ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

*International Journal of Development Research*
*Vol. 12, Issue, 12, pp. 60924-60929, December, 2022*
https://doi.org/10.37118/ijdr.25725.12.2022

RESEARCH ARTICLE

OPEN ACCESS

# LAND USE AND LAND COVER CHANGES IN CHAPADA DIAMANTINA, BAHIA, BRAZIL

**Thamires Oliveira do Bomfim[1], Édico Oliveira Gomes[2], Mario Andres Alvarado Castillo[3], José da Silva Cerqueira Neto[4], Rosângela Leal Santos[5], Melika Chicava Riley[6] and Elane Fiuza Borges[7]**

[1,2,3,4,5,6]Graduate Program in Earth and Environmental sciencesmodeling (PPGM), Feira de Santana State University (UEFS)

[7]Human Sciences Department, Feira de Santana State University (UEFS)

## ARTICLE INFO

***Article History:***

Received 06th September, 2022
Received in revised form
11th October, 2022
Accepted 24th November, 2022
Published online 25th December, 2022

***Key Words:***

Landscape changes, LULC, Remote Sensing.

****Corresponding author:***
***Haladu Haruna Kaugama Ph.D***

## ABSTRACT

Information on Land Use and Land Cover (LULC) is important to help decision-makersabout the consequences of human activities on the environment. Understanding the action of biophysical and socioeconomic factors on temporal and spatial scales helps in understanding landscape transformations. Information about LULC are produced on global, national, and regional scales. Ibicoara is a municipality located in the state of Bahia, Brazil, within the region of Chapada Diamantina. Due to its rich scenery, such as mountains and numerous waterfalls, Ibicoara has been standing out in regional tourism, particularly in ecotourism. This work aims to analyze the changes in Land LULC in the municipality of Ibicoara-BA, over a period of 30 years (1990 to 2020), to identify the factors that have contributed to these changes. Therefore, we used data from the MapBiomas Project, geoprocessing techniques in the Geographic Information System (GIS) environment, and statistical analyses in an R environment. Sankey diagram, land use change matrix, and land use map were produced to analyze the LULC changes. The results indicate that municipality underwent severe landscape changes between 1990 and 2020, especially showing a reduction in vegetation, to the detriment of other classes, such as urban areas and agriculture. It was also noted that the implementation of the Agropole Mucugê-Ibicoara and the construction ofApertado's damfavored the increase of agriculture due to greater access to water for irrigation.



**Citation:** ***Thamires Oliveira do Bomfim, Édico Oliveira Gomes, Mario Andres Alvarado Castillo, José da Silva Cerqueira Neto, Rosângela Leal Santos, Melika Chicava Riley6 and Elane Fiuza Borges. 2022.*** "Land use and land cover changes in chapada diamantina, bahia, brazil.*", International Journal of Development Research*, 12, (12), 60924-60929.

# INTRODUCTION

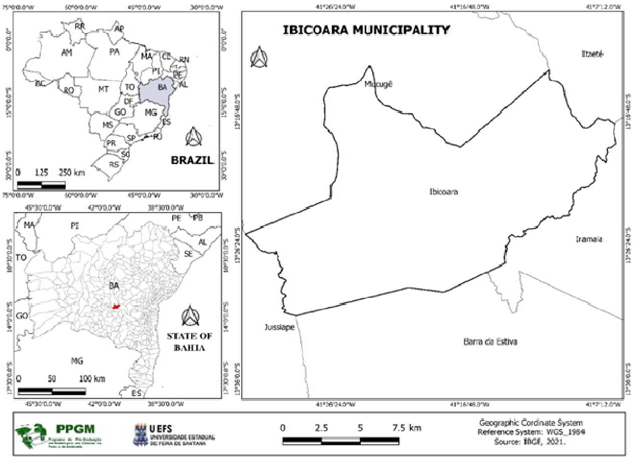
The replacement of the natural soil layer, caused by housing and infrastructure works, with the removal of vegetation, causes soil degradation, decreased water infiltration, increasing the percentage of surface runoff water, triggering erosive processes and promoting changes in the hydrological cycle (GOMES and ANDRADE, 2016). Thus, soil degradation ends up being a continuous process requiring studies capable of understanding its spatial and temporal dynamics (SALVATI and ZITTI, 2009). The removal of native vegetation is one of the main factors of landscape alterations. Maurano, Escada & Remo (2019) say that high rates of deforestation combined with global concern about the consequences of deforestation had given rise to various government policies of control and enforcement. Due to these factors caused by the removal of vegetation from the ground, Peters et al., (2016) say that land use should be a primary factor of study when thinking about more sustainable production processes and well-planned regional Land Use.

Thus, there is a need to develop studies that show changes in Land Use and occupation in the most diverse regions of Brazil and the world with suitable applicability. The analysis monitoring of land use is one of several applications of remote sensing (NOVO, 2008). The use of satellite imaging data associated with GIS has made it possible to carry out temporal analysis of Land Use and Land Cover, to identify the strengths and weaknesses of each region (ROSA et al., 2017). Since the launch of LANDSAT 1 on July 23, 1972 (NASA, 2021) several environmental studies have been developed with the help of satellite images. In the last decades and years, many techniques of LULC mapping and change detection have been developed and applied (CORDELL et al., 2017; ZIOTI et. al., 2021; BEUCHLE et al., 2015; MISHRA, RAI and RAI, 2019; DIAS, ALBUQUERQUE and RODRIGUES, 2020; ABDI, 2020; ABDULLAH et al., 2019; PARENTE et al., 2019; SARAIVA, et al., 2020; BAEZA et al., 2022). In geotechnological development, the MapBiomas Project is the first product that quantifies LULC changes in all Brazilian biomes with 30 m pixel size data.

The project uses cloud processing and automated classifiers developed and operated on the Google Earth Engine platform, thus generating a historical series (SOUZA et al., 2020). The process developed by Mapbiomas includes stages: LANDSAT dataset, classification with algorithm Random Forest, post-classification, map integration, transition map, statistics of area, and accuracy assessment (SOUZA et al., 2020). The Mapbiomas dataset allows different applications like an estimation of vegetation gain and loss and the change drivers and it is available on the internet (https://mapbiomas.org/) open access for non-commercial use (SOUZA et al., 2020). Since Mapbiomas was available, in 2017, several authors are using the LULC maps for these assessments for publication in different places (ROSAN, et al., 2021; FENDRICH, et al., 2020; CRUZ, BLANCO and OLIVEIRA JÚNIOR, 2021; ALMEIDA, et al., 2018; RIBEIRO, 2022; de MELO et al., 2022; SANTIAGO, BARBOSA and CORREIA FILHO, 2021; SANTOS and BRITO 2021; LOURENÇO et al., 2021). Ibicoara is a municipality located in Chapada Diamantina, Bahia, Brazil. Currently, the municipalities of Ibicoara and Mucugê are marked by large-scale agriculture, being recognized as a large agricultural pole, which recalls the diamond cycle of the region, which with its decline boosted the tourism, and today also represents one of the main economic sources in the Chapada Diamantina region (BORGES, 2009). According to the Chapada Diamantina National Park Management Plan (BRASIL, 2007), all regions in Chapada, have been gaining ground in local ecotourism since the decline of mining in the region. Also, the plan clarifies that this fact has been causing a floating population, which is attracted by the natural beauties present in the area, such as the existing waterfalls. In this context, the first objective of this work is to analyze the Land Use and Land Cover changes in the municipality of Ibicoara-BA, Brazil between the years 1990 and 2020 through Mapbiomas data. The second objective of this work is to identify the change drivers, that is, the main factors that are contributing to the changes occurring in the region. In this way, the results of this work can serve as an indication of which and where the transformations of the landscape are taking place, helping the decision-makers. For this, the study area and the methods used in this assessment will be detailed in the next sections.

# METHODS

**Study Area:** The municipality of Ibicoara is located in the central-southern mesoregion of Bahia, specifically in the Seabra microregion, which belongs to the territory identified as Chapada Diamantina (SEI, 2018). It is approximately centered at a latitude and longitude of 41.40 °W e 13.39 °S, 509 km from the capital of the state, Salvador (Figure 1). Occupying a territorial extension of approximately 817,355 km$^2$ with an average altitude of 1,070 m, it borders the municipalities of Abaíra, Andaraí, Barra da Estiva, Iramaia, Jussiape, and Mucugê. According to the Brazilian Institute of Geography and Statistics, IBGE (2021), the municipality of Ibicoara has an estimated population of 19,990 inhabitants and a population density of 20.34 in hab/km$^2$, with a degree of urbanization of public roads of 2.1%. Its economic base is ruled mainly by agriculture and tourism, being part of one of the largest agricultural regions of Bahia, the Mucugê-Ibicoara Agricultural Pole. In relation to one of the geomorphological aspects, existing in the region is the great plateau called Pediplano Cimeiro, lowered in relation to Serra do Sincorá but with altimetric heights of 1,000 to 1,300 m (BORGES, 2008). The geomorphology type is Central Pediplano of Chapada Diamantina, countryside Pediplano, and the Western border of the Diamantina highland. The soil characteristics of the municipality are Latosols, Neosol, and Luvisols (SEI, 2013). The Human Development Index (HDI) is evaluated at 0.591 with a Gross Domestic Product (GDP) per capita of 15,724.83 reals, and a schooling rate of the population aged between 6 and 14 years of age of 96.3% (IBGE, 2021). The climate of the municipality is considered Tropical Altitude or Oceanic Climate (Cwb), with an average annual temperature of 18.4 °C, and with an annual rainfall of 1,166.2 mm. The region is inserted in two hydrographic basins: Rio de Contas and Rio Paraguaçu.



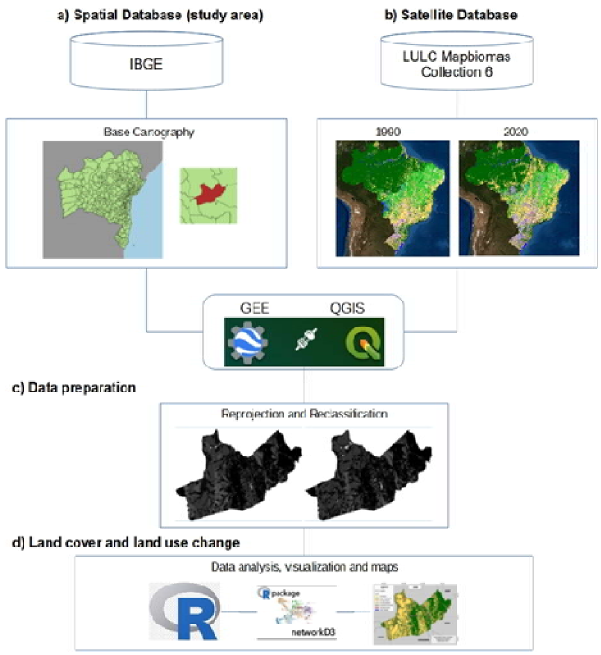




**Figure 2. Methodological Flowchart**

According to data from the Brazilian biomes provided by IBGE, the municipality of Ibicoara is part of the "Caatinga" biome.Despite being located in the semi-arid region of Bahia, Chapada Diamantina as a whole has peculiar vegetation cover characteristics (BORGES, 2008). These characteristics are provided by the local climate, relief and soil. The vegetation of the municipality of Ibicoara according to SEI data (2013) is formed by woody grass "Cerrado" with Gallery Forest, Cerrado-Seasonal Forest Contact, Montano Ecological Refuge, Open Arboreal "Cerrado" without Gallery Forest, Seasonal Forest Semideciduous Montana and Dense Arboreal "Caatinga" with palm trees.

**Satellite and Spatial Data:** The land use and land cover maps in spatial resolution 30 m × 30 m, were acquired from the MapBiomas Project collection 6 (MAPBIOMAS, 2021), with the use of the cloud computing platform Google Earth Engine (GEE). These maps cover the full country of Brazil from 1985 to 2021 with more than 80% accuracy (SOUZA et al., 2020). Information about municipal boundaries were obtained from the IBGE database, in shapefile format.

**Data Preparation:** The LULC maps produced by MapBiomas are originally classified into 6 general classes (forest, non-forest natural formation, agriculture, non-vegetated area, water bodies, and not observed); subdivided into 19 subclasses (https://mapbiomas.org/download). Thus, we have reclassified the subclasses of LULC present in the study region into 7 broad classes (forest formation, savannah formation, agriculture, rural formation, urbanized area, outcrop rocky, and water body), as shown in Table 1.. Each image was projected from the Geographic Information System (GIS), using the QGIS software (v. 2.18.20) and the reference coordinate system WGS-84.

**Land Use and Land Cover Changes:** The information was entered and analyzed in R statistical software (RStudio version 1.4.1717). The areas of each class were then quantified in $km^2$ and percentage, as well the transitions in LULC during the change were characterized. Transition matrix was used to produce the Sankey Diagram, which illustrate the flows and patterns of land cover or land use transitions overtime periods. Sankey diagrams were generated using the 'networkD3' package (Allaire, 2017). In this analysis, the extreme years of this study were selected: 1990 as the starting point and 2020 as the arrival point. In this configuration, the system indicated all the flow lines in gray.

# RESULTS AND DISCUSSION

From the processing carried out, the changes (gains and losses) in each class were quantified and it is presented in Figure 3. After analyzing the diagram, it was observed that the largest flows towards each class originate from the class itself, therefore not representing a change in use, but maintenance. It is possible to observe that the Forest Formation (FL01) class was the one that lost the least amount of area when compared to the others. Observing the Agriculture class (AGR) in the year 2020, it can be seen that the thicker lines that arrive originate from the Savannah Formation (FL02) and Rural Formation (FL03) classes, that is, the areas that most contributed to the increase in class. The quantification of the changes is important to know how much it is changing over time.

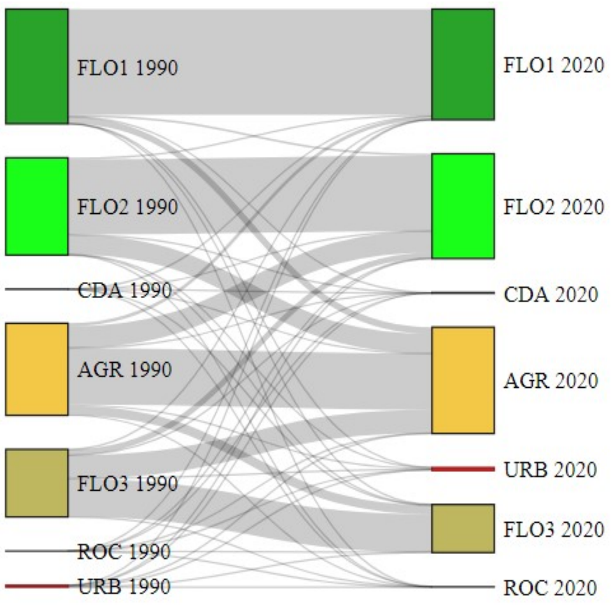



**Figure 3. Sankey Diagram**

Table 2, constitutes a matrix of land use and cover change. The lines and the rows are represented by the values for the year 1990, while the columns contain information from 2020. It was observed an expansion of the agricultural area with an increase of 15.5%, from 20,457 $km^2$ in 1990 to 23,633 $km^2$ in 2020. Also, in the 90s, the municipality of Ibicoara had 17.74 km² of planted area, increasing to 50.94 km² in 2020, with an increase of approximately 287.2% (PAM, 2021). This fact reinforces the results of the increase in the areas of the agriculture class, in this work the agriculture class is not limited to the planted area but also represents areas of pasture and forest plantation. The scenario observed in Ibicoara, with the expansion of agricultural areas, is similar to studies carried out in other regions (ADHIKARI et al., 2015; GUIMARÃES et al., 2017; BRITO and SILVA, 2019; RITSE et al., 2020) which also observed this expansion in the analyzed period. The tendency to expand agricultural areas is repeated in other cities in the country, such as the city of Baianópolis, in the extreme west of Bahia, where in the research made by Guimarães et al. (2017), a growth of 11.2% was observed in a period of twenty years. In another study raised by Silveira et al. (2022), an analysis was made for two Brazilian biomes, the Amazonian Biome and Atlantic Forest, there was an increase of 338.56% and, 0.58%, respectively. Approximately 75% of the area, there was a predominance of a forest, savannah, and grassland formations, totalizing 62,160.84 $km^2$ in the year 1990 (Table 2). The results of this work show that there was a reduction of these areas by up to 70% (58,581.72 $km^2$) observed in the year 2020. The areas of forest formation are concentrated in the central and northeast regions. In these areas (Figure 3). The work developed by Beuchle et al (2015), based on a systematic remote sensing sampling, showed that the percentage of natural vegetation cover in Caatinga Biome was 67.4% in 1990 and it was reduced to 63.2% in 2010. So, the results found in the current work are similar to what happens in the biome.
The changes in agricultural areas (AGR), represented by the yellow color on the map (Figure 4), were evidenced in the northern and western regions of Ibicoara. In this context, the loss of area is mainly of the savannah formation (FL02) and grassland formation (FL03).

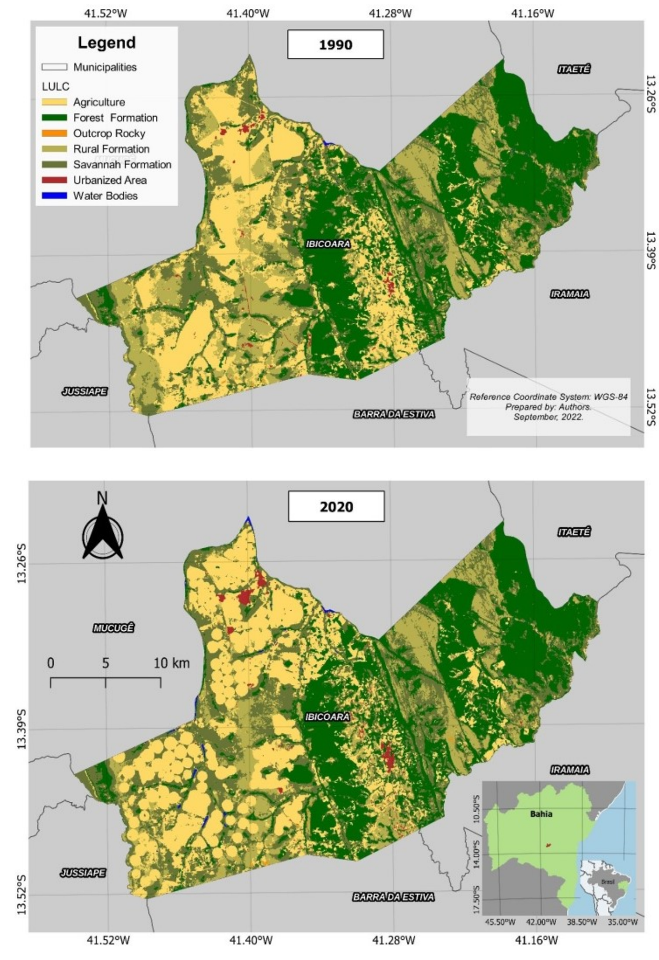



**Figure 4. Land Use and Land Cover map**

From the map produced, it was observed that the most significant change occurred in the AGR class. In addition to growth, the area changed its shape, starting to present itself in circular shapes. Considering the center of the territorial area, practically the entire region located on the left side is destined for agriculture. The practice of central pivot irrigation, considered modern agriculture, is characterized by a circular pattern due to the system used (BORGES.and SILVA, 2009). In 1990 this type of irrigation occurred on a small scale in the municipality of Ibicoara. In this period, the practice of grazing predominated in the region, characterized by extensive cattle raising.In the year 2020, the large number of areas irrigated by the central pivot was noticeable (Figure 4).

**Table 1. Land Use and Land Cover Classes, Abbreviation and Details**

| Class | Abbrev. | Details |
|---|---|---|
| Forest Formation | FLO1 | Vegetation types with a predominance of continuous canopy. |
| Savannah Formation | FLO2 | Vegetation types with predominance of semi-continuous canopy species. |
| Agriculture | AGR | Forestry, Pasture Areas of pasture, natural or planted, Agriculture and Grassland Mosaic, Other Temporary Crops, Coffee (beta), Other Perennial Crops |
| Rural Formation | FLO3 | Types of vegetation with predominance of herbaceous species |
| Urbanized Area | URB | Urbanized areas with a predominance of non-vegetated surfaces, including roads, pathways, and buildings.<br>Other Non-Vegetal Areas, non-permeable surfaces (infrastructure, urban sprawl, or mining |
| Outcrop Rocky | ROC | Naturally exposed rocks on the Earth's surface |
| Waterbody | CDA | Rivers, lakes, dams, reservoirs, and other bodies of water |

Source: Authors (2022), adapted from MapBiomas (2021).

**Table 2. Land Use and Land Cover change matrix in Ibicoara-BA, Brazil**

| | | 2020 (analyzed) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Area (km$^2$) | | | | | | | | |
| | | FLO1 | FLO2 | AGR | FLO3 | URB | ROC | CDA | Total | Gain |
| 1990 (reference) | FLO1 | 23490 | 461 | 1492 | 10 | 2 | 3 | 33 | 25490 | 2000 |
| | FLO2 | 327 | 16723 | 4333 | 126 | 52 | 7 | 69 | 21638 | 4915 |
| | AGR | 746 | 4767 | 12502 | 2049 | 349 | 35 | 9 | 20457 | 7955 |
| | FLO3 | 34 | 1296 | 5197 | 8407 | 53 | 40 | 5 | 15032 | 6626 |
| | URB | 1 | 28 | 79 | 73 | 210 | 8 | 0 | 400 | 190 |
| | ROC | 1 | 10 | 29 | 21 | 0 | 10 | 2 | 73 | 63 |
| | CDA | 4 | 6 | 1 | 1 | 0 | 2 | 23 | 36 | 14 |
| | Total | 24604 | 23291 | 23633 | 10686 | 666 | 106 | 141 | 83127 | |
| | Loss | 1114 | 6568 | 11130 | 2280 | 456 | 95 | 118 | | 21762 |
| | Percentage (%) | | | | | | | | | |
| | | FLO1 | FLO2 | AGR | FLO3 | URB | ROC | CDA | Total | Gain |
| | FLO1 | 28.26 | 0.55 | 1.79 | 0.01 | 0.00 | 0.00 | 0.04 | 30.66 | 2.41 |
| | FLO2 | 0.39 | 20.12 | 5.21 | 0.15 | 0.06 | 0.01 | 0.08 | 26.03 | 5.91 |
| | AGR | 0.90 | 5.73 | 15.04 | 2.47 | 0.42 | 0.04 | 0.01 | 24.61 | 9.57 |
| | FLO3 | 0.04 | 1.56 | 6.25 | 10.11 | 0.06 | 0.05 | 0.01 | 18.08 | 7.97 |
| | URB | 0.00 | 0.03 | 0.09 | 0.09 | 0.25 | 0.01 | 0.00 | 0.48 | 0.23 |
| | ROC | 0.00 | 0.01 | 0.03 | 0.02 | 0.00 | 0.01 | 0.00 | 0.09 | 0.08 |
| | CDA | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.04 | 0.02 |
| | Total | 29.60 | 28.02 | 28.43 | 12.86 | 0.80 | 0.13 | 0.17 | 100.00 | |
| | Loss | 1.34 | 7.90 | 13.39 | 2.74 | 0.55 | 0.11 | 0.14 | | 26.18 |

**Table 3. Dam characteristics**

| **NAME** | **MAINLY USE** | **YEAR** | **MATERIAL** | **VOLUME (hm$^3$)** | **BLOCKED WATERCOURSE** |
|---|---|---|---|---|---|
| Brejinho Saladino I | Irrigation | 2010 | Earth | 0,086 | Riachão |
| Bagisa II | Irrigation | - | - | 0,002 | Paraguaçu River |
| Brejinho Maracujá | Irrigation | 2006 | - | 0,014 | Riachão |
| Brejinho Sede | Irrigation | 2006 | - | 0,369 | Without name |
| Fazenda Paraíso I | Irrigation | 2010 | Earth | 0,475 | Fazenda Paraiso I Dam |
| Fazenda Progresso I | Irrigation | 2004 | Earth | 0,059 | Paraguaçu River |
| Brejinho Tonhão | Irrigation | 2010 | Earth | 0,132 | Brejinho Carlinhos Dam |
| Brejinho Carlinhos | Irrigation | 2006 | - | 0,314 | Riachão |
| Arizona I | Irrigation | 2004 | Earth | 0,032 | Paraguaçu River |
| Brejinho Saladino II | Irrigation | 2006 | - | 0,169 | Riachão |
| Fazenda Progresso III | Irrigation | 2004 | Earth | 0,43 | Riachão |
| Arizona III | Irrigation | 2007 | Earth | 0,182 | Paraguaçu River |
| Lagoa dos Patos II | Flow regulation | - | Earth | 0,006 | Paraguaçu River |
| Lagoa dos Patos I | Flow regulation | - | Earth | 0,007 | Paraguaçu River |
| Arizona II | Irrigation | 2004 | Earth | 0,278 | Paraguaçu River |
| Fazenda Paraíso II | Flow regulation | 2018 | Earth | 0,045 | Fazenda Paraiso II Dam |
| Riacho Lagoinha | Irrigation | 1999 | - | 0,235 | Riachão |
| **Total Volume** | - | - | - | 2,835 | - |

Source: ANA, 2022.

However, for the classification used in this work, both pasture and agriculture areas are included in the same class, called AGR. In the northeast region of the municipality of Ibicoara, the forest formation class prevailed. There were changes such as the increase in agriculture and urban areas, but on a small scale. The northeast end of the municipality, more specifically in the Cascavel District, is the region that is part of the Chapada Diamantina National Park (BRASIL, 2007). The Chapada Diamantina National Park was created in 1965 and regulated by Decree Number 91,655 on September 17, 1978 (BRASIL, 1978).

The Decree in Article 1 says that the purpose of creating the Park is "to protect samples of the ecosystems of Serra do Sincorá, in Chapada Diamantina, ensuring the preservation of its natural resources". The creation of the National Park also aims to provide controlled public use and the development of educational and scientific research actions. The results shown in Figure 3 indicate thus, the maintenance of Forest Formation areas, ensuring efficiency in the preservation of natural resources in this area. The area of water bodies increased from 36 to 141 km$^2$ in the studied period. The land use map showed that the new areas classified as water are located in the western region of the municipality. Between 1999 and 2010, the construction of 17 dams in the municipality of Ibicoara was authorized, 14 of which have irrigation as their main use and 3 as flow regulation. The total storage capacity of the 17 existing dams is 2.835 $hm^3$(Table 3). The construction of the dams accompanied the implementation of the Agropolo Mucugê-Ibicoara. Of the 17 dams built, 9 belong to the company "Lavoura e Pecuária Igarashi" (ANA, 2022), originally from southern Brazil, currently operating in the central west and northeast of the country. (IGARASHI WEBSITE, 2022). A study developed in the municipality of São Gabriel, also located in Chapada Diamantina, identified an increase in the area of the water bodies class, from 0.72 km2 in 2007 to 1.6 km2 in 2018 (ABREU and BORGES, 2021). The authors associated the small area of water bodies with the pluviometric regime, and deforestation of riparian forests, in addition to the special resolution of the image used (30 m).

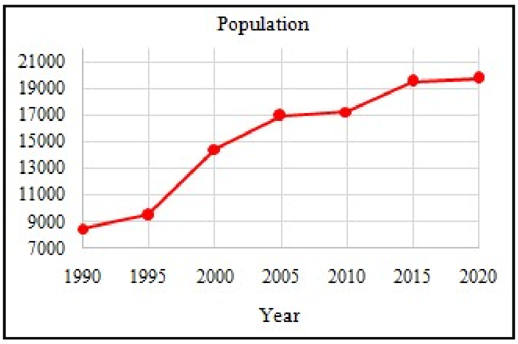



**Figure 5. Population of Ibicoara**

Urban areas were in small proportions when compared to other uses (0.48% in 1990 and 0.8% in 2020). The analyzed data demonstrates the growth of urbanization areas, mainly in the commercial center, urban headquarters, and the city's northern region (Figure). According to the results found, the urbanized area grew from 400 $km^2$ to 666 $km^2$in the studied period. In the study carried out by Salvat and Zitti (2009) it was identified that population density is an important factor to be observed, as it directly affects soil vulnerability. Urban growth is confirmed when compared with IBGE data on the population residing in the municipality of Ibicoara. The population in 1990 was 8,461 inhabitants and, according to estimates, in 2020 the population grew to 19,786 inhabitants (Figure 5). There was an increase in the population from 9,478 in 1999 to 14,453 in 2000, representing the highest growth rate in the period studied. This period of growth coincided with the intensification of investments in agricultural activities in the region. The LULC map (Figure 4) showed that urban growth took place mainly in the north and center-east of the municipality. Almeida et al (2018) and Silva et al (2022) when analyzing the dynamics of land cover in the municipalities of Caruaru and Toritama, located in the agreste of Pernambuco and the buffer zone of the Jaru Biological Reserve in Rondônia, respectively also observed the increase in urbanization and agriculture to the detriment of the loss of forest cover.

# CONCLUSION

The Chapada Diamantina, in Brazilian Caatinga Biome, has been under increasing anthropic pressure. There isn't sufficient knowledge of historical LULC changes in the region. In this context, our results represent a good chance to know LULC changes in a municipality inserted in Chapada Diamantina territory. Satellite images obtained from Mapbiomas associated with programming in R environment and geoprocessing techniques in a Geographic information system constituted an effective tool in obtaining data for analysis of Land Use and Land Cover in Ibicoara. The data analysis made it possible to quantify each class of interest researched and identify changes in the study area. The analysis ofLULC changes in the municipality of Ibicoara between the years 1990 and 2020 showed the predominance of areas of natural vegetation in both periods. Despite this, there was a reduction in the vegetation area, associated with the growth of urban areas and agriculture. The intensification of investments in the Agricultural agropole triggered the population increase in the region between 1999 and 2000.Land Use and Land Cover studies are important tools for monitoring local development, serving as a subsidy for territorial regional management and planning with a view to aid in sustainable development. The analyzed area still lacks published data in order to identify changes in LULC. It is also suggested to carry out fieldwork, obtaining aerial images aiming at greater details and validation of the maps obtained from the orbital remote sensing data.

# REFERENCES

Abdullah, A. Y. M., Masrur, A, Adnan, M. S. G., Baky, M. A. A., Hassan, Q. K., Dewan, A. (2019). Spatio-Temporal Pattnerns of Land Use/Land Cover Change in the Heterogeneous Coastal Region Of Bangladesh Between 1990 and 2017. Remote Sensing. doi:10.3390/rs11070790

Abreu, F. B.; Borges, E. F.. (2021). Análise espacial do uso e cobertura das terras no município de São Gabriel-Bahia, 2007 e 2018. Revista Ibero Americana de Ciências Ambientais, v.12, n.7, p.535-548, 2021. DOI: http://doi.org/10.6008/CBPC2179-6858.2021.007.0046

Adhikari, S., Southworth, J., Nagendra, H.(2015). Understanding forest loss and recovery: a spatiotemporal analysis of land change in anda round Bannerghatta National Park, India. Journal of Land Use Science. Vol. 10, n.4, 402-424.

Allaire, J.J. 2017. Network Package – Rdocumentation

Almeida, DNO, Oliveira, LMM, Candeias, ALB, Bezerra, UA, Leite, ACL (2018). Uso e cobertura do solo utilizando geoprocessamento em municípios do Agreste de Pernambuco. Revista Brasielira de Meio Ambiente, V.4, n.1. 058-068 (201😎

ANA, National Water Agency. (2022). National Information System on Dam Safety 2. Retrieved from:https://www.snisb.gov.br/portal-snisb/consultar-barragem.

Baeza, S; Vélez-Martin, E.; De Abelleyra, D.; Banchero, S.; Gallego, F.; Schirmbeck, J.; Veron, S.; Vallejos, M.; Weber, E.; Oyarzabal, M.; Barbieri, A.; Petek, M.; Guerra Lara, M.; Sarrailhé, S.S.; Baldi, G.; Bagnato, C.; Bruzzone, L.; Ramos, S.; Hasenack, H..(2022). Two decades of land cover mapping in the Río de la Plata grassland region: The Mapbiomas Pampa initiative Remote Sensing Applications: Society and Environment. 28(2022). https://doi.org/10.1016/j.rsase.2022.100834

Beuchle, R, Grecchi, C. R, Deliger, Y. E. S. R., Eva, H. D, Sano, E, Achard, E. E. 2015. Land cover changes in the Brazilian Cerrado and Caatinga biomes from 1990 to 2010 based on a systematic remote sensing sampling approach. Applied Geography. http://dx.doi.org/10.1016/j.apgeog.2015.01.017

Borges, E.F. 2008. Aplicação das geotecnologias para a definição do mapa geoambiental do município de Mucugê – BA. Master's Thesis - Graduate Program in Earth and Environmental Sciences Modeling, Feira de Santana State University, Feira de Santana, Bahia, Brazil.

Borges, E. F., Anjos, C. S., Santos, P. S. 2009. Estudos de Detecção de Mudança da Paisagem no Pediplano Cimeiro - Chapada Diamantina (BA). Natal. Anais XIV Simpósio Brasileiro de Sensoriamento Remoto - SBSR, Natal, RN, Brasil. do Iguaçu, PR, Brasil.

Borges, E., & Silva, A. (2010). Técnicas de segmentação de imagens e classificação por região: mapeamento da cobertura vegetal e uso do solo, Mucugê-BA (satellite imagery classification: cover and soil use map using digital image processing). Mercator, 8(17), 209 a 220. Retrieved from http://www.mercator.ufc.br/mercator/article/view/258.

BRASIL.(1978). Decreto N 91.655, DE 17 de setembro de 1978. Cria o Parque Nacional da Chapada da Diamantina.

BRASIL.(2007). Ministério do Meio Ambiente. Instituto Chico Mendes: Apoio IBAMA. Plano de Manejo Parque Nacional Chapada Diamantina- Parte I, Versão Preliminar BRASÍLIA. Retrieved from: https://www.gov.br/icmbio/pt-br/assuntos/ biodiversidade/ unidade-de-conservacao/unidades-de-biomas/

caatinga/ lista-de-ucs/parna-da-chapada-da-diamantina/ arquivos/ parna_chapada_diamantina.pdf.

Brito, B. N., Silva, B. E.(2019). Multitemporal analysis of land use and coverage in the Cerrado Biosphere Reserve. Ateliê Geográfico. Goiânia-Go, V. 13, n.2, p.73-91.

CERB.(2021). Barragens – Construção, operação e manutenção. Retrieved from: http://www.cerb.ba.gov.br/atividades/barragens-construção-operação-e-manutenção.

Cordell, S., Questad, J. E., Asner, G. P., Kinney, K. M., Thaxton, J, M., Uowlo, A., Brooks, S. Chynoweth, M. W. (2017). Remote sensing for restoration planning: how the big picture can inform stakeholders. Restoration Ecology. Vol. 25, N°S2, pp. S147-S154.

Cruz, J. S., Blanco, C. J. C., Oliveira Júnior, J. F. (2021). Modeling of land use and land cover change dynamics for future projection of the Amazon number curve. Science of the Total Environment. http://dx.doi.org/10.1016/j.scitotenv.2021.152348

Maurano, L. E. P., Escada, M. I. S., Renno, C. D. (2019). Padrões espaciais de desmatamento e a estimativa da exatidão dos mapas do PRODES para Amazônia Legal Brasileira. Ciência Florestal, v. 29, p. 1763-1775.

Fendrich, A. N., Barreto, A., Faria, V. G., Bastiani, F., Tennesond, K., Pinto, L. F. G, Sparovek, G. (2020). Disclosing contrasting scenarios for future land cover in Brazil: Results from a high-resolution spatiotemporal model. Science of the Total Environment. https://doi.org/10.1016/j.scitotenv.2020.140477

Gomes, E. O., Andrade, P. R. G. S.(2016). Aplicação de um reservatório de detenção para controle da drenagem de água pluvial em residencial de interesse social. 10° Simpósio Brasileiro de Captação e Manejo de Água de Chuva Belém - PA – Brasil.

Guimarães, B. P., Gomes, R. A.T., Junior, O. A. C., Guimarães, R.F., Hermuche, P. M. (2017). Land-Use and Land-Cover Dynamicsin the municipality of Baianópolis (BA) in the twenty-yer period (1988-2008). Espaço & Geografia. Vol. 20, n. 2. 471:500.

IBGE Cidades.(2021). Panorama Ibicoara. Avaiable from: https://cidades.ibge.gov.br/brasil/ba/ibicoara/panorama 2021

Igarashi. Feeding the Brazilian family, c2021. Homepage. Retrieved from: < https://igarashi.com.br/ />. Accessed: 01 de jun. de 2022.

Lourenço, V. R., Carvalho, A. A., Almeida, G. C., Montenegro A. A. A. (2021). Comparison of water masses areas in a semiarid basin using spectral indices and MapBioma's classification. Journal of Hyperspectral remote Sensing. v.11, n.4

Abdi, A. M. (2020). Land cover and land use classification performance of machine learning algorithms in a boreal landscape using Sentinel -2 data. GIscience & Remote Sensing. https://doi.org/10.1080/15481603.2019.1650447

MAPBIOMAS.(2021). Cobertura e uso do solo. Disponivel em: http://mapbiomas.org/map#coverage. Acesso em: 01 out. 2021.

Abdi, A. M. (2020). Land cover and land use classification performance of machine learning algorithms in a boreal landscape using Sentinel -2 data. GIscience & Remote Sensing. https://doi.org/10.1080/15481603.2019.1650447

Melo, E. T., Leduc, A. O. H. C, Barbosa, E. C. C., Vasconcelos, N. R. (2022). Avaliação do papel ecológico das reservas legais da floresta Atlântica da Bahia determinado pelo uso do solo. Revista Brasileira de Gestão Ambiental. DOI: 10.18378/rbga.v16i1.9280

Mishara, P. K., Rai, A., Rai, S. C. (2019). Land use and land cover change detection using geospatial techniques in the Sikkim Himalaya, India . The Egyptian Journal of Remote Sensing Sciences. https://doi.org/10.1016/j.ejrs.2019.02.001

NASA.(2021). Jeffrey, J. G. LANDSAT 1. Retrieved from: https://landsat.gsfc.nasa.gov/landsat-1-3/landsat-1.

Novo, E. M. L. M. (1992). Sensoriamento remoto: princípios e aplicações: São Paulo: E. Blucher.

PAM – Producao Agricola Municipal,.(2021). Produção Agrícola Municipal. Sistema IBGE de Recuperacao Automatica – SIDRA. Avaiable from: https://sidra.ibge.gov.br/pesquisa/pam/tabelas.

Parente, L., Taquary, E., Silva, A. P., Souza, C., Ferreira, L. (2019). Next Generation Mapping: Combining Deep Learning, Cloud Computing, and Big Remote Sensing Data. Remote Sensing, 2019, ch. 11.

Peters, C., Picardy, J., Darrouzet-Nardi, A., Wilkins, J., Griffin, T., Fick, G. (2016). Carrying capacity of U.S. agricultural land: Ten diet scenarios. Elementa: Science of the Anthropocene. 4:116.

Ribeiro, F. O. (2022). O uso do MapBiomas na análise de perda de vegetação natural e apoio a Legislação Florestal atual em Bragança (Pará). Revista Brasileira de Meio Ambiente, v.10, n.3, p.150-167.

Ritse, V., Basumatary, H., Kulnu, A. S., Dutt, G., Phukan, M. M., Nabajit, H., (2020). Monitoring land use land cover changes in the Eastern Himalayan Landscape of Nagaland, Northeast India. Environmental Monitoring and Assessment. 192:711.

Rosa E. .P, Trentin R., Dias D.F., Santos V. S.(2017). Mapeamento do uso e ocupação da Terra no Município de Jaguari – RS. Anais: XVII Simpósio Brasileiro de Geografia Física Aplicada, p.6890-6894.

Rosan, T. M.; Ganzenmuller, R.; O'Sullivan, R.; Pongratz, J.; Mercado, L.M.; Aragao, L.E.O.C.; Heinrich, V.; von Randow, C.; Wiltshire, A.; Tubiello, F.N.; Bastos, A.; Friedlingstein, P. and Sitch, Stephen. (2021). A multi-data assessment of land use and land cover emissions from Brazil during 2000-2019. Environmental Research Letters. https://doi.org/10.1088/1748-9326/ac08c3

Salvati L., Zitti, M..(2009). Assessing the impact of ecological and economic factors on land degradation vulnerability through multiway analysis. Ecological Indicators 9:357–363.

Santiago, D. B., Barbosa, H. A., Correia Filho, W. L. F. (2021). Alterações na eficiência do uso da água relacionadas com fatores climáticos e uso e ocupação do solo, na região do MATOPIBA. Research, Society and Development. http://dx.doi.org/ 10.33448/rsd-v109.17891

Santos, L. A. C., Brito, T. R. C. (2021). Análise temporal do uso e cobertura do solo da capital brasileira do amianto: Minaçu, estado de Goiás. Revista Brasileira de Geografia Física. v. 14, n.03 (2021) 1443-1452.

Saraiva, M., Protas, E., Salgado, M., Souza Jr., C. (2020). Automatic Mapping of Center Pivot Irrigation Systems from Satellite Images Using Deep Learning. Remote Sensing. doi:10.3390/rs12030558.

SEI.(2013). Superintendência de Estudos Econômicos e Sociais da Bahia, 2011. Estatísticas dos Municípios Baianos. SEI, v. 4, n. 1, Salvador.

SEI.(2018). Mapa territórios de identidade, Bahia.

Silva, ECS, Silca, MV, Jesus, DRA, Carvalho, MBF, Barros, LGP, Mendonça, A, Felzke, LF (2022). Análise Temporal do uso e ocupação do solo na zona de amortecimento da Reserva Biológica do Jaru, Rodônia. IJDR. Vol. 12, 08, pp. 58466-58469, 2022. https://doi.org/10.37118/ijdr.25169.08.2022

Souza Jr., C. M.; Shimbo, J.Z.; Rosa, M.R; Parente, L.L.; Alencar, A.A.; Rudorff, B.F.T.; HAsenack, H.; Matsumoto, M.; Ferreira, L.G.; Saouza-Filho, P.W.M.; Oliveira, S.W.; Rocha, W.F.; Fonseca, A.V.; Marques, C.B.; Diniz, C.G.; Costa, D.; Monteiro, D; Rosa, E.R.; Véllez-Martin, E.; Weber, E.J.; Lenti, F.E.B.; Paternost, F.F.; Pareyn, F.G.C.; Siqueira, J.V.; Viera, J.L.; Ferreira Neto, L.C.; Saraiva, M.M.; Sales, M.H.; Salgado, M.P.G.; Vasconcelos, R.; Galano, S.; Mesquita, V.V.; and Azevedo, T. (2020). Reconstructing Three Decades of Land Use and Land Cover Changes in Brazilian Biomes with Landsat Achieve and Earth Engine. Remote Sensing, 2020, ch.13.

Zioti, F., Ferreira, R. K., Queiroz, R. G., Neves, A. K., Carlos, F. M., Souza, F. C., Santos, L. A., Simões, R. E. O. (2021). A platform for land use and land cover data integration and trajectory analysis. International Journal of Applied Earth Observations and Geoinformation. https://doi.org/10.1016/j.jag.2021.102655.

*******