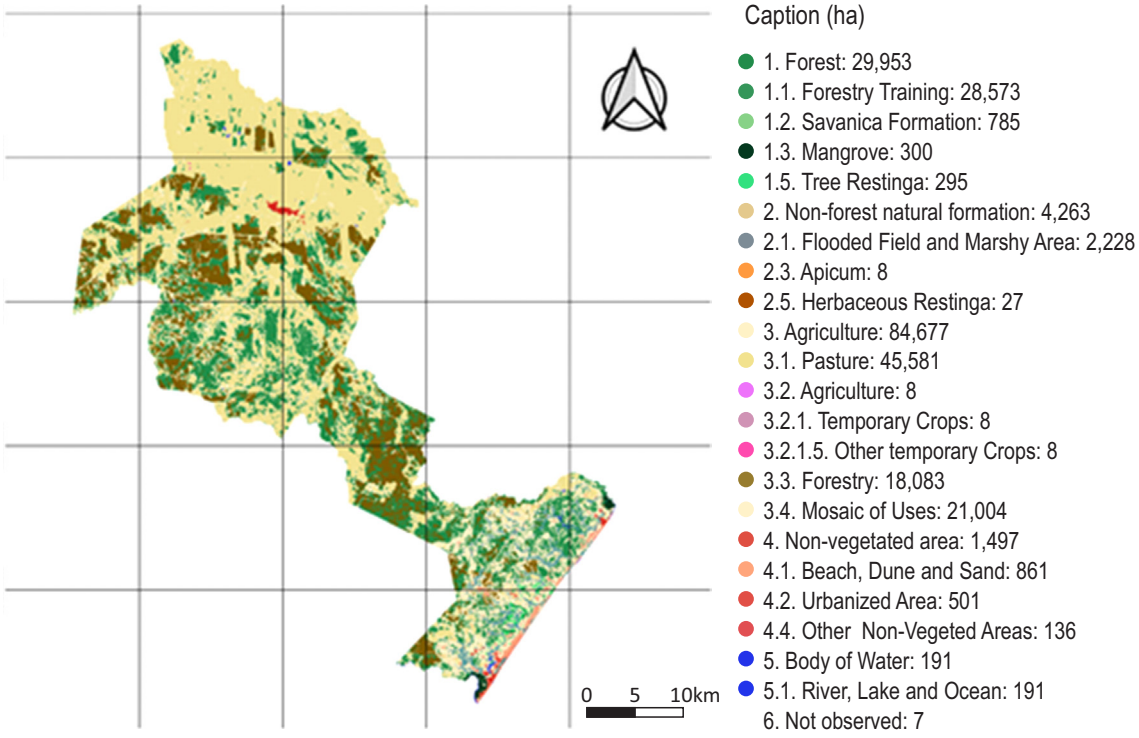
In addition, there were also reductions in Restinga Arbórea (-12.9%), Apicum (-50%), and Campo Alagado (-3.1%). Restingas have suffered over time from degradation and environmental losses in coastal regions due to the large and growing real estate and tourism development, as their environmental scenic beauty is an excellent attraction for these ventures [15].

The results also showed the relevance of geoprocessing, remote sensing, and technologies in general, especially the MapBiomas platform, as instruments to contribute to the temporal visualization of changes in land use and coverage, enabling studies in several areas, but especially in the environmental area [12].

Conclusion

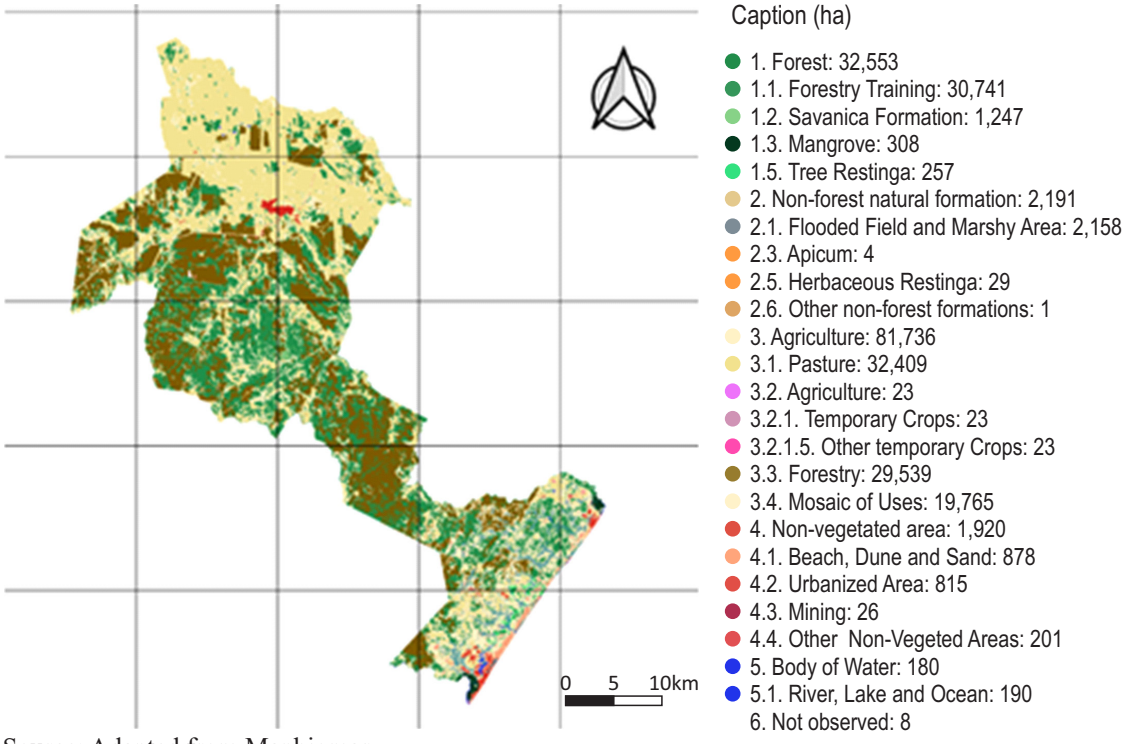
Therefore, from the mapping of land use and occupation, carried out through data made available by the MapBiomas platform and the use of the Qgis software, it was possible to perceive the changes that occurred in land use and occupation in the municipality of Entre Rios - Bahia (Brazil), in the period analyzed (2002-2022), with emphasis on the increase in forestry, agriculture, urbanized area, mining activity and the reduction of water bodies. Thus, the importance of monitoring natural resources is highlighted in the face of the challenges of reconciling economic, social, and environmental development.

Figure 1. Land use and land cover map of Entre Rios, Bahia, Brazil, 2002.



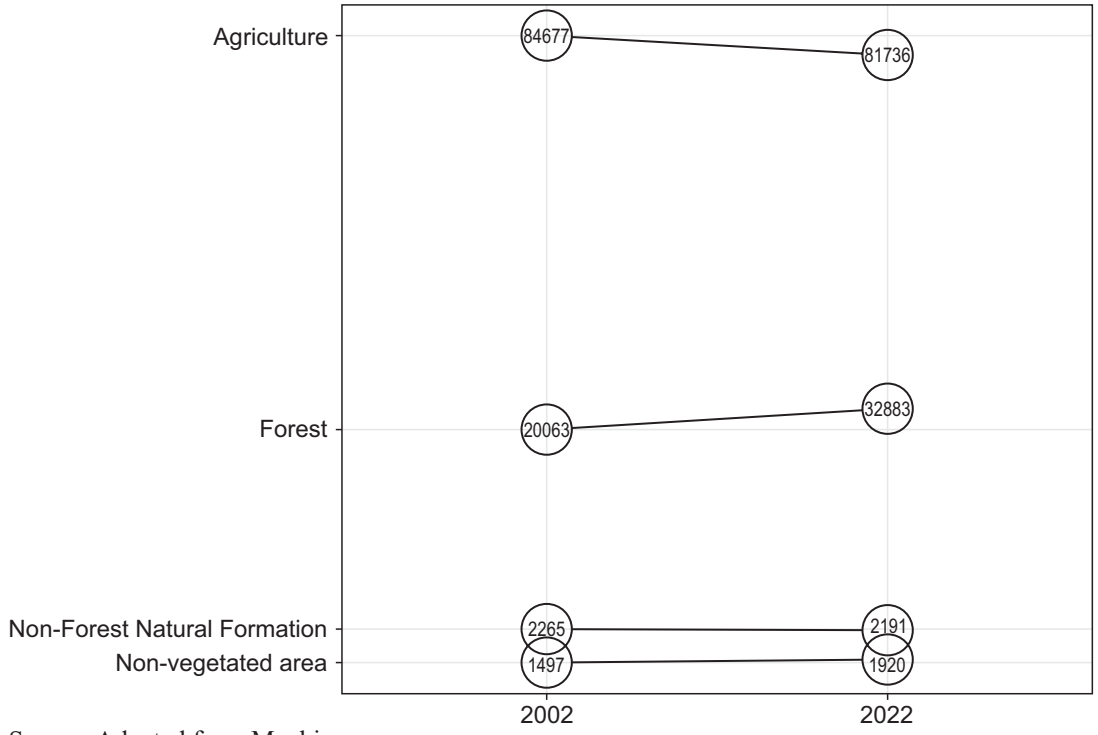
Source: Adapted from Mapbiomas.

Figure 2. Land use and land cover map of Entre Rios, Bahia, Brazil in 2022.



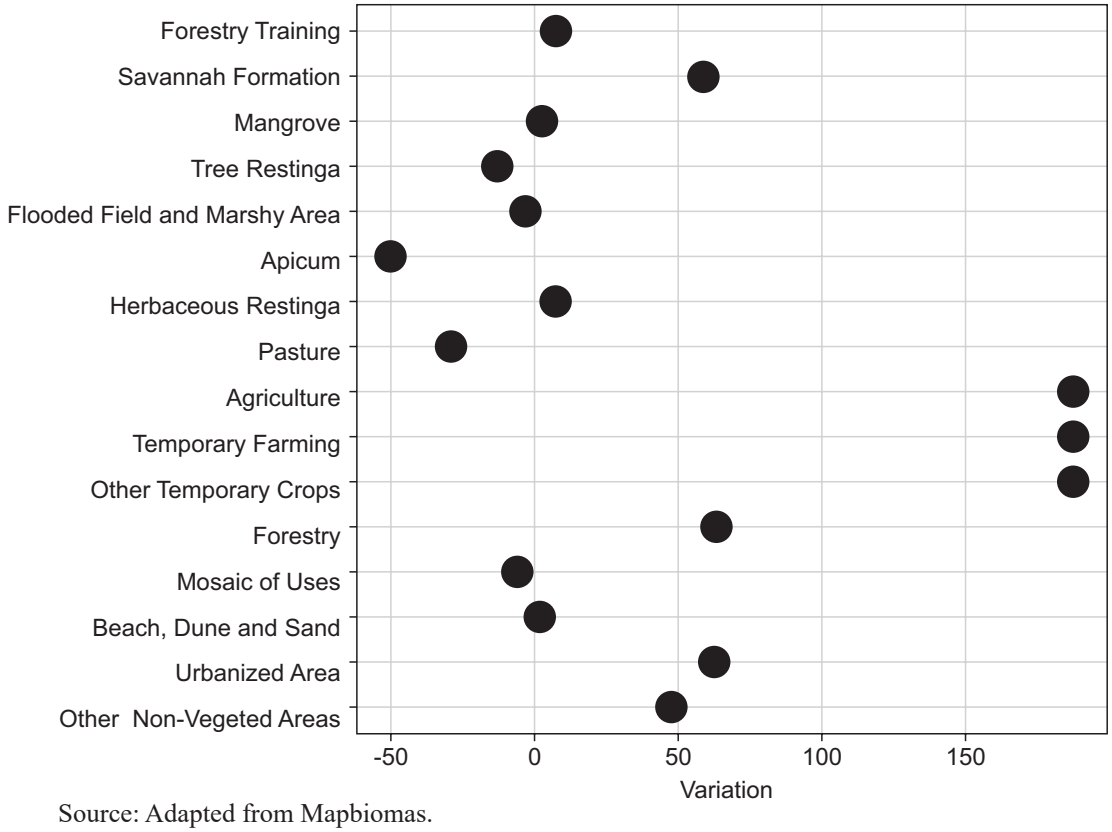
Source: Adapted from Mapbiomas.

Figure 3. Changes in level 1 classes between 2002 and 2022 in Entre Rios, Bahia, Brazil.



Source: Adapted from Mapbiomas.

Figure 4. Changes in specific classes between 2002 and 2022 in the municipality of Entre Rios -BA.



Source: Adapted from Mapbiomas.

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