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Solo use in Juiz de Fora (MG) between 1985 and 2021: an analysis by Remote Sensory

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SUMMARY
Due to the accentuated urbanization process and the lack of adequate urban planning, neglecting environmental issues, Brazilian municipalities are increasingly impacted by extreme precipitation events, leading to several problems. Thus, the municipality of Juiz de Fora, due to its site condition and susceptibility to the occurrence of mass movements and floods, when associated with heavy rains, has many impacts on the population. The main objective of this research is to present the recognition of the Use and Occupation development process in the municipality of Juiz de Fora-MG, thus helping studies and future projects based on this theme. With this, a quantitative analysis of the urban occupation growth of the locality was carried out through the QGis software with the MapBiomas database, presenting information over five decades, during the years 1985 and 2021. Based on this proposal, it was found a growth of urban areas between this period, also justifying the decrease of rivers and lakes, and with the products generated in this work, it was possible to identify which classes were preserved and which areas decreased representing the change in the economic profile of the municipality of Juiz de Fora - MG. Therefore, the research contemplates and contributes to the incorporation of these parameters in monitoring the use of hydrological resources.

KEY WORDS: Geoprocessing. MapBiomas. Remote sensing. Juiz de Fora. Soil Coverage.

1. INTRODUCTION

Understanding the transformations in urban space means understanding the various processes that led and made it possible to reach the current condition. The perception of a city's urban dynamics provides support for reflection on the possibilities and limits of policies aimed at controlling and directing urban growth, leading to the search for solutions that enable greater access to the city's wealth for all its citizens (TASCA, 2022).

According to Tasca (2022), faced with manifestations in urban space arising from the movement of capital, society is faced with a conflictive process of organizing the territory, according to practices that seek the private appropriation of income. This is "transformed through human work and the forms of representation of societies that occur in a given environment" (PIMENTA; FIGUEIREDO, 2014, p. 11).

According to Paulo (2018), the increase in the urban population in cities began with the industrial revolution, between the 19th and 20th centuries, with the migration of rural workers in search of jobs in the cities. This episode became known as the rural exodus, resulting in population growth.

The rapid urbanization process, without adequate planning and in accordance with legislation, exposes the importance of studies based on Brazil's urban formation. However, the focus was given to economic and social aspects, and environmental issues were neglected and ignored, according to Monteiro and Mendonça (2003).

The formation of the city of Juiz de Fora - MG, was a consequence of geomorphological constraints, political decisions and economic strategies, and urban occupation took place along the Paraibuna River, where there were exchange relations with Rio de Janeiro and Paraty, according to Tasca's approach (2022).

According to McKinney (2006), urban and demographic growth modifies the landscape, as well as the ecological functions of the locations where this expansion occurs. The transformations are observed more intensely in the urban environment, resulting in the devastation of the native forest, with only small dimensions remaining, making it impossible to disperse flora and fauna, with significant changes in the microclimate, such as temperature and humidity. These factors act in different ways, and in different magnitudes, depending on the

particularities of each fragment - such as its size, shape, soil and microclimatic conditions. All these factors have a great influence on its composition and structure (ALVEY, 2006; MCKINNEY; 2008).

The peripheral landscape of cities often provides a certain similarity with the rural landscape, due to its proximity to it. However, with the gradual addition of more residences, peripheral residents are moving further and further away from the natural landscape. Similarly, these residents are being involved by the city, moving away from the green that was the primitive landscape and starting to use the 'artificial' green (PAIVA; GONÇALVES, 2002). According to Henke-Oliveira (1996), green areas were ignored for a while, being related to the lack of civilization and rusticity, opening space for the growth and development of cities. However, vegetation, whether afforestation, green areas, lawns or urban forests, is an element belonging to the urban and natural ecosystem.

Juiz de Fora, although it still has a predominantly rural territory (information taken from the study itself indicates that around 77.64% of the region is made up of preserved forests and pastures, while only 20.54% of the total area is urbanized), follows a continuous process of urban development. According to the map of "Use and Occupation of land in the Urban Sectors of PD 9 - Parceling and zoning", produced by Tasca (2022), the North region is a strategic area of expansion in the Army's area of influence, being an area which has a growth in farms and condominiums and also irregular lots. The Northeast region of Juiz de Fora presents social contrasts based on real estate developments for the upper class and housing complexes for low income people. In the Eastern extension, the process of peripheralization is understood, with little or no potential for densification. The South has excessive density, as does the Northwest, with a great expansion process, with the possibility of consolidating the industrial sector. The center of the city has residential and commercial centers, a concentration of urban functions. Finally, the West region had its expansion induced by private condominiums for the upper class with a single-family standard and popular "Minha Casa Minha Vida" developments.

It is extremely important to study urban transformation, regarding land usage and occupation, where the main objective is to investigate this development through the MapBiomas project, from collection 7 published in August 2022, and the use of *Sistemas de Informação Geográficas* (GIS) using QGis software. This research seeks to offer information for future studies and assist in decision making, enabling measures to mitigate urban and, consequently, social and environmental impacts.

2. MATERIALS AND METHODS

Research investigation requires different approaches, parameters and technical methodologies, as "all research is based on a theory that serves as a starting point for the investigation" (PRODANOV E FREITAS, 2013, p. 43). To enhance a study "it is necessary to read a lot, continuously and constantly, as most knowledge is obtained through reading" (MARCONI AND LAKATOS, 2003, p. 19).

In the search for bibliographical research to develop the proposed theme, it is based on the survey of corresponding materials, referring to the problems of growth and occupational

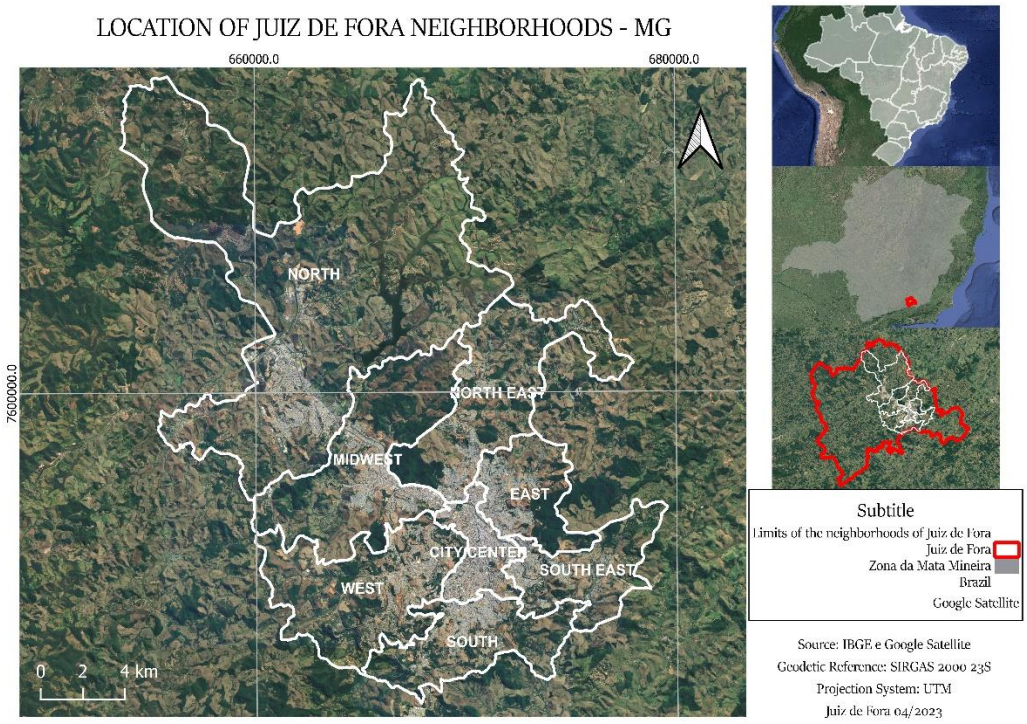
changes in Juiz de Fora - MG. Therefore, materials such as articles, dissertations and theses will be analyzed in order to present and detail the content exposed.

In addition to these investigations, we used the software QGIS with GRASS 3.22.11 for data processing, importing the MapBiomas database from the urban area of Juiz de Fora in order to quantify the changes between the years 1985 and 2021. The MapBiomas project was born from a Remote Sensing seminar in 2015, where some of the researchers at that event decided to develop annual maps of land use in Brazil. According to Rosa, Shimbo and Azevedo (2019, p. 95), MapBiomas is "an open and collaborative monitoring initiative, created in 2015, to fill this gap".

2.1 Field of Study

According to data from the Brazilian Institute of Geography and Statistics (IBGE, 2021), in 2010 the city of Juiz de Fora (Figure 1) had 516,247 inhabitants. In the 2021 census there was population growth, reaching 577,532 inhabitants. Therefore, the city presents a very significant increase in urban expansion, being the fourth most populous city in Minas Gerais. The city attracts a floating population from the surrounding area, highlighting the Zona da Mata of Minas Gerais, Vertentes, the south of Minas and some cities of Rio de Janeiro in the Paraíba Valley that seek it mainly for education and health services.

Figure 1 – Location of Juiz de Fora Neighborhoods



Source: The Authors, 2022.

Juiz de Fora is located in the Mountain Unit of Zona da Mata, belonging to the Northern Mantiqueira Region. This region is distinguished by being mountainous, with altitudes close to 1,000m at the highest points, 670 to 750m at the bottom of the Paraibuna river valley and average levels around 800m. The urban perimeter of the city is entirely within the middle course of the Paraibuna River. Juiz de Fora is contained in the Medium Paraibuna basin, belonging to

the Paraíba do Sul River basin, and its urban perimeter is drained by 156 sub-basins of different sizes (CESAMA, n.d.).

2.2 Data acquisition

For the research, raster-style maps of Land Use and Occupation were used, prepared by the MapBiomas organization, from 1985 to 2021, analyzed each decade (1985, 1995, 2005, 2015 and 2021). The base images are accurate to 30 meters and were classified into 11 classes, which make up the urban region covered by the study. Districts were not included in this analysis.

3. RESULTS AND DISCUSSIONS

Using the QGis 3.22.11 software, the general areas of each class shown in table 1 were removed for the pre-established period. In a first analysis, forest formation in the region increased by 23.82% between 1985 and 2021, justified in part due to the validity of Federal Law No. 12,651/12, which regulated Legal Reserve areas, imposing on private owners to allocate part of the property to the preservation of native forest. At the same time of the application of the legislation, there was an increase in forestry areas through pine and eucalyptus for the purpose of extracting raw materials for steel mills and civil construction. However, the biggest highlight is the urban area class, which increased by 59.11%, predominantly over the former pasture areas, which decreased by 76.66%.

Table 1 - Division of Areas by Classes of Juiz de Fora for the years 1985 to 2021

N°	Class of Use and Occupation	1985 Area (km²)	1995 Area (km²)	2005 Area (km²)	2015 Area (km²)	2021 Area (km²)
3	Forestry Formation	64.35	64.16	65.91	77.87	79.68
9	Silviculture	0.02	0.81	0.00	0.14	0.09
15	Pasture	206.35	185.79	203.23	164.83	152.01
21	Agriculture and Pasture Mosaic	67.07	89.37	53.03	70.73	76.71
24	Urban Area	51.29	51.00	68.54	76.72	81.61
25	Other non-vegetated areas	2.14	1.56	1.74	2.07	2.49
29	Rocky outcrop	0.01	0.04	0.09	0.20	0.34
33	River, Lake and Ocean	4.43	4.50	4.81	4.78	4.41
41	Other Temporary Crops	0.00	0.00	0.00	0.00	0.02
46	Coffee	0.12	0.00	0.00	0.00	0.00
48	Other Perennial Crops	0.00	0.00	0.00	0.00	0.00

Source: The Authors, 2022.

In Figure 2 it is possible to graphically identify the increase in the urban area class of 59.11% between 1985 and 2021, highlighting the period from 1995 onwards. In relation to pastures, a sharp decrease can be observed from 2005 onwards. In contrast, the agricultural mosaic had a significant increase from this year mentioned.

After this general analysis of the areas, graphs were created using the SCP plugin (Semi-Automatic Classification Plugin) to obtain comparative maps separated by decades, allowing the identification of transitions between classes and demonstrating the location where

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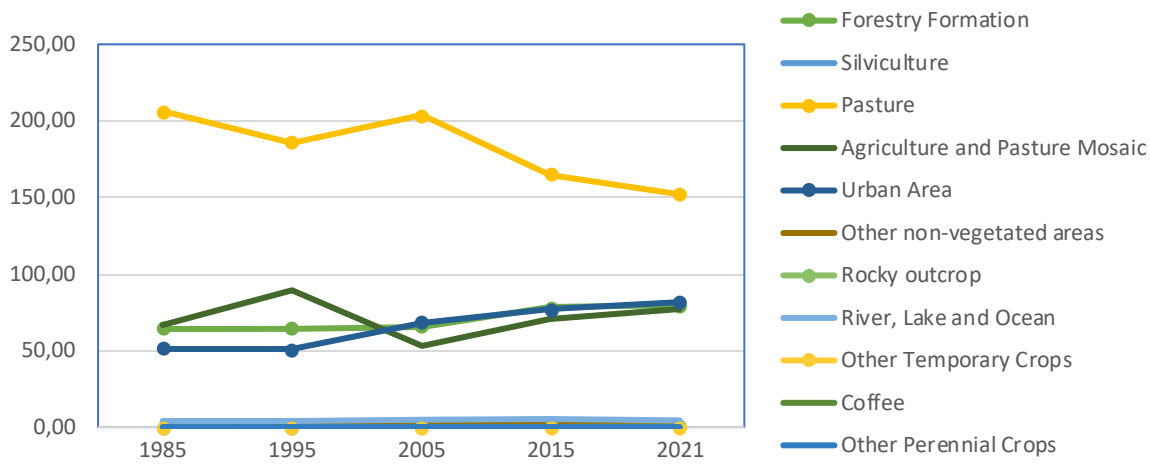
they occurred in the established period. As a result of this work, it was possible to draw a profile of the change in Use and Occupation of the city of Juiz de Fora and identify the formation process of some neighborhoods.

Figure 2 – Evolution of Use and Occupation Classes in Juiz de Fora



Source: The Authors, 2022.

3.1 Changes between decades

3.1.1 Period from 1985 to 1995

The changes between decades were significant and can contribute to the understanding of the social and economic profile of this City. Figure 3 demonstrates the Use and Occupation of the researched region in the years 1985 (beginning of the databases) and 1995; With these maps, it was possible to create Figure 4, which is a map that highlights the regions that underwent the greatest change in use, using stronger colors in the regions that underwent the greatest changes in this decade.

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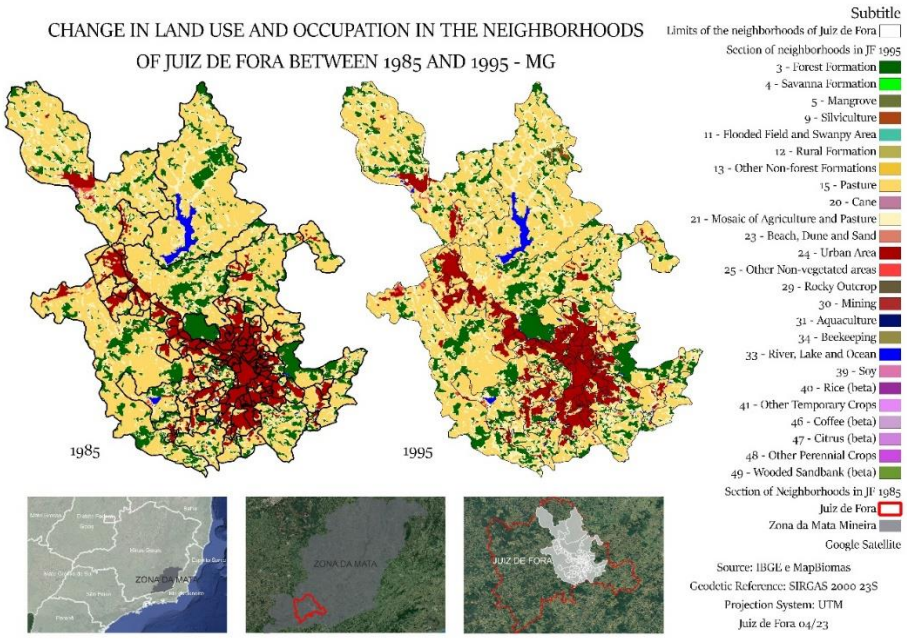
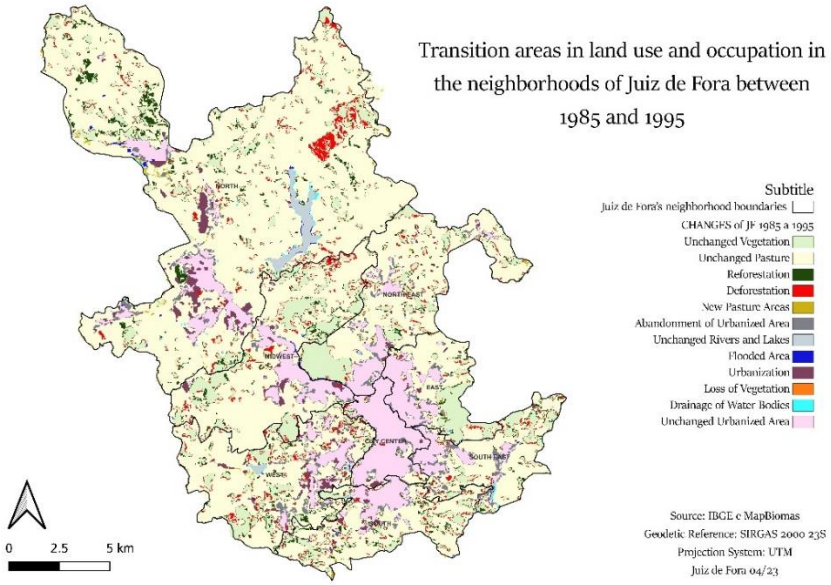
Figure 3 – change in land use and occupation in the neighborhoods of Juiz de Fora between 1985 and 1995 – MG



Source: The Authors, 2022.

Figure 4 shows in red the areas of deforestation and dark green the areas in which there was reforestation. During this period, the forest formation class suffered a reduction of approximately 0.3% in the Northern Region of the city; the increase in urban areas was significant with an increase of 34.39% in this period, representing the highest among all periods analyzed. Agricultural activities increased by 0.63%, representing a period of few significant changes.

Figure 4 – Class Transition Areas between 1985 and 1995



Source: The Authors, 2022.

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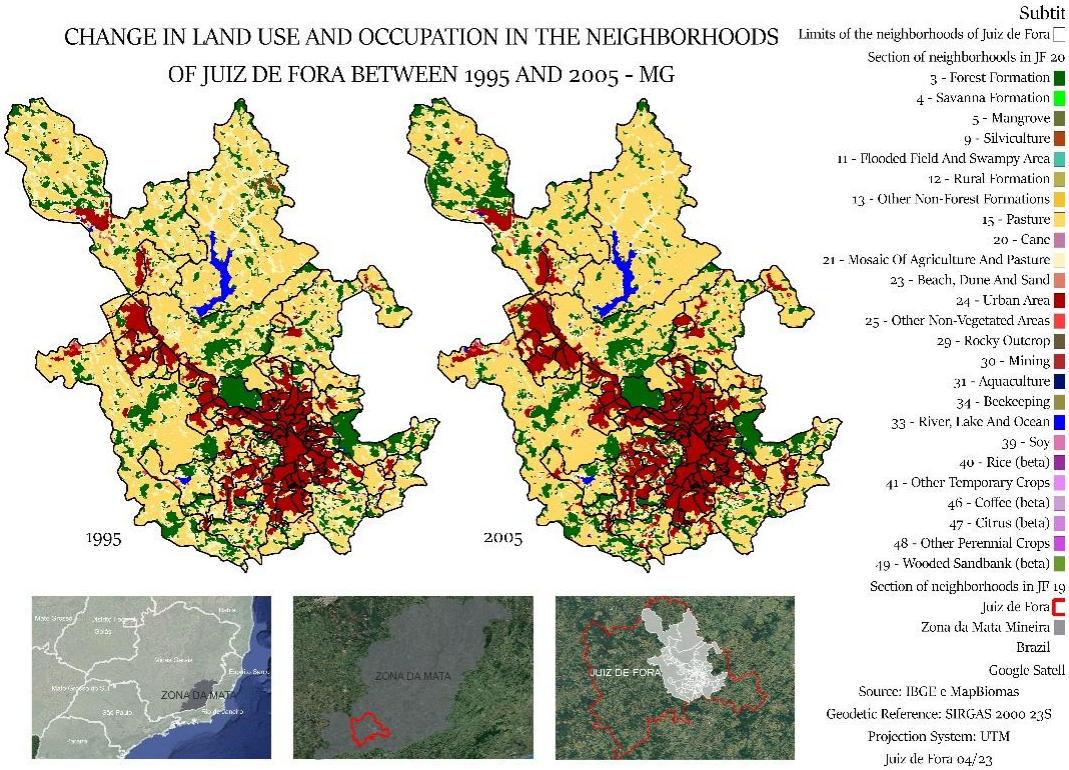
3.1.2 Period from 1995 to 2005

In this decade the increase in urban areas was small. Figure 5 demonstrates the reduction in areas of agricultural and pastoral activity by around 6.87% in the same period. The decrease in urban areas indicates the denser and less distributed population formation process in space, which can modify several sectors such as commerce, transport, among others.

Figure 5 – Evolution of Land Use and Occupation in neighborhoods in the city of Juiz de Fora between 1995 and 2005



Source: The Authors, 2022.

From Figure 6, it can be seen that the process of deforestation and reforestation continued accentuated in the northern region, while new urban areas identified by the color purple appeared on the map; there was also an increase in the forestry area of 2.73%.

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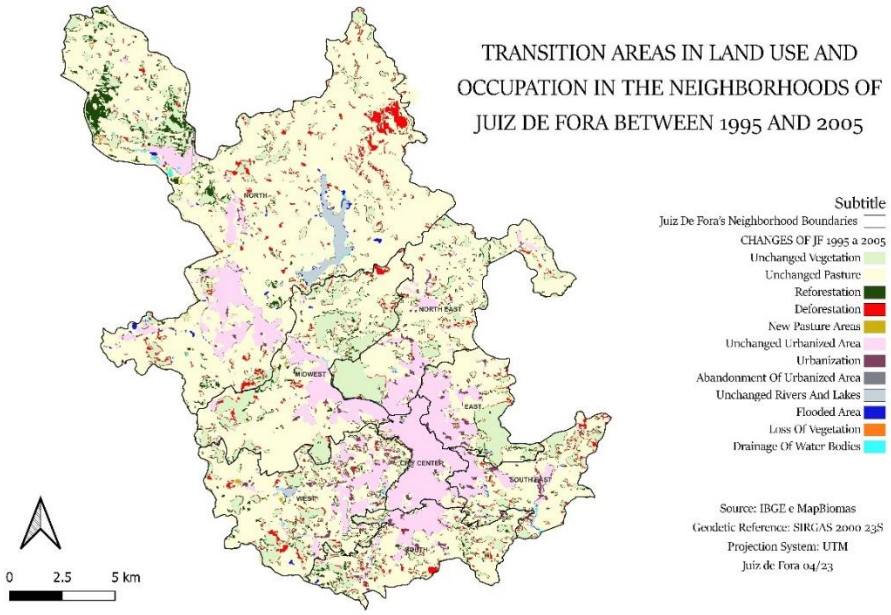
Figure 6 – Class Transition Areas between 1995 and 2005

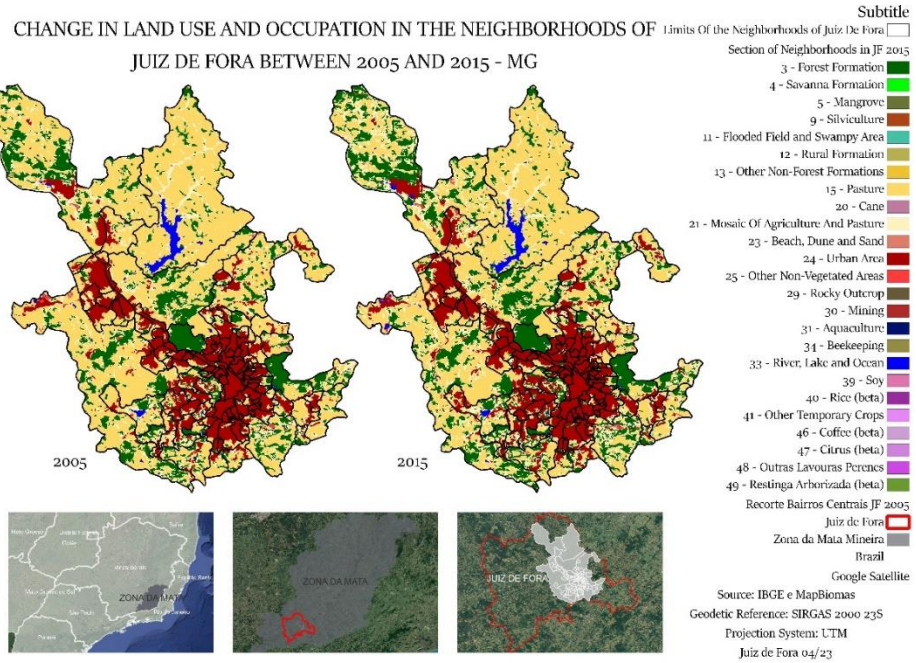


Source: The Authors, 2022.

3.1.3 Period from 2005 to 2015

During this period, the physical space of the city underwent few changes in Land Use and Occupation. This factor indicates the occurrence of a densification of already consolidated spaces, since there was no increase in urban areas. Figure 7 indicates the space with similar areas in 2005 and 2015.

Figure 7 – Evolution of Land Use and Occupation in neighborhoods in the city of Juiz de Fora between 2005 and 2015



Source: The Authors, 2022.

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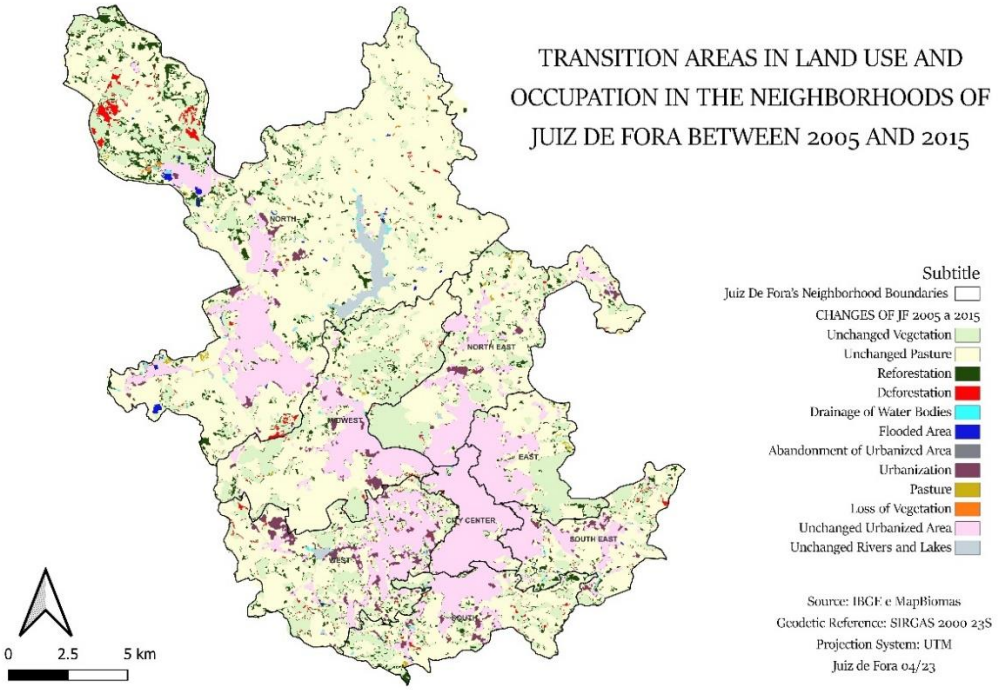
Figure 8 shows, due to the predominant light colors, that the space has changed little over a decade. It is possible to identify reforested areas in the North alongside others that have been deforested, something contradictory. There is the emergence of areas with volume of water dammed to form artificial lakes or small dams.

Figure 8 – Class Transition Areas between 2005 and 2015



Source: The Authors, 2022.

3.1.4 Period from 2015 to 2021

The final period of study can be characterized as the one with the least change in the city's physical space, with change rates between classes below 1%. Figure 9 demonstrates the MapBiomas data and Figure 10 shows the regions that underwent modifications (dark colors) and the regions that remained the same.

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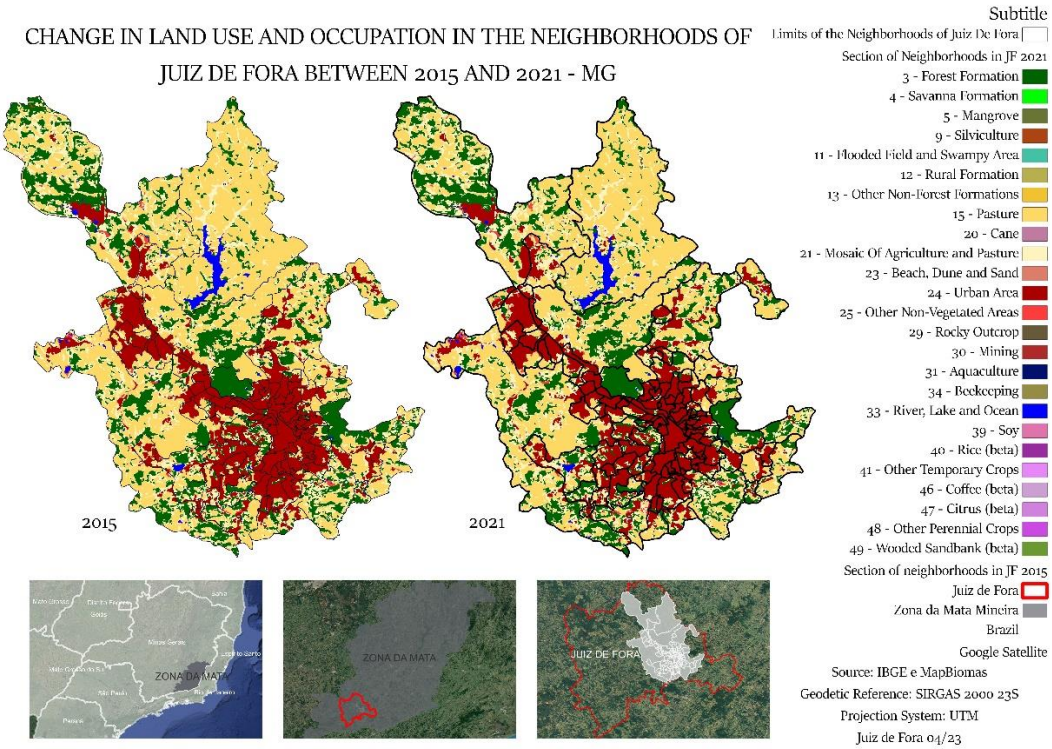
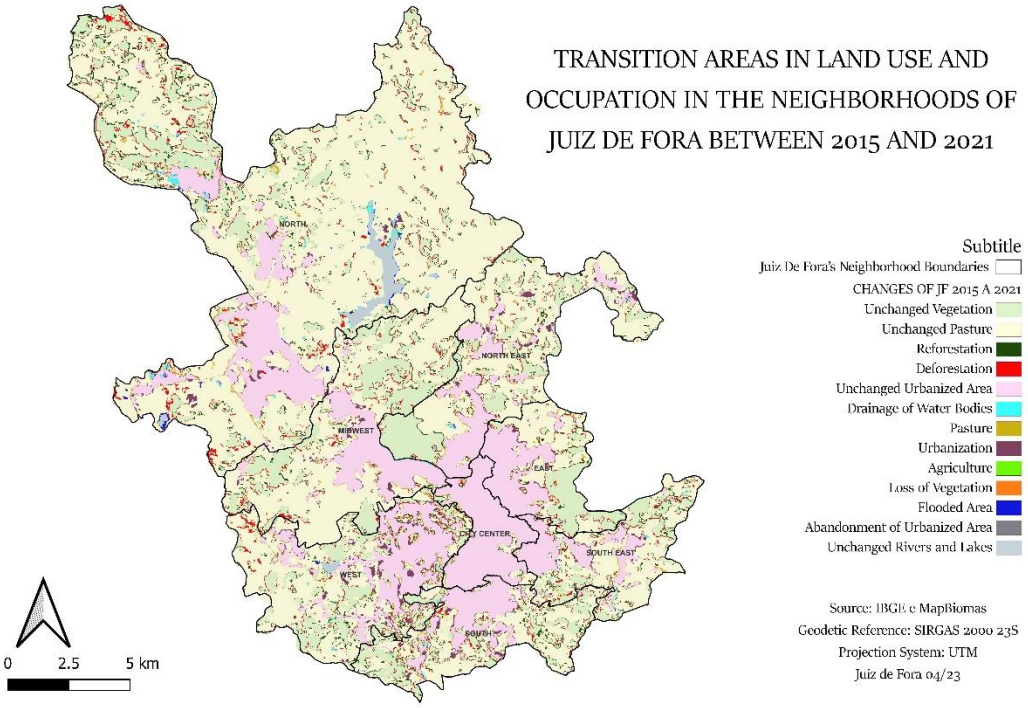
Figure 9 – Evolution of Land Use and Occupation in neighborhoods in the city of Juiz de Fora between the years 2015 and 2021



Source: The Authors, 2022.

Figure 10 – Class Transition Areas between 2015 and 2021



Source: The Authors, 2022.

Carrying out the general analysis of the mapping, it is clear that in the northern region of the city of Juiz de Fora there was an increase in the urbanized area, mainly close to the Barreira do Triunfo, Nova Era and Benfica neighborhoods. And the period in which the most significant growth occurred was between 1985 and 1995, due to the growth of nearby industries.

Deforestation could be observed near the area where the AMG 3085 State Highway is located, between the entire period from 1985 to 2005, which was inaugurated in 2017. This highway tends to attract and enable urban expansion to a fragile area, which is not interesting for the Dr. João Penido Reservoir supply source. Still in the North Zone, there was a great incentive for reforestation between 1985 and 2005 by Arcelor Mittal to obtain raw materials for blast furnaces.

Through a thorough analysis of the Northeast region, from 1985 to 2021, an increase in the urbanized area near the neighborhoods of Grama, Bandeirantes, Parque Guarani, Bom Clima, among others, can be observed. In the West region, between 2005 and 2015, including Parque das Águas, Belo Vale and Monte Castelo. It was a period in which there was government investment in Social Housing. There was also an increase in the urbanized area in the West region, comprising *Universidade Federal de Juiz de Fora* in 1985, and private condominiums between 2005 and 2015. More recently there was the construction of BR-440 and the *Estrega do Lago Condominium*, changing the landscape near the São Pedro Dam (ROCHA et al., 2022).

The increase in urbanization also reached the South region, which comprises the Santa Luzia, Teixeiras and Salvaterra neighborhoods between 2005 and 2021; Another observation in this location was a large area of deforestation for the construction of the *Fazendinha do Ipiranga* neighborhood from 1995 to 2015.

In the East and Southeast, this expansion of the urbanized area also occurred between 1985 and 2005 and 1985 and 2015, respectively; however, in the Southeast there was deforestation in the approximate extent of Mata do Ribeirão, Marmelos and Seminário da Floresta from 1985 to 2015. Table 2 refers to all the data obtained in the preparation of the analyzed maps, showing the classes that did not change and the classes that were chosen due to their importance and expressiveness in the socioeconomic and environmental sectors.

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Table 2 – Areas and Percentages of Class Transition in the City of Juiz de Fora

Class Transition	1985 -1995		1995 - 2005		2005 - 2015		2015 - 2021	
	Area Km²	Percentage	Area Km²	Percentage	Area Km²	Percentage	Area Km²	Percentage
Unchanged Vegetation	52.11	13.1	53.16	9.7	64.18	16.2	70.33	18.1
Unchanged Pasture	252.55	63.5	255.51	46.6	230.50	58.0	216.41	55.6
Unchanged Rivers and Lakes	3.67	0.9	3.70	0.7	4.06	1.0	3.80	1.0
Abandonment of Uban Area	9.39	2.4	1.05	0.2	0.09	0.0	0.08	0.0
Unchanged Urban Area	41.83	10.5	49.78	9.1	68.36	17.2	74.06	19.0
Loss of Vegetation	0.03	0.0	0.05	0.0	0.15	0.0	0.75	0.2
Reforestation	13.48	3.4	164.08	29.9	15.79	4.0	2.43	0.6
Deforestation	13.23	3.3	12.77	2.3	3.76	0.9	9.88	2.5
Pasture	1.38	0.3	0.90	0.2	0.76	0.2	3.06	0.8
Drainage of Water Bodies	0.68	0.2	0.67	0.1	0.75	0.2	0.98	0.3
Urbanization	8.84	2.2	6.03	1.1	8.23	2.1	7.11	1.8
Flooded Area	0.84	0.2	1.12	0.2	0.73	0.2	0.56	0.1
Totals	398.02	100.0	548.81	100.0	397.35	100.0	389,45	100.0

Source: The authors, 2022.

With the data obtained in the remote sensing analysis, it was possible to identify that the main agent of transformation of the landscape in the city of Juiz de Fora was the urbanization process that took place between the period analyzed in this article, with the emergence of new neighborhoods between the decades of the 1980s and 1990s and the implementation of residential condominiums, mainly between the years 2000 and 2015, which configured the period of time in which urbanization intensified, transforming pasture landscapes (the class with the greatest change) into consolidated residential regions. With the significant increase in population, it became necessary to implement infrastructure that met social and economic demand, mainly the construction of new transport routes, influencing the emergence of areas of deforestation and reforestation in the North Zone of the city. The period between 2015 and 2021 saw a recession in space change, thus obtaining the lowest rates of change. The maps generated also made it possible to identify the dynamics of space fragmentation over the decades.

4. CONCLUSIONS

This article aimed to analyze how the physical space of the city of Juiz de Fora and its main neighborhoods was used. The analysis used resources from Geographic Information Systems and Remote Sensing, widely used by the academic community to identify important variables for urban expansion and environmental preservation.

The study of transitions in land use and occupation makes it possible to identify changes in the social, economic and environmental profile. Remote management of urban and agricultural areas makes it possible to identify important factors, such as the situation of water resources and their availability so that space does not suffer from shortages, as well as preventing the population of areas most affected by extreme events; management also

allows the identification of degraded areas resulting from deforestation, contributing to timely decision-making and agility in measures against environmental crimes. With this analysis it was possible to observe whether regions designated as Legal Reserves are being duly respected. Likewise, periods of economic recession or industrial investments have been identified, allowing an expansion of unused spaces.

Given the above and the results obtained, it can be concluded that the city studied had a territorial expansion in the period covering the years 1985 to 1995; It is still observed that a significant part of the North region suffered from deforestation processes between 1985 and 2021. The present study contributed to the identification of the profile change in each region. A possible development of this research would be the application of ecological landscape metrics through the Qgis LecoS plugin. This would allow us to quantitatively study the quality of the remaining fragments with a view to preserving and forming physical corridors through conservation units, legal reserves and permanent preservation areas (PPA) (ROCHA, LAPA & GOMES, 2023).

The way these processes occurred will allow public managers to create sustainable urban growth models, protecting flora, fauna, water resources, air quality, conserving what remains of Juiz de Fora – MG's environmental heritage for current and future generations.

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