

USE OF GEOTECHNOLOGY TO DETERMINE URBAN EXPANSION IN THE DISTRICT OF VILA NEGRI, MUNICIPALITY OF TAQUARITINGA-SP- BRAZIL

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Abstract: Understanding the urban space from a complex and broad vision, going beyond the physical and environmental aspects, is important for increasing the quality of life and the environment must be considered as a socially developed place, shared and subject to multiple interests. The aim of this study was to identify and measure urban expansion in the district of Vila Negri, Taquaritinga, SP, using geotechnology and remote sensing techniques. High resolution satellite images and *Google Earth Pro* (GEP) software were used to collect a land use database. The methodology of visual interpretation of images by visual comparison in the free *software* GEP was used to identify and measure variations in urban expansion by multitemporal analysis, in the period from 2004 to 2022. The results showed that the changes that occurred in the district of Vila Negri in the The last 18 years have been marked by changes in the surface of the sugarcane crop, which continues to advance, over the citrus growing area.

Keywords: Natural vegetation cover. Urban elements. Rural geographic space. Google earth pro. Urban changes.

INTRODUCTION

The emergence or development of most cities are usually close to water resources (ASSAD, 2013), but without proper urban planning they cause significant changes in the natural landscape, which can be easily identified in the analysis of satellite images. In this regard, Melo, Sousa and Moraes (2016) evaluated the characteristics of the urbanization process in the city of Teresina-PI, in a specific region known as Ponte Estaiada. This study was carried out by means of a multitemporal analysis using Google Earth Pro satellite images between 2005 and 2015. The occupation of that space over time promoted changes in socio-spatial dynamics and in the urban landscape.

Urban agglomerations are often very close to permanent preservation areas (APPs) (ASSAD, 2013; GROSSI, 2022), and, in this case, pressure on such natural resources is inevitable. The municipality of São Miguel do Oeste, SC, extreme west of Santa Catarina is an example of human occupation along the APPs, as it had a strong influence of migratory processes and in the construction of that city it was established near the headwaters of the Guamirim River, in an area of propitious relief, basically flat, in the 70s, following the logic of expansion taking place close to the water source (MAZIERO et al., 2021).

In the current metropolitan region of Belém, it was observed that the advance of urban expansion occurred in a disorderly manner, a dilemma that is also evident in other large Brazilian cities, where the occupation of geographic space occurred in various ways, with the uses and occupation of the land determining the way peculiar in the relationship of society and nature as conflicting. Thus, there is an intense loss of natural vegetation cover in the central areas of the city, as well as in areas of urban expansion, reflecting in the reduction of green areas and a negative pressure on water resources (TUCCI, 2008; FEITOSA et al., 2011; ARAÚJO, LUZ and RODRIGUES, 2012).

Vianna (2020) comments that in recent years the municipality of Seropédica, RJ, with its 25 years of existence, has achieved economic growth, notably supported by the municipal government with initiatives to attract industries, mining companies and logistics companies, due to the proximity with the Port Region of Itaguaí, RJ, where the investments provided a significant Gross Domestic Product (GDP) when compared to the GDP of small farmers. Such investments originate economic, social and environmental impacts, leading them to a process of rural exodus and deterritorialization. Even with

the installation of a center of knowledge and knowledge, attracting so many teaching, research and extension institutions, the cooling process of family farming activities was not reversed.

THEORETICAL FOUNDATION

Population growth is inherent to development and, to a certain extent, necessary as long as this increase does not have negative consequences for the environment and its inhabitants (TOMASONI; PINTO & SILVA, 2009). Territorial and population expansion must be concomitant with urban structural growth in order to provide minimum survival conditions for individuals who must use the space sustainably (TUCCI, 2008). However, the reality of the urbanization process is still not ideal, considering that the territorial planning is inadequate, generating an often disorderly growth, accompanied by a lack of infrastructure that guarantees quality of life.

According to Borges et al. (2020), when studying the urban transformations of a city with less than 12,000 inhabitants, with a large part of this population in 2010 (50%) living in the rural area, found that the increase in the urban area and environmental problems were due to incentives local governments, mainly offering housing developments. From this same perspective, França (2021) portrays in his article the interests of a local population, the most common urban difficulties in small towns in the northern region of Minas Gerais, and the failure to participate in the decision-making process of space planning urban geographic. Citizens seek to improve the conditions of their lives, notably in relation to urban infrastructure, urban furniture, employment, schools, health, transportation, leisure, security, among others.

Carvalho (2018), makes important considerations about the importance of the land cover situation in hydrological units, as

the different uses can represent an important indicator of the quality of the natural environment and ensure the sustainability of water resources in the urban and rural ecosystem. These authors also report that:

“Certainly, each of the Brazilian river basins presents geoenvironmental particularities that individualize them and that could help to define the maximum limits of land use capacity and consequent deforestation. For this reason, studies of watersheds, focused on the evolutionary characterization of land cover, for the survey of protected areas and for the characterization of vulnerability to the triggering of erosion processes, become important tools to help, for example, in the elaboration Water Resources Plans and Ecological-Economic Zoning”.

Ferrari, Melo and Mendes (2014) reported that the population of Jales in the 50's was 95% rural, and in 2010 this population was only 6%. This decline in the rural population, who lived in the city and worked in the countryside, results from the implementation of the sugarcane production system of the sugar and alcohol industries, which caused substantial changes in the economic development of the micro region of Jales, and, consequently, generated environmental impacts (FEITOSA et al., 2011).

For Oliveira and Nascimento (2018), the implementation of an undertaking in the pulp and paper segment was enough to mark the restructuring of the local urban space in the city of Imperatriz, MA. The authors conclude that the urban space of Imperatriz was restructured due to the implementation of the Suzano Papel e Celulose factory. Thus, the urban space became a speculative element in the process of expanding the urban fabric, primarily meeting the needs of the installed enterprise.

Urban development in peripheral cities, such as Japeri-RJ, has recently experienced a lack of investment in urban infrastructure, land

use with irregular occupations and undesirable economic activities, such as landfills, mining companies and polluting industries close to places inhabited by population needy, which led to major environmental impacts, conditioning the urbanized region to low socioeconomic indices (ALCANTARA et al., 2020).

The adoption of public policies from an environmental point of view that aim to preserve the urban green, highlights the wide benefits of maintaining natural tree formation (CORREIA FILHO et al., 2021), which guarantees the socio-environmental quality of the populations, where the urban space can be investigated using satellite images with robust software, such as QGIS, and found in this study that the neighborhood had inadequate urban planning, and in some neighborhoods a poor infrastructure was identified with few green and leisure areas (ARAÚJO, LUZ & RODRIGUES, 2012).

Barros (2014) comment that measures capable of establishing the correct and sustainable use of natural resources in the territory to be urbanized must be applied in urban space planning actions. He further reports that:

“The density levels combined with the morphology of the space are associated, for example, with the existence of green areas, as well as the maintenance of permanent preservation spaces. The modifications produced by the intervention of the population in the natural space may result in aggressive aspects to the inhabited region. Faced with such significant data, the need for a reorganization of spaces already occupied and the planning of future occupations, must be associated with actions that promote a better use of natural resources and that also consider determining aspects for the formation of the urban environment”.

The use of geotechnologies in the analysis of the suppression of vegetation resulting from

urban expansion in the last 20 years, in the municipality of Teresina-PI, allowed to identify that the municipality has been expanding and losing part of the natural vegetation, an important condition in promoting shading, thermal comfort and maintenance of quality air (FEITOSA et al., 2011).

Gomes (2013) reports that the creation of urban parks in Ribeirão Preto began in 1965, and in 2007 Ribeirão Preto implemented 13 parks. However, the parks are not well distributed throughout the urban fabric, in a way that favors their use by all parts of the population. It appears that the best-structured spaces are located in areas of increasing real estate value, which are generally not accessible to the low-income population.

The occupation of space over time can promote changes in socio-spatial dynamics and in the urban landscape, and these changes can be verified using satellite images from *Google Earth Pro* (MELO, SOUSA & MORAES, 2016). These authors found that there was a notable development in this specific area of the city, but without proper urban planning and with significant changes in the urban landscape, which can be easily identified in the analysis of satellite images.

Ferreita and Silva (2019) used satellite images and remote sensing techniques to assess changes in land use and occupation in areas that were once traditional for soybean and corn cultivation, in the Rio Brillhante Hydrographic Basin, MS. These authors verified that the advance of the sugarcane culture continues very strong in the mentioned basin. They warn that the option of occupying sugarcane exclusively can lead to potential socio-environmental damage from this activity on the environmental balance of the watershed, especially in the maintenance of water resources and forest remnants.

The use of geotechnologies, due to its versatility, has been used to analyze, for

example, the suppression of vegetation resulting from urban expansion, where one can see the advance of urbanization, expanding disorderly, which causes losses of part of the nearby natural vegetation. to urban agglomerations, and this vegetation, when maintained, is an important condition in promoting shading, thermal comfort and air maintenance (FEITOSA et al., 2011).

The use of geotechnologies in education has enabled the development of a critical census of public school students, based on the observation of interactions between man and nature. With the use of satellite images and in order to socialize pedagogical practices with the use of images from geographic maps, photographic records and satellite images from *Google Earth Pro*, Ongaratto and Rocha (2013) point out that the use of images for the analysis of the land use contributed significantly to the teaching and learning of Geography content, where students felt more motivated and stimulated to learn the discipline's content.

The use of free software *Google Earth Pro* (GEP), as it is freely accessible and easy to handle, is very useful to be used in the public education network, but also as an alternative to aid in the management of urban space, in conducting or managing the afforestation of a given city by the power municipal (CECATO, RODRIGUES & BOVERIO, 2020). In this regard, Rodrigues, Ferrarezi and Bovério (2020) developed a relatively simple methodology for using the GEP software to determine the abundance of urban trees, in such a way that the technique also allows high school and elementary school teachers to use this tool with ease. the main purpose of assisting in teaching learning and diversifying the application of different contents of Geography and Biology. The aim of this study was to identify and measure urban expansion in the district of

Vila Negri, Taquaritinga, SP, using satellite images available on the software *Google Earth Pro*.

MATERIALS AND METHODS

The present study was carried out in the district of Vila Negri, municipality of Taquaritinga-SP, under the coordinates, latitude 21°23'40.74"S and longitude 48°37'55.64"W. The climate of the region is classified as humid mesothermal in summer hot (Cwa). The geological constitution of the area belongs to the Bauru formation and the predominant relief is gently undulating (RODRIGUES, PISSARRA & CAMPOS, 2009). The main soil unit is classified according to the pedological map of the State of São Paulo, according to Oliveira et al.(1999) as Argisols and the original vegetation is composed of Tropical Broadleaf Forest.

To determine the urban expansion of the district of Vila Negri, Taquaritinga, SP, the free software *Google Earth Pro* (GEP) was used, for the use of territorial demarcation practices adapted from Rodrigues, Ferrarezi and Bovério (2020), and for comparison of satellite images according to Ongaratto and Rocha (2013), by multitemporal analysis between the years 2004 to 2022. Initially in the year 2003/2004 the urban expansion was measured from the perimeter and area determination, moment in satellite image maps available in the *GEP software* were made (Figures 1, 2, 3 and 4).

Once in the desired district, use two transects, one in a north-south direction (NS) and the other in an east-west direction (LO), in such a way that these lines present a right angle between them, as shown in Figure 1. From a shorter period (2003/4) to the immediately following period (2022), where the variation in the urban district perimeter and the urban elements that stood out the most in terms of their variations were determined.

RESULTS AND DISCUSSION

In Figure 1, it is possible to notice that the technique for identifying and demarcating landscape elements (RODRIGUES, FERRAREZI & BOVERIO, 2020) highlights the different land uses by quadrant. It is clearly evident that quadrant 1 (Q1) features an extensive permanent preservation area (APP) with a perimeter of 5.6 km and an area of 21.8 ha, while quadrants 2 and 4 have a smaller APP area and with the limit to the urban environment, which makes these areas suffer a constant anthropogenic pressure. It is also observed, in quadrants 1 and 2 of Figure 1, the installation of a housing area, consisting of 122 residences in the initial construction phase, lacking urban infrastructure (asphalt and lighting).

According to IBGE 2010 data, the Vila Negri District had a population of 485 individuals in the urban area and 443 in the rural area, a fact that may explain the increase in housing density from 2003/2004 to 2022. Sugarcane intensifying in these 18 years, the rural exodus was inevitable, which is referenced by the reports and Roma (2011).

When analyzing the image of the district, after a period of 18 years (Figure 2), it is noted that the APP areas in quadrant 1 have changed little. However, the urban area stands out in quadrants 1 and 2, where there was human occupation, probably coming from agricultural families in the nearby rural environment, or even from the municipal seat, as they are a source of labor in the rural area, mainly to meet the demands of the

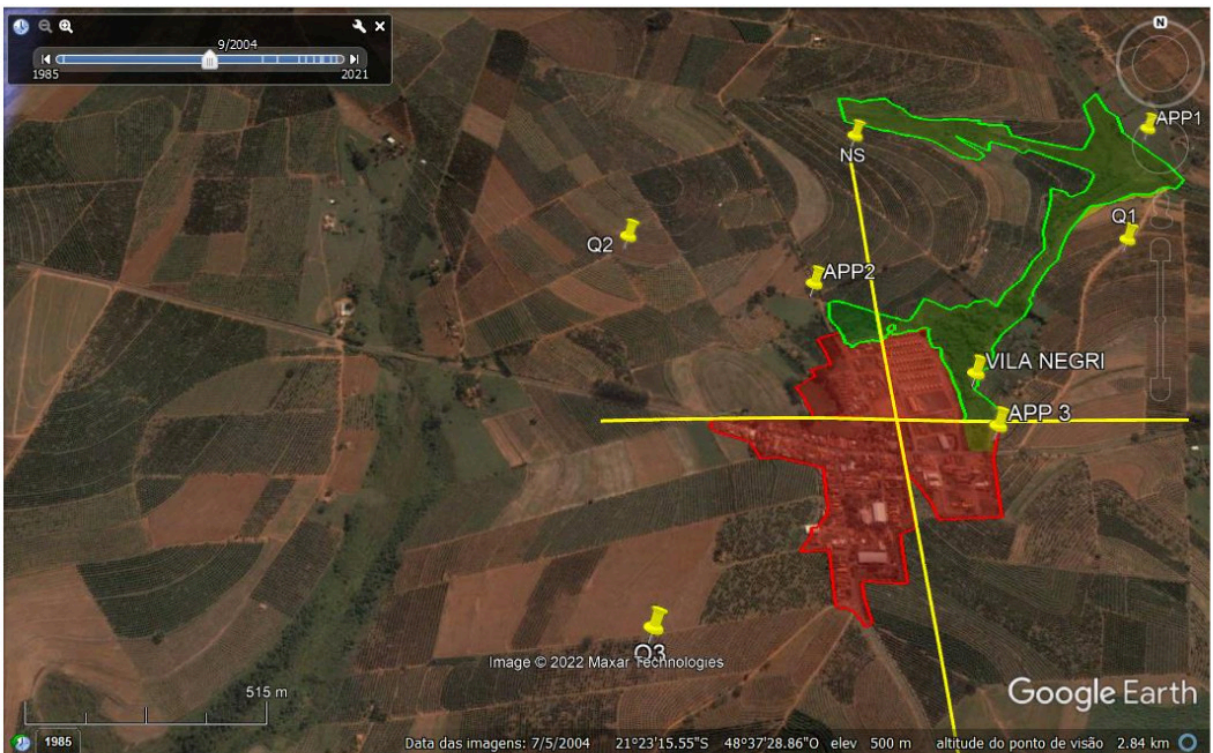


Figure 1. Urban area of the district of Vila Negri, Municipality of Taquaritinga in the year 2003/4.

Source: The authors(2022). Lines in yellow represent the north-south and east-west transects, Lines in red indicate the contour of the urbanized area, In green: contours of the permanent preservation areas (APP), Q1, Q2, Q3 and Q4: represent the quadrants.

lemon, orange and guava crops, and thus avoid long journeys.

The most significant change in land use and occupation can be seen in the east of the district and further north (Figure 1), a region where sugarcane cultivation is more present. These changes that have occurred over the last 18 years are confirmed by Roma (2011), who found that such changes in land use and occupation by sugarcane cultivation significantly altered the rural landscape in several regions of the State of São Paulo.

Figure 3 identifies the changes in land use and occupation in the region south of quadrants 3 and 4, and it is noted that the changes are not homogeneous in the rural landscape closer to the district of Vila Negri. In Figure 3 it is possible to observe (15 yellow circles) the maintenance of the culture of the district (Citriculture), represented by the

plots. However, it is possible to note that the use and occupation of the soil in the vicinity of the district are already present, due to the advance of sugarcane cultivation (5 circles in lime green).

In Figure 4 it is possible to verify significant changes in land use and occupation, the presence of a degraded area, with ongoing erosion (Purple circle). Circles marked in light blue denote the presence of dammed water resources, which are present in the four quadrants.

Such water resources, apparently, had little visual variation in their respective areas and are important to contribute to the water sustainability of the region. It is also possible to identify in Figure 4, in the rural area very close to the urban district area, the presence of dammed water resources, composing an area of water depth, probably with the capacity

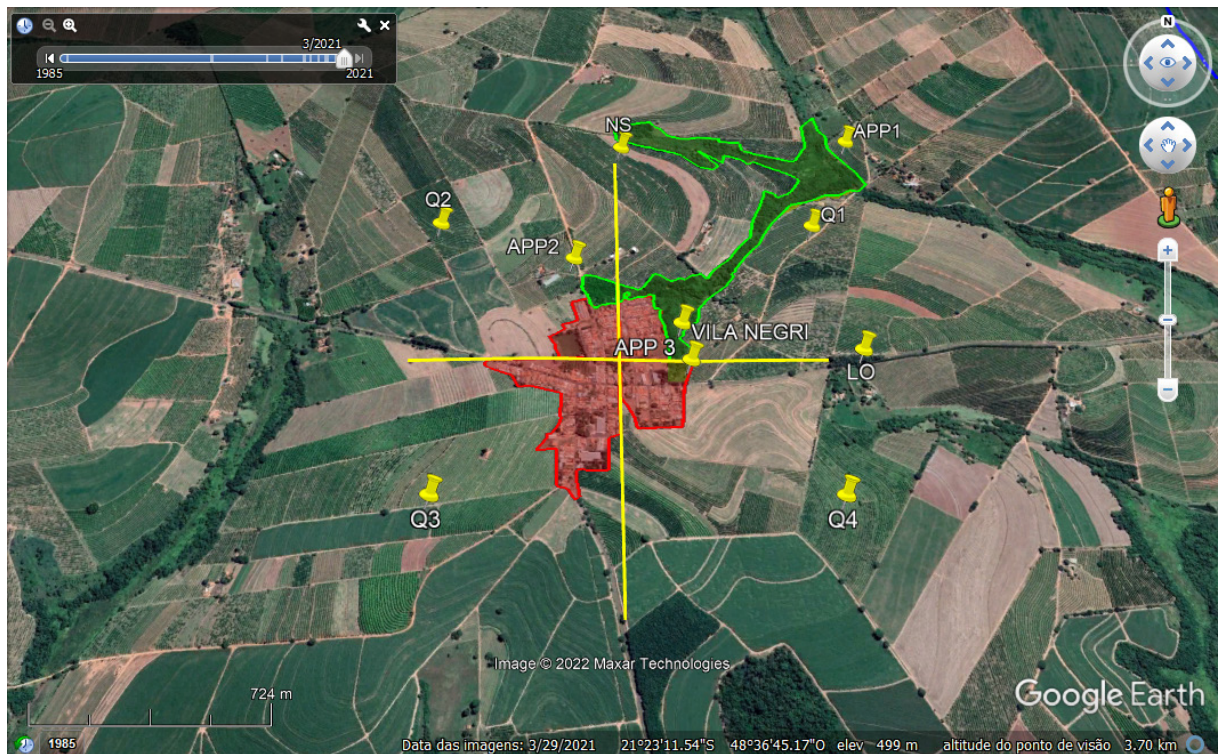


Figure 2. Urban area of the district of Vila Negri, Municipality of Taquaritinga in the year 2022.

Source: The authors (2022), LO: East-West, NS: North-South.

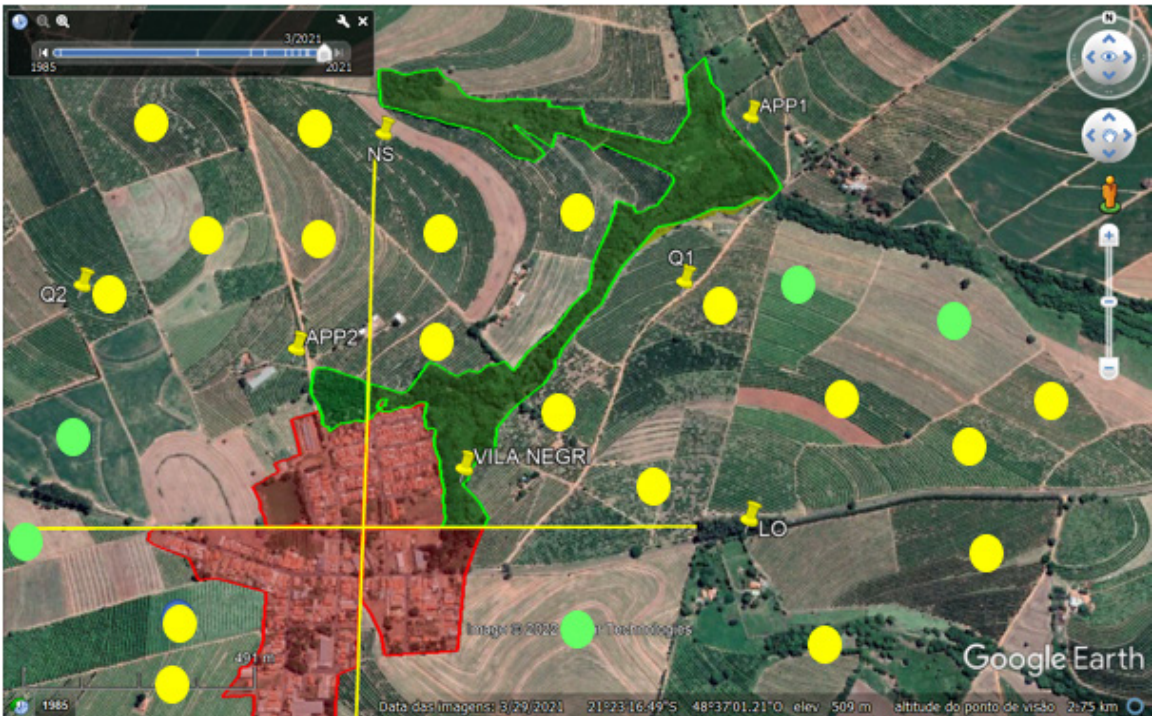


Figure 3. Changes in land use and occupation in the district of Vila Negri, Municipality of Taquaritinga in the year 2022.

Source: The authors (2022).

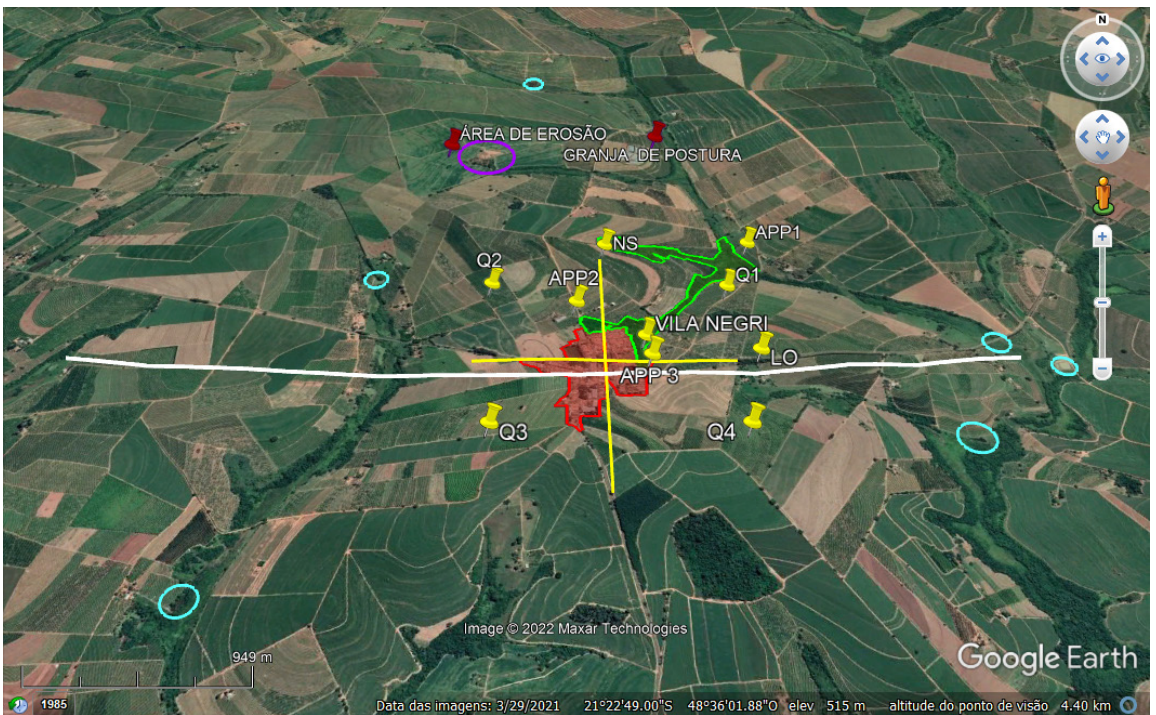


Figure 4. Urban-rural area of the district of Vila Negri, Municipality of Taquaritinga, in the year 2022.

Source: The authors (2022); White East-West line indicates soil profile cut line, Light blue circles indicates dammed water resources, In purple, Q 2: indicates erosion area.

to water wild animals. In this same space, it is observed that the permanent preservation areas were maintained and, in some cases (white arrow, R) shows a significant area that was recomposed, probably to comply with the new environmental legislation from 2012. Differently from Feitosa et al. (2011), who, with the use of geotechnologies, found environmental pressures due to urban expansion in the city of Teresina — Piauí.

In this period of 18 years there was the installation of a significant agricultural enterprise characterized by laying poultry. According to PMDRT (2013), sanitation in rural areas does not have an efficient individual system for the treatment of domestic sewage. Most rural roads are not paved and are visited weekly for garbage collection. The district has only a district wake. The water supply in rural properties that have residents in their respective areas is carried out by the common well system (waterhole type cistern) and, to a lesser extent, by a perforated well with greater flow (greater depth), semi-artesian well.

Urban expansion in such a small district, or the changes that eventually occurred in urban elements, underwent little change over these 18 years. Even surrounded by conservation areas, it is noted that the afforestation in that district is quite sparse, and could be better managed to guarantee better thermal comfort to the population. The changes that took place in the district of Vila Negri are partly in accordance with the reports by Rocha (2016), where the author noted that the municipality of Bonito, RJ, was in permanent conflict between rural and urban, as it still has several rural areas, but the majority of the population is recognizably urban. Feitosa et al. (2011) reported that the environmental changes promoted by the urban expansion of Teresina — Piauí, interfered in the microclimate of the city.

Changes in land use and occupation in the region under study are in line with reports by Roma (2011), where the expulsion of small farmers from their properties alters the family productive structure and leads to a condition of material poverty and rural culture. The small farmer is removed from his land, a fact that accelerates migratory flows and there is a regression in labor relations. Thus, it is denoted that the restructuring of agriculture causes profound social impacts, as observed with the expansion of the sugar and alcohol sector, in which monoculture with land concentration is reaffirmed, generating the expropriation of the small rural producer, who resides in cities and becomes impoverished. The advance of sugarcane, the adoption of new technologies and the mechanization of sugarcane cutting generate socio-environmental impacts and increase unemployment, reinforcing poverty in cities with characteristics of a more rural society.

The de-ruralization process commented on by Vianna (2020) probably occurred in an attenuated manner in the district of Vila Negri over the period of 18 years, probably motivated by changes in land use and occupation, from sugar and alcohol activity overcoming citrus growing. Not unlike the results found in this study, Ferreira and Silva (2019) report that changes in land use and occupation in areas with another agricultural tradition (soybean-corn) accumulate social inequalities and inevitable socio-environmental impacts, with significant damage for native vegetation areas. The pressure on forest remnants protected by Brazilian legislation is intense. The occupation of geographic space over time in the Vila Negri district promoted few changes in the socio-spatial dynamics and in the urban landscape, and visually greater changes in the rural environment, corroborating data from

Melo, Sousa & Moraes (2016) that similar to this study, used satellite images from Google Earth over a ten-year period.

CONCLUSION

The changes in land use and occupation that have occurred in the district of Vila Negri over the last 18 years have been marked by

the implementation of sugarcane cultivation to the detriment of the citriculture plant production system. The techniques employed in this study, with the use of *Google Earth Pro software*, can be used by public or private companies, and in curricular contents of geography and sciences of the public teaching network.

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