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Analysis of the transition of the land use and cover: subsidy to public policies of soil use in the Brazilian Savannah

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A B S T R A C T

The changes in the land use and cover to supply the human demands have caused an unbalance in the ecosystems. Therefore, understanding the space-time dynamics of the transformations of soil use allows enabling technical-scientific basis to protect vulnerable areas, which is possible through the application of the Geographic Information System (GIS), and of remote sensing products. Thus, the objective was to analyze the changes of the land use and cover in the years of 2013 and 2020 in the hydrographic basin of Montividiu River, in the state of Goiás, Brazil, using images of Operational Land Imager (OLI) system. The verification of the pattern and magnitude of the changes of the land use and factors that have influenced the process occurred by a synergy of orbital data, observation on the field, and geospatial analysis with the Cross-tabulation Matrix. Conversions between classes of pasture, exposed soil, agriculture, Cerrado's natural vegetation, industry, rural buildings, water, and the like, were identified, emphasizing the domain of agriculture areas since 2013, the decrease of native vegetation, and expansion of areas of exposed soil, industries areas, urban areas, areas destined to eucalyptus plantation, and rural buildings. The results showed transformations in the soil cover, and the environmental implications of the changes of land use in the hydrographic basin of Montividiu River, enabling data to subsidize policies of local land use and other studies.

Keywords: anthropic actions, geotechnologies, soil use policies, water resources.

Análise da transição do uso e cobertura da terra: subsídio à políticas públicas de uso do solo na Savana Brasileira

R E S U M O

As mudanças no uso e cobertura da terra para atender demandas humanas tem provocado desequilíbrio nos ecossistemas. Assim, compreender a dinâmica espaço-temporal das transformações do uso do solo permite disponibilizar embasamento técnico-científico para proteção de áreas vulneráveis, o que é possível por meio da aplicação de Sistemas de Informações Geográficas (SIG) e de produtos de sensoriamento remoto. Com isso, objetivou-se analisar as mudanças no uso e cobertura da terra nos anos de 2013 e 2020 na bacia hidrográfica do Rio Montividiu, no estado de Goiás, Brasil, utilizando imagens do sensor Operational Land Imager (OLI). A verificação do padrão e magnitude das mudanças no uso da terra e os fatores que influenciaram no processo ocorreram pela sinergia de dados orbitais, observação em campo e análise geoespacial com a Matriz de Tabulação Cruzada. Foram identificadas conversões entre as classes de pastagem, solo exposto, agricultura, vegetação natural do Cerrado, indústria, construção rural, água e outras, com destaque para o domínio de áreas agrícolas desde 2013, redução da vegetação nativa e expansão de áreas de solo exposto, industrial, urbana, de áreas destinadas ao plantio de eucalipto e de construção rural. Os resultados retrataram as transformações na cobertura do solo e as implicações ambientais das mudanças no uso da terra na bacia hidrográfica do Rio Montividiu, fornecendo dados para subsidiar políticas de uso da terra local e outros estudos.

Palavras-chave: ações antrópicas, geotecnologias, políticas de uso do solo, recursos hídricos.

Introduction

Increasing anthropogenic actions reflect on the removal of the vegetation, the agricultural expansion, the populational growth, the urbanization, the policy of land ownership, and the climatic variability (Belay & Mengistu, 2019; Degife et al., 2019), also affecting the energy flux of a hydrographic basin with the alteration of the hydrological regime, the erosion, and the dynamic of soil loss and sediment carriage (Adhami et al., 2019; Aneseyee et al., 2020; Desta & Fetene, 2020; Kusi et al., 2020), reaching the water supply service, which presents meaningful spatial differences between the availability and the demand, with water deficits and incompatibilities which rebound harmful effects to the human survival and development (Chen et al., 2020). Furthermore, the quality of the water is highly influenced by the use and management of the soils in a hydrographic basin. The water regime influences the dragging of superficial materials in the rainy season, as well as the increase in the concentrations of pollutants from disposals, due to the reduction of the water volume flowing in the drought season (Fia et al., 2015). Passos et al. (2021) relate such impacts to bad space management, not being applied to those technical or environmental criteria which aim to respect the support capability of nature.

In this respect of land-use changes, we emphasize the protection of the ecosystems, among them the Cerrado which concentrates the greatest national production of soybean, placing the country in first place in the global production raking (CONAB, 2021). The soybean crop represents 90% of the expansion of the agricultural area in Brazil, which corresponds to 9.5 million hectares between 2000 and 2017, with 5 million only between 2007 and 2014. On the other hand, the Cerrado is the least protected biome of the country with only 8.1% of its extension legally secured. This happens because the environmental policies, since the beginning of the 2000s, are focused on the protection of the Amazon Forest. As the Soy Moratorium as the Forestry Code neglected the protection of the Cerrado, pushing the advance of the agricultural border at the expense of the degradation of the native vegetation of the region (Magalhães et al., 2020), justifying it by the great availability of cheap lands, plain topography, rainfall favorable regime, and by the dissemination of chemical technology, enabling the correction of the acidity of the soils of the Cerrado (Lopes et al., 2020). Thus, the Cerrado has been through great changes in its landscape with the expansion of agriculture and pastures, which increased the pressure over the preservation of biodiversity (Gonçalves et al., 2020).

Historically, the programs supported by the government to stimulate the occupation of the Cerrado emphasized from the 1970s due to the building of road infrastructure which gave access to the Brazilian capital (Brasília), causing deep changes in the landscape (Machado & Walter, 1995; Bonanomi et al., 2019). The combination of the rural development and the preservation policies requires governmental actions which approach, properly, the theme, after all, the intensity and the rhythm of the transformation of the land use are associated, among other motivations, to different degrees of capitalization, use of agricultural inputs, and income obtained among the types of frontier (Schielein e Börner, 2018). Therefore, intensification programs supported by the government were instituted, was the creation of the Program of Development of the Cerrado (Polocentro) in 1975, and the Japan-Brazilian Program of Cooperation for the Development of the Cerrado (Proceder) initiated in 1979, both provided with substantial resources to finance infrastructure, and tax incentives to subsidize the economic activities (Almeida & Buainain, 2016; Alves et al., 2020; Lopes et al., 2020).

Polocentro was implemented due to the articulation of the Brazilian Federal Government along with the Government of the states of Goiás, Minas Gerais, and Mato Grosso (Brazil, 1975), and it has placed the Middle-West region of Brazil as a potential producer of grains, fibers, animal protein, and energy (Wagner, 1982), because it enabled the creation of infrastructure, and investments by rural producers (Bastos, Barbosa & Oliveira, 2012). The program, which was active from 1975 to 1980, was executed in 12 centers of the evolved Brazilian states, and there's an estimative that it has influenced the occupation of 2,4 million ha (30% of the total region of the program which aimed to achieve with agriculture). Moreover, one of the goals of the Polocentro was that 60% of the explored area was destined for different crops, however, a meaningful extension of the areas was occupied by livestock, and part of the spaces by soybean crops (with the transition from 80,000 ha to 508,289 ha during the duration of the program), presenting diversifications in the production (Pires, 2000).

Therefore, due to the productive inefficiency, and intensification of the Brazilian inflationary process, it was verified that only subsidies weren't enough to reach the objectives of the program, pointing out the need for intervention in the agricultural process. After all, the resources invested until then caused an increase in the price of the land, and they didn't present a greater number of jobs, with the reduction of small rural properties. Thus, there was an advance in the negotiations to implement Proceder which involved the Brazilian and Japanese governments (Pires, 2000; Paiva et al., 2017).

Proceder, on the other hand, was characterized by the insertion of private money from international capital, in the agricultural practices, which culminated with alterations in the dynamics of the land use (Bastos, Barbosa e Oliveira, 2012). The merger of the capital was due to the interest of the Japanese government in importing grains, and the program was developed by steps: the first phase constituted on colonization projects, and the application of capital in the state of Minas Gerais (Brazil); the second step, nominated Proceder II, was executed in the states of Minas Gerais, Goiás, Mato Grosso do Sul, and Bahia (Brazil); and, Proceder III was developed in the states of Tocantins, and Maranhão (Brazil). The program approached the insertion of agricultural areas, defined the procedures for land use (technologies to be implemented and type of cultivation), accomplished the selection of settlers, coordinated the rural producers through cooperatives, and the distribution of the production, as enabled consulting for the governments of the federal and state spheres as to building and infrastructure (Pires, 2000; Santos, 2017). Therefore, concerning the colonization projects, the results overcame the initial goals of Proceder (Paez et al., 1984). The Southwest of Goiás state, inserted in this scenario since the Green Revolution which occurred from 1970, was favored by physical/natural aspects (plain relief, deep and well-drained soils), and political (Proceder allowed the agrobusiness expansion in the microregion (Lemes et al., 2021). However, although all the planning, the program brought economic and environmental losses to the region, marked by the noncompliance of the settlers, and the withdrawal of enterprises – the abandon of areas already cultivated implied in the opening of new areas of Cerrado for being cheaper (Pires, 2000).

In addition to these, the Research Center of Farming of the Cerrado (CPAC) from the Research Brazilian Enterprise of Farming (EMBRAPA) had as an objective to evaluate natural resources like soil, climate, and vegetation; expand agricultural activities with the overcome of limiting factors to the process (acidity, low fertility of the soil, and water deficiency); and, promoting the development of livestock and fruit farming (EMBRAPA, 2012). The new infrastructure associated with high technology on the field culminated in the installation of agroindustry units in the region of Rio Verde (GO), altering the scenario of the Middle-West with the expansion of industries, and, consequently, creating jobs (Sano, 2011). The production of food to supply the cities created a dispute between the soil use, resulting across the years in a dynamic arrangement which pleads modern policies, as the recent launching of Inovagro, a project of the Nacional Bank of Economic and Social Development (BNDES) capable of stimulating the demand for lands in new frontier areas (Schielein & Börner, 2018).

Due to the discussions over spatial transformations, and water vulnerability, different studies seek to represent the spatial and temporal dynamics of this development that comes from the "national integration" (Lopes et al., 2020), with evolutionary dynamics characterized by the uses which consume water the most in the world (such as agriculture, industrial and urban uses) (Damaceno et al., 2021). In this scenario, the identification and classification of the elements which occupy Earth's surface are substantial to the accreditation of the environment (Lemes et al., 2021). The use of remote sensing as a studying tool of extensive geographic areas enables environmental monitoring economically when capturing information from the atmosphere and enabling it as a product to be classified and validated (Jin et al., 2019). The classification is the process that makes data useful with several factors that influence the quality of the final product, as a type of image, class options, validation, pre and post-processing, and auxiliary data (Meneses et al., 2012; Khatami et al., 2016). This compilation of spatialized data is enabled through the Geographic Information System (GIS) which favored the diagnosis and characterization of territories of interest (Silva et al., 2021).

After the elaboration and validation of the maps, Pontius Junior et al. (2004) propose using the Cross-Tabulation Matrix to analyze the changes in land use and cover, identifying the quantitative of alterations in the areas through the relation of the classes in distinct moments to verify the loss or gain of space, being a method adopted in studies by Suarez & Soares Filho (2013), Teferi et al. (2013), Campos & Queiroz Filho (2017), Belay & Mengistu (2019), Degife et al. (2019), Neves et al. (2019), Alves et al. (2018b), Alves et al. (2021), etc.

Thus, it's verified the importance of using geospatial intelligence, satellite, or in loco observations associated with mathematic models, to explore space-time variations, and understanding the transformations of the regional ecosystem (Huang et al., 2019; Jin et al., 2019). According to Alves et al. (2018b), territorial and environmental management is benefited by the use of geotechnologies on studies of hydrographic basins, that's because there's the supply of trustworthy data promptly, being considered a practical and economical use of methods. According to Silva & Rosa (2019), due to so many spatial reordering in Cerrado's landscape, the incorporation of geoprocessing methods is necessary and positive to make mappings with quality, using compatible and low-cost devices. Knowing the geographic space better is important to accomplish the diagnosis and planning of the potential land use, allowing the decision-making by environmental agencies (Fia et al., 2015).

In the face of what was exposed, and considering that there's a loophole in the knowledge of Brazilian Cerrado due to the few studies developed in the region, and the importance of those to elaborate efficient and sufficient preservation strategies for the biome (Gonçalves et al., 2010), since the changes in land use and cover in the last few years suppressed vegetation areas of Cerrado, implying relevant environmental impacts in hydrographic basins, the objective of this article was to analyze the changes of land use and cover in the years of 2013 and 2020 in the hydrographic basin of Rio Montividiu , in the state of Goiás, Brazilian Savannah, using images of Operational Land Imager sensor (OLI). This sensor is connected to Landsat 8, a satellite that was launched in 2013 which enables images with a spatial resolution of 15 m. Although the abundant literature on remote sensing, as far as we know the studies over the use of OLI sensor for analysis of the transformations of the land in different years are still uncommon. The criteria of the OLI sensor and the sensitivity to determine radiance amplitudes favor the understanding of the dynamics of the land use and vegetation cover, because the generated images aren't distinguished by the spatial resolution.

The hydrographic basin of Rio Montividiu has environmental, economic, and social importance, which there's high farming productivity, besides being the water source for several uses. The results will enable a scientific basis for the optimization of the planning and management of the hydrographic basin, in addition to favoring improvements to the welfare of the society.

Material and methods

Study area

The study area is located in the Southwest of the state of Goiás, more specifically in the municipality of Montividiu (Image 1). The hydrographic basin of Montividiu River is located among the geographic coordinates 17°19'5.69"S/ 51°40'46.18"W and 17°19'16.70"S/ 50°59'18.32"W, with the mouth of Verde River or Verdão River, being the main water collection source for the supply of the urban population of the municipality, with a granting of 60 $L.s^{-1}$, according to the case No. 18922015 of 12/26/2015 (SEMAD, 2018). Besides, this water body is the water source for the irrigated farming production (mainly soybean and corn), and livestock.

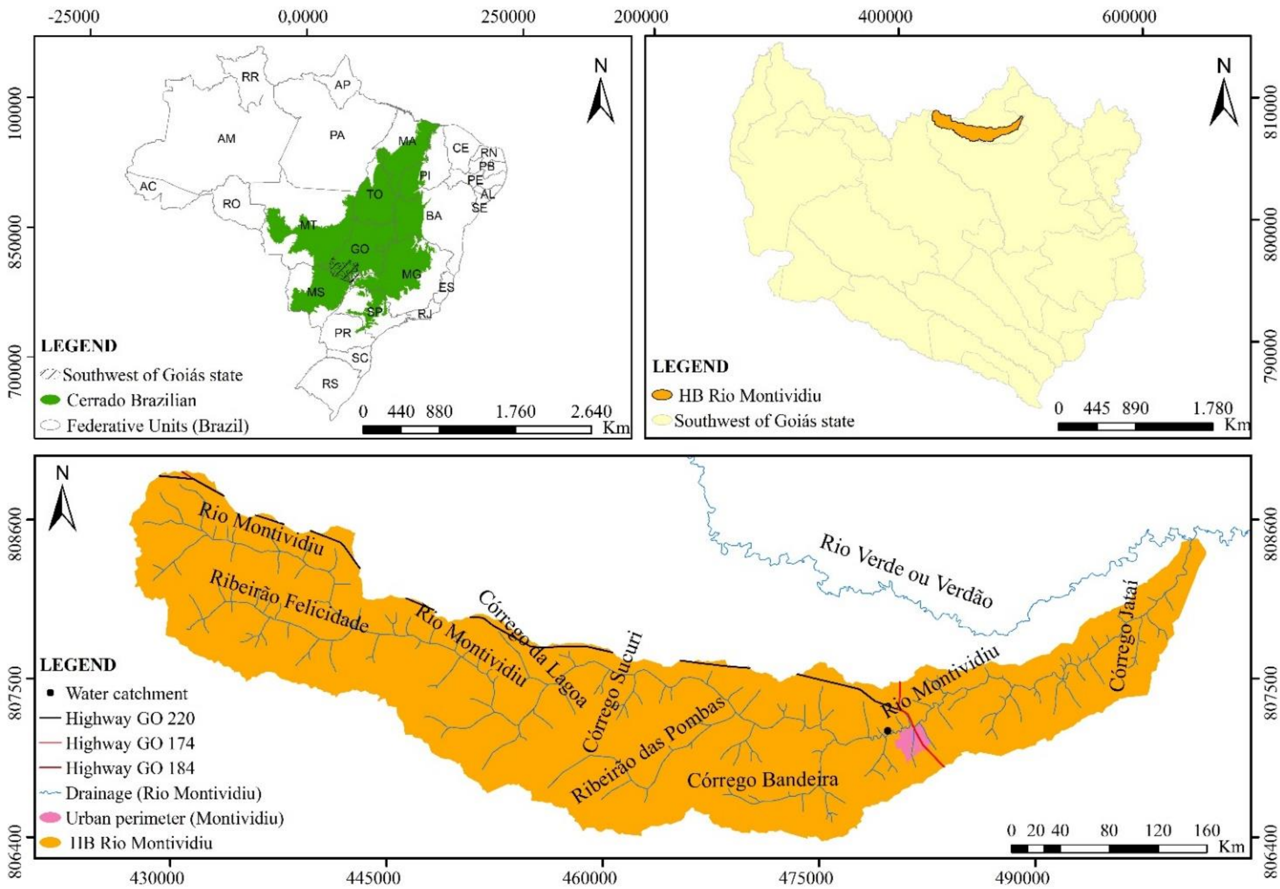


Image 1. Location of the hydrographic basin of Montividiu River, Southwest of Goiás state, Brazil.
Source: Map organized by the authors from the geographic database enabled by SIEG (2020). Elaborated in the Plain Coordinate System: Datum Sirgas 2000, UTM, Zone 22S.

The basin is inserted in the Cerrado Biome (Brazilian Savannah), corresponding to 22% of the Brazilian territory (2 million km²), and it's composed of different phytophysiognomies (savannah, forest, and grassland shrub vegetation) (Ribeiro, Diniz-Filho & Barberi, 2010; Roitman et al., 2018; Hidasi-Neto et al., 2019; Oliveira et al., 2019; Borges & Loyola, 2020; Silva et al., 2021). This diversity is due to the seasonal rainfall, the geotechnical characteristics, the fire regime, and also because of its strategic location which institutes it as an ecological corridor (Ribeiro, Diniz-Filho & Barberi, 2010).

It's an area of high climatic instability and high degradation of the natural vegetation, which makes it vulnerable to environmental changes (Borges & Loyola, 2020) – for example, it's estimated that by the year 2050, from 31% to 34% of the remaining native vegetation will be extinct due to the lack of minimum protection and the pressure from the agricultural expansion (Borges et al., 2019).

According to the climatic classification by Köppen-Geiger, the location of the study area reverberates the Aw climatic type, characterized by a tropical climate with summer rainfall, with two well-defined seasons: fall and dry winter (from May to September), and rainy spring/summer (from October to April), and the coldest month with an average temperature of 18°C (Oliveira et al., 2019; Moura, 2021). Concerning the rainfall, it was observed in the weather station of Montividiu (code 1751004) for 34 years (from January 1986 to December 2019), verifying an average of monthly totals of 120.54 mm, and an annual average index of 1,446.44 mm (Image 2) (ANA, 2020).

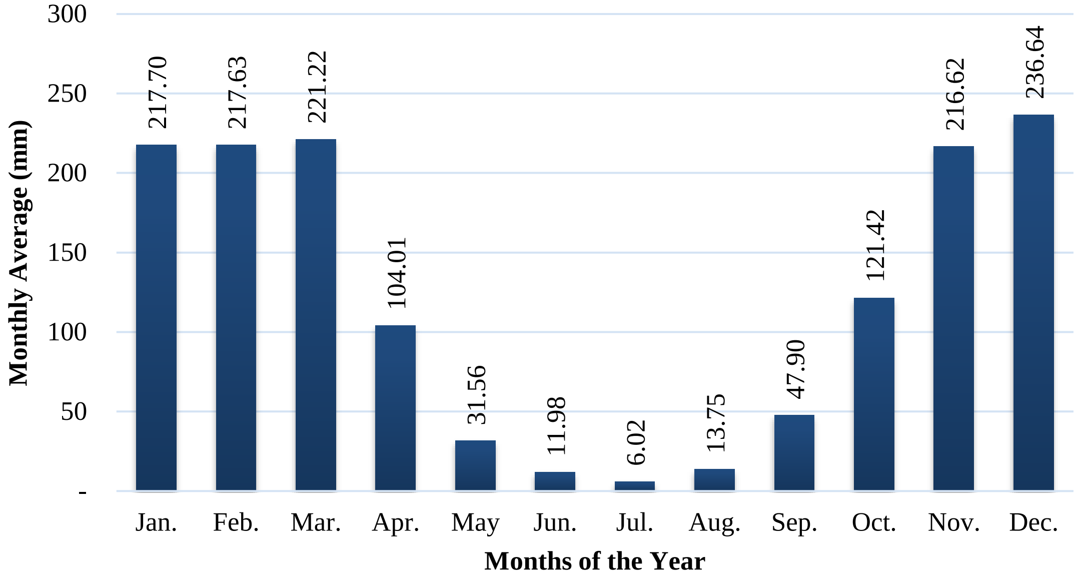


Image 2. Monthly average of the rainfall index in the station of Mondividiu (station No. 01751004) from January 1986 to December 2019, Southwest of Goiás state, Brazil
Source: Elaborated by the authors from data enabled by ANA (2020).

The relief of the region varies from plain to wavy smoot, which favors the dissemination of mechanical farming and irrigable areas (Hidasi-Neto et al., 2019). The geology of the hydrographic basin of Montividiu River is composed of sedimentary and igneous formations. The first one refers to the Bauru Group – Vale do Rio Peixe Formation, composed of the lithotypes sandstone and sandy clay, and the Undifferentiated Detrital Cover Unit, composed of unconsolidated sand sediments, clay, and gravel. While the second one comes from São Bento Group – Serra Geral Formation, composed of the lithotypes basalt and dacite, according to the Geologic Map of the State of Goiás and Distrito Federal (scale 1:500,000), generated by the Superintendence of Geology and Mining/State Agency of Industry and Commerce (SGM/SIC), and enabled by SIEG (2020).

Concerning the total area of the basin, in and decreasing order, the undifferentiated detrital covers represent 72.98%, Serra Geral Formation about 21.38%, and Vale do Rio do Peixe Formation about 6.54% (SIEG, 2020).

The soils present in the hydrographic basin of Montividiu River are, predominantly, Dystrophic Red Latosol (LVd) with clayey or very clayey texture (about 72.27% of the total area), followed by Dystroferric Red Latosol (LVdf) with clayey or very clayey texture (about 25.41% of the total area), and Haplic Gleisol Tb Dystrophic Plinthosol (GXbd) with clayey texture (about 2.32% of the total area) – information on the Soils Map of the Master Plan of the Hydrographic Basin of Paranaíba River (scale 1:250,000), generated in March 2005 by Universidade Federal de Viçosa (UFV, 2005)/ Rural Minas Foundation (Rural Minas, 2005), and enabled by SIEG (2020).

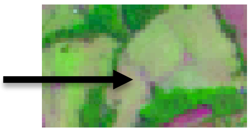
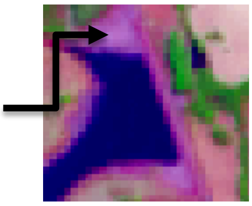
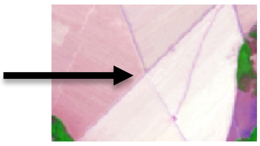
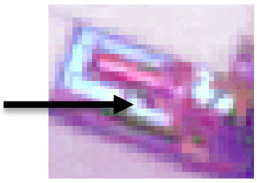
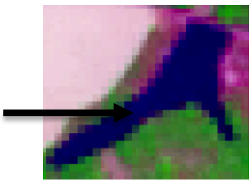
Orbital data and methodological procedures

The maps of land use and cover were developed according to the Technical Manual of Land Use (Brazil, 2013), and elaborated through ArcGis Advanced 10.8.1® software, licensed under the code #647261 (ESRI, 2020), using images of OLI sensor connected to the Landsat 8 satellite, at the orbit/point 223/072, generated by National Aeronautics and Space Administration (NASA, 2000), enabled on Earth Explorer, official, website of the United States Geological Survey (USGS, 2020).

The choice of images of 2013 and 2020 occurred due to the use of OLI sensor/Landsat 8 (in operation since 2013), to try products of this sensor for analysis of land use and base it in the same interpretation patterns. Using Landsat 8 products implies a better performance concerning spatial, spectral, and radiometric resolutions with the availability of a greater number of images a day (Bannari et al., 2016; Dong et al., 2016; Holden & Woodcock, 2016; Loveland & Irons, 2016; Scaramuzza et al., 2017). The images obtained from the Landsat 8 sensor /OLI Collection 2 Level 2 are enabled with radiometric and atmospheric correction. To obtain a better quality of the image, a contrast enhancement was applied, allowing better differentiation between the present elements. Empirically, the options of Minimum-Maximum were defined to manipulate the histogram of the images through ArcGIS software.

The used scenes refer to two periods, in May 2013 and September 2020. For each scene, a composition was accomplished combining the bands (B) B6 (natural with atmospheric removal), B5 (Near-Infrared), and B4 (Red), both with a spatial resolution of 30 m. Next, each colorful composition was merged with B8 (panchromatic), with a spatial resolution of 15 m, obtaining images with a spatial resolution of 15 m. Initially, classifications were accomplished through the Interactive Supervised Classification algorithm (an ArcGIS tool), obtaining satisfactory results, but to generate even more representative results, was made the option to classify the images manually. Posteriorly, topological corrections were made. It's important to emphasize that the validations through observations on the field, interpretations of images enabled by Google Earth Pro (Google, 2020), and images from Sentinel-2 (ESA, 2020) subsidized the elaboration of the interpretation key of the images of the OLI sensor (Table 1), and, consequently, defined the preliminary and final legends, obtaining cartographic products, according to the graphic precision of IBGE (1999), at the scale 1:75,000.

Table 1. Interpretation key of the images of Landsat 8/ OLI Sensor for mapping and classification of land use and cover in the basin of Montividiu River, Southwest of Goiás state, Brazilian Savannah.

Classes	Landsat 8 / OLI Sensor	Tone/color	Texture
Cerrado/woods		Dark green	Rugged
Pasture		Light green	Plain-medium
Exposed soil		Red-colored	Plain-medium
Farming area		Light green or white	Plain
Rural Buildings		White	Plain-medium
Water surface		Blue	Plain

Source: Elaborated by the authors (2020) based on the studies by Ayach et al. (2012); Rex et al. (2018); and Medeiros, Silva & Lunardi (2019).

Then random samples were selected (different from the ones initially used in the classification) in the images of Landsat 8/OLI sensor, crossing these samples with the map of land use and cover, giving origin to the confusion matrixes.

From the results of the confusion matrixes, statistical tests were accomplished with the application of the Kappa index (Cohen, 1960) to evaluate the probability of correct and incorrect classification of a pixel (Teferi et al., 2013; Alves et al., 2018a; Belay & Mengistu, 2019; Degife et al., 2019; Alves et al., 2020; Aneseyee et al., 2020; Breunig et al., 2020; Das & Angadi, 2020; Mengue et al., 2020; Rana & Suryanarayana, 2020; Zhang et al., 2020).

The calculus of the Kappa index (Cohen, 1960) can be accomplished through Equation 1 (E1):

$$K = \frac{n * \sum_{i=1}^{c} X_{ii} - \sum_{i=1}^{c} X_{i+} * X_{+i}}{n^2 - \sum_{i=1}^{c} X_{i+} * X_{+i}} \quad \text{(E1)}$$

Where: K is an estimative of the Kappa coefficient; n, the total number of samples; c, the total number of classes; X_{ii}, the value of line *i* and column *i*, that is, the value of the diagonal of the confusion matrix, descending; X_{i+}, the sum of line *i*; and X_{+i}, the sum of column *i* of the confusion matrix.

The changes in the study area were analyzed with the use of the Cross-tabulation Matrix, a method proposed by Pontius Junior et al. (2004), and presented in Chart 1.

Chart 1. General crossed-tabulation matrix for the comparison of two maps in two distinguish moments.

Class at moment 1	Class at moment 2				Total at moment 1	Loss
	Class 1 (j)	Class 2 (j+1)	Class 3 (j+2)	Class 4 (j+3)		
Class 1 (i)	C_{11}	C_{12}	C_{13}	C_{14}	$\sum_{j=1}^{n} C_{1+}$	$\sum_{j=1}^{n} C_{1+-}C_{11}$
Class 2 (i+1)	C_{21}	C_{22}	C_{23}	C_{24}	$\sum_{j=1}^{n} C_{2+}$	$\sum_{j=1}^{n} C_{2+-}C_{22}$
Class 3 (i+2)	C_{31}	C_{32}	C_{33}	C_{34}	$\sum_{j=1}^{n} C_{3+}$	$\sum_{j=1}^{n} C_{3+-}C_{33}$
Class 4 (i+3)	C_{41}	C_{42}	C_{43}	C_{44}	$\sum_{j=1}^{n} C_{4+}$	$\sum_{j=1}^{n} C_{4+-}C_{44}$
Total at moment 2	$\sum_{i=1}^{n} C_{+1}$	$\sum_{i=1}^{n} C_{+2}$	$\sum_{i=1}^{n} C_{+3}$	$\sum_{i=1}^{n} C_{+4}$	$\sum_{i=1}^{n} C_{ij} = At$	
Gain	$\sum_{i=1}^{n} C_{+1-}C_{11}$	$\sum_{i=1}^{n} C_{+2-}C_{22}$	$\sum_{i=1}^{n} C_{+3-}C_{33}$	$\sum_{i=1}^{n} C_{+4-}C_{44}$		

Where: C_{ij}: is the change of the land use and cover (dimensionless) from class i to class j, considering classes i, in lines, corresponding to moment 1, and classes j, in the columns, at moment 2;
C_{jj}: is the persistence of class $\sum_{j=1}^{n} C_{1+}$: in Total column moment 1 is the total of class 1 at moment 1; At: is the total area $\sum_{i=1}^{n} C_{1+}$: in the line Total moment 2 is the total of class 1 at moment 2; Gains: total of class in category j, C_{1+}, due to the difference of persistence of class C_{jj}; Loss: represents the total of loss related to each class of soil use *i* between the moments 1 and 2, it's calculated for each class through the difference between the total of the line and the persistence to the corresponding class.

Analyzing the data from the Cross-tabulation Matrix, Pontius Junior et al. (2004) propose other calculus to make it easier to understand the transformations in the land use and cover: percentage of classes, in %C – Equation 2 E2); exchange, in Sj – Equation 3 (E3); and, total alteration – Equation 4 (E4).

$$\%C_{i,t} = \left(\sum_{j=1}^{n} C_{ij}\right)/At \quad \text{(E2)}$$

Where: $\%C_{i,t}$: percentage of class i at moment t; $\sum_{j=1}^{n} C_{ij}$: sum of the specific class; At: total area of the classes in analysis.

$$S_j = 2*\min*\left(\left(\left(\sum_{j=1}^{n} C_{ij} - C_{jj}\right)/At\right)*100, \left(\left(\sum_{i=1}^{n} C_{ij} - C_{jj}\right)/At\right)*100\right), \text{ when } i = j \quad \text{(E3)}$$

$$\text{Total change} = (((\sum_{j=1}^{n} C_{ij} - C_{jj})/\text{At})*100) + (((\sum_{I=1}^{n} C_{ij} - C_{jj})/\text{At})*100) \quad \text{(E4)}$$

Where (E3 and E4): S_j: is the total alteration; $((\sum_{j=1}^{n} C_{ij} - C_{jj})/\text{At})*100$: the losses of the total area, in percentage; and $((\sum_{I=1}^{n} C_{ij} - C_{jj})/\text{At})*100$: the gain of the total area, in percentage.

The analysis of gains, losses, persistency, exchange, and liquid change was accomplished relating the years of 2013 and 2020.

Results

From the confusion matrixes (Table 2 and Table 3), the obtained results of the Kappa index for 2013 and 2020 were, respectively, 0.96 and 0.98. In the confusion matrixes were confronted, respectively, 3,301 and 2,316 points which were distributed among the classes, not presenting uniformity of samples among themselves.

Table 2. Confusion Matrix of the classification of the image of May 2013 in the hydrographic basin of Montividiu River, Southwest of Goiás state.

Class	Validation sample (Kappa)											
	1	2	3	4	5	6	7	8	9	10	11	Total
1	61	0	0	0	3	0	0	0	0	0	0	64
2	0	493	0	0	0	0	0	0	0	0	0	493
3	0	3	49	0	0	0	0	0	0	0	0	52
4	0	29	0	516	0	0	0	0	0	1	0	546
5	0	10	0	0	1297	9	0	0	0	0	0	1316
6	0	9	0	0	5	502	0	0	0	0	0	516
7	0	0	0	0	1	0	55	4	0	0	0	60
8	0	0	0	0	7	0	0	80	0	0	0	87
9	0	2	0	0	2	2	0	0	46	0	0	52
10	0	0	0	0	0	0	0	0	0	58	0	58
11	0	0	0	0	0	0	0	0	0	0	57	57
Total	61	546	49	516	1315	513	55	84	46	59	57	3301

The classes are: others (1); farming area (2); rural buildings (3); highways (4); natural vegetation of the Cerrado (5); pasture (6); exposed soil (7); water (8); eucalyptus (9); urban area (10), and industrial area (11).
Source: Elaborated by the authors (2020).

Table 3. Confusion Matrix of the classification of the image of September 2020 in the hydrographic basin of Montividiu River, Southwest of Goiás state.

Class	Validation sample (kappa)											
	1	2	3	4	5	6	7	8	9	10	11	Total
1	28	0	0	0	2	0	0	0	0	0	0	30
2	0	578	0	0	0	0	0	0	0	0	0	578
3	0	0	54	0	0	0	1	0	0	0	0	55
4	0	6	0	286	0	1	2	0	0	0	0	295
5	1	2	0	0	823	1	0	0	0	0	0	827
6	0	4	0	0	4	265	0	0	0	0	0	273
7	0	1	2	0	2	1	46	0	0	0	0	52
8	0	0	0	0	3	0	0	57	0	0	0	60
9	0	2	0	0	0	0	0	0	15	0	0	17
10	0	0	0	0	0	0	0	0	0	77	0	77
11	0	0	0	0	0	0	0	0	0	0	52	52
Total	29	593	56	286	834	268	49	57	15	77	52	2316

The classes are: others (1); farming area (2); rural buildings (3); highways (4); natural vegetation of the Cerrado (5); pasture (6); exposed soil (7); water (8); eucalyptus (9); urban area (10), and industrial area (11).

Source: Elaborated by the authors (2020).

The results of the transition between the different categories of land use and cover of the hydrographic basin of Montividiu River are presented in tables 4 to 7. It was verified that in 2013 about 77% of the basin area was destined for farming use, mainly soybean production and winter corn crops, followed by the native vegetation of the Cerrado (17.43%), intensive and extensive grassland (4.19%), and, with less representativity, the categories of urban area (0.44%), exposed soil (0.20%), highways (0.16%), water (0.12%), industrial area (0.10%), rural buildings (0.10%), eucalyptus (0.08%), others (0.17%). The native vegetation class of the Cerrado incorporates cerradões, dirty field fragments, and riparian forest/gallery.

In 2020, there was a small expansion of farming areas (77.15%), and pasture (4.55%), with the reduction of the natural vegetation of the Cerrado (16.68%). The area use was complementary by the following classes: urban area (0.49%), exposed soil (0.34%), highways (0.16%), water (0.11%), industrial area (0.11%), rural buildings (0.14%), eucalyptus (0.10%), and the like (0.17%).

Table 4. Transition matrix of land use and cover among the years of 2013 and 2020 in the hydrographic basin of Montividiu River, Southwest of Goiás state, Brazil.

Category 2013 (ha)	Category 2020 (ha)											Total 2013	Loss
	1	2	3	4	5	6	7	8	9	10	11		
1	76.10	0,00	0.00	0.00	0.00	0.00	0.00	3.42	0.00	1.57	2.09	83.18	7.08
2	0.00	52904.88	1.96	26.89	22.91	5.13	0.00	474.12	0.00	65.91	17.24	53519.03	614.15
3	0.00	0.00	72.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	72.34	0.00
4	0.00	0.00	0.00	308.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	308.06	0.00
5	0.00	0.00	0.00	0.00	67.67	0.00	0.00	0.00	0.00	2.97	0.00	70.64	2.97
6	0.00	1.49	2.40	0.00	0.14	42.62	0.00	0.98	0.00	5.84	0.00	53.46	10.84
7	0.00	0.00	0.00	0.00	0.00	0.00	119.70	0.00	0.00	0.00	0.00	119.70	0.00
8	0.32	574.45	1.83	8.85	1.56	3.63	0.00	2277.14	0.00	31.86	9.26	2908.89	631.76
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	109.78	0.00	0.00	109.78	0.00
10	0.00	8.81	1.01	0.00	1.60	2.98	0.00	12.40	0.00	111.59	3.31	141.70	30.11
11	2.29	131.30	0.00	0.00	0.57	14.54	0.00	392.04	0.00	16.38	11558.10	12115.22	557.12
Total 2020	78.72	53620.93	79.54	343.80	94.45	68.89	119.70	3160.10	109.78	236.11	11589.99	69502.00	1854.02
Gain	2.62	716.05	7.20	35.74	26.78	26.27	0.00	882.96	0.00	124.52	31.89	1854.02	67647.99

Legend: 1: water; 2: farming area; 3: industrial area; 4: urban area; 5: rural buildings; 6: eucalyptus; 7: others; 8: pasture; 9: highways; 10: exposed soil; 11: natural vegetation of the Cerrado.
Source: Elaborated by the authors (2020).

Table 5. Total area and liquid variation of each category of land use and cover among the years of 2013 and 2020 in the hydrographic basin of Montividiu River, Southwest of Goiás state, Brazil.

Category	Total 2013 (ha)	%C 2013	Total 2020 (ha)	%C 2020	Liquid variation (ha)	Liquid variation (%)
1	83.18	0.12	78.72	0.11	4.46	0.01
2	53519.03	77.00	53620.93	77.15	101.90	0.15
3	72.34	0.10	79.54	0.11	7.20	0.01
4	308.06	0.44	343.80	0.49	35.74	0.05
5	70.64	0.10	94.45	0.14	23.81	0.03
6	53.46	0.08	68.89	0.10	15.43	0.02
7	119.70	0.17	119.70	0.17	0.00	0.00
8	2908.89	4.19	3160.10	4.55	251.20	0.36
9	109.78	0.16	109.78	0.16	0.00	0.00
10	141.70	0.20	236.11	0.34	94.41	0.14
11	12115.22	17.43	11589.99	16.68	525.23	0.76
Total	69502.00	100.00	69502.00	100.00	1059.38	1.52

Legend: 1: water; 2: farming area; 3: industrial area; 4: urban area; 5: rural buildings; 6: eucalyptus; 7: others; 8: pasture; 9: highways; 10: exposed soil; 11: natural vegetation of the Cerrado.

Source: Elaborated by the authors (2020).

The results show that the areas that didn't suffer alterations (persistency) among the analyzed years were: 76.12% (farming area), 16.63% (natural vegetation of the Cerado), 3.28% (pasture), 0.44% (urban area), 0.16% (highways), 0.16 (exposed soil), 0.11% (water), 0.10% (industrial area), 0.10% (rural buildings), 0.06% (eucalyptus), and 0.17% (others). It's possible to notice that there weren't meaningful losses and gains among the classes, with bigger gains attributed to pasture (1.27%), and agriculture (1.03%), while bigger losses happened in areas destined to pasture (0.91%), agriculture (0.88%), and natural vegetation of the Cerrado (0.80%).

Table 6. Persistency, losses and gains for each category of land use and cover among the years of 2013 and 2020 in the basin of Montevidiu River, Southwest of Goiás state, Brazil

Category	In ha			In %		
	Persistency	Loss	Gain	Persistency	Loss	Gain
1	76.10	7.08	2.62	0.11	0.01	0.00
2	52904.88	614.15	716.05	76.12	0.88	1.03
3	72.34	0.00	7.20	0.10	0.00	0.01
4	308.06	0.00	35.74	0.44	0.00	0.05
5	67.67	2.97	26.78	0.10	0.00	0.04
6	42.62	10.84	26.27	0.06	0.02	0.04
7	119.70	0.00	0.00	0.17	0.00	0.00
8	2277.14	631.76	882.96	3.28	0.91	1.27
9	109.78	0.00	0.00	0.16	0.00	0.00
10	111.59	30.11	124.52	0.16	0.04	0.18
11	11558.10	557.12	31.89	16.63	0.80	0.05
Total	67647.99	1854.02	1854.02	97.33	2.67	2.67
Total area = 69502.00 ha						

Legend: 1: water; 2: farming area; 3: industrial area; 4: urban area; 5: rural buildings; 6: eucalyptus; 7: others; 8: pasture; 9: highways; 10: exposed soil; 11: natural vegetation of the Cerrado.
Source: Elaborated by the authors (2020).

The greatest liquid variations happened in the areas occupied by natural vegetation of the Cerrado (525.23 ha), pasture (251.20 ha), farming (101.90 ha), and exposed soil (94.41 ha). And in the areas of pasture and agriculture we can observe the greatest exchanges, about 1263.52 ha and 1228.29 ha, respectively.

Table 7. Losses, gains, exchanges, absolute value of the liquid variation and total of changes of each category of land use and vegetation cover among the years of 2013 and 2020, in the basin of Montividiu River, Southwest of Goiás state, Brazil

Category (ha)	Loss	Gain	Liquid variation	Exchange	Total of change
1	7.08	2.62	4.46	5.23	9.70
2	614.15	716.05	101.90	1228.29	1330.19
3	0.00	7.20	7.20	0.00	7.20
4	0.00	35.74	35.74	0.00	35.74
5	2.97	26.78	23.81	5.93	29.75
6	10.84	26.27	15.43	21.68	37.11
7	0.00	0.00	0.00	0.00	0.00
8	631.76	882.96	251.20	1263.52	1514.72
9	0.00	0.00	0.00	0.00	0.00
10	30.11	124.52	94.41	60.22	154.63
11	557.12	31.89	525.23	63.78	589.01
Total	1854.02	1854.02	1059.38	2648.65	3708.03

Legend: 1: water; 2: farming area; 3: industrial area; 4: urban area; 5: rural buildings; 6: eucalyptus; 7: others; 8:

pasture; 9: highways; 10: exposed soil; 11: natural vegetation of the Cerrado.
Source: Elaborated by the authors (2020).

The spatializations of the land use and cover can be observed on Image 3 (years of 2013 and 2020, respectively).

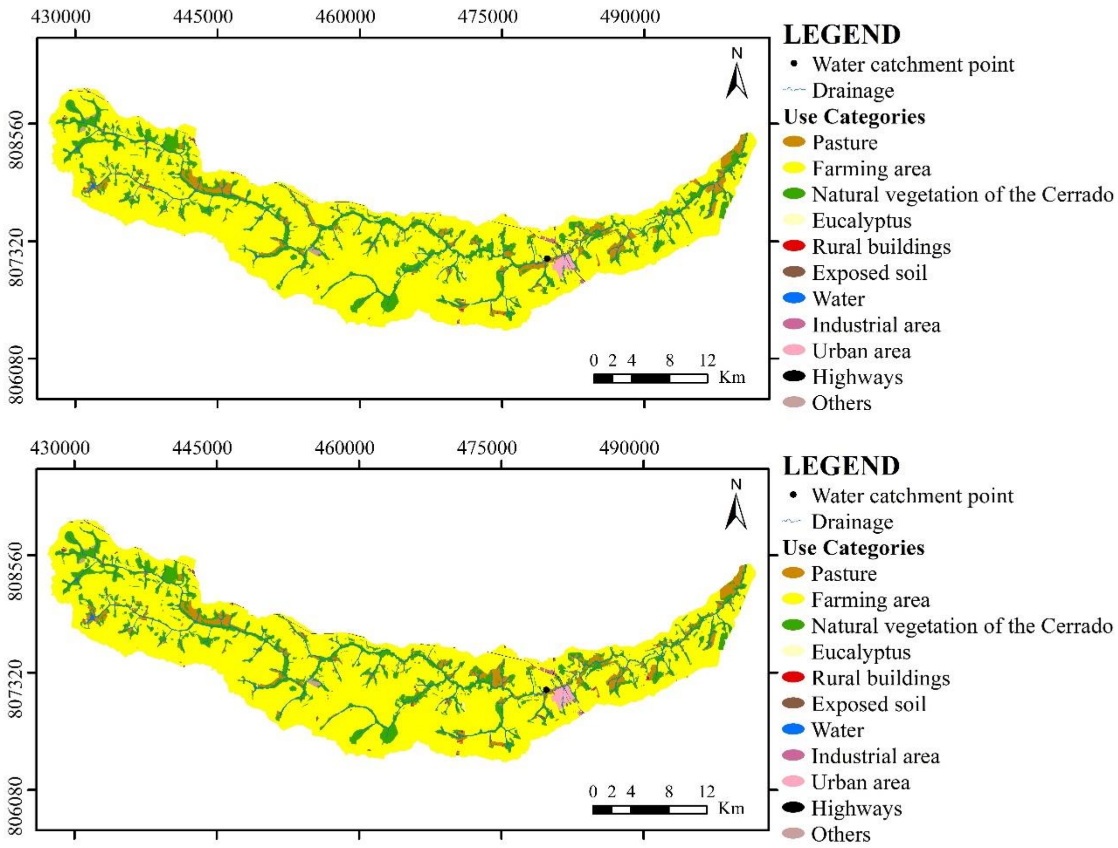


Image 3. Land use and cover, respectively, in 2013 (May), and in 2020 (September) in the hydrographic basin of Montividiu River, Southwest of Goiás state, Brazil.
Source: Map organized by the authors from the geographic database enabled by SIEG (2020), and USGS (2020). Elaborated with the Plain Coordinates System Sirgas 2000, UTM, Zone 22S, scale 1:75,000.

Discussion

The global changes in land use are motivated mainly by the substitution of tropical forests by agriculture, pasture, and urbanization (Song et al., 2018; Mello et al., 2020). Consequently, Cerrado's vegetation cover loss also occurred through the insertion of pasture, irrigated crops, and urban expansion (Souza et al., 2021). The dynamics on the land use of the hydrographic basin of Montividiu River confirmed the predominance of farming areas that were, probably, implemented due to the characteristics of the Southwest of Goiás state: low declivities, great extensions of Latosol, climate seasonality, easy access through Highways GO 220, GO 174, and GO 184, proximity to the Metropolitan Region of Goiânia, to the federal Capital (Brasília), to the Triângulo Mineiro and São Paulo (favoring the production flow), implementing public policies of development and technological advancement (Alves, Martins & Scopel, 2020; Martins & Galvani, 2020; Alves et al., 2021). Such incentives have rebounded since 1970, and the production of grains has spread through the Cerrado to this day (Pizarro & Araújo Sobrinho, 2017).

Considered nowadays one of the most important Brazilian regions in the production of grains, the Southwest of Goiás had its economic formation originated from public investments which made it possible to commercialize lands of the Middle-West by smaller prices, arousing the interest of immigrants from the regions South and Southeast who purchased great areas of land like the ones from de municipalities of Jataí, Rio Verde, Santa Helena de Goiás, and Chapadão do Céu, presented the greatest changes on the field from the 1980s (Martins, Oliveira & Queiroz Júnior, 2014). With the productive advance subsidized by farming modernization, there were transformations in space, as on the field as in the city (Silva, Mendonça &

Lunas, 2015), bringing to the Southwest of Goiás the expansion of mechanical areas, the increase in deforested areas, implementation of poultry and swine industries, urbanization, and the like (Pizarro & Araújo Sobrinho, 2019). The growth of agriculture implies the development of the economy and the creation of income in the sectors related to commerce and service, however, represents a high cost to nature (Soares et al., 2020), causing impacts in the hydrographic basins as water erosion, soil and water pollution.

Observing an addition in the urban and industrial areas in the hydrographic basin of Montividiu River, it was verified that the formation of the territory comes from the dynamism of the countryside, once the cities are centers of commerce and a reflex of the decisions made on the field, protecting workers and agencies which supervise the activities of the agribusiness, with the installation/location of the industries an influenced part by investments in the production. Thus, the development of the cities of agribusiness and agroindustry (Pizarro & Araújo Sobrinho, 2017). The percentage added to rural buildings justifies itself through the need for support to the farming production (as the building of warehouses), and the installation of food companies (Alves, Martins & Scopel, 2020).

The modernization of the field caused an inversion of the population contingent in the state of Goiás, including the Southwest of Goiás. In the 1970s, Goiás registered a rural population of 1,702,000 inhabitants, while the urban population was of 1,237,000 inhabitants. The situation was inverted from the 1980s, and in 2010, Goiás had an urban population of 5,421,000 inhabitants and only 583 thousand in the rural area. This rural-urban mobility from the agricultural expansion expels traditional residents who are substituted by the workforce of other regions, changing the production criteria. The loss of the cultural patterns of the rural communities is a reflex of the intense occupation of the Cerrado (Pires, 2000). Moreover, small landowners have become employees and expanded the urban mass (Silva, Mendonça & Lunas, 2015).

While analyzing the dynamics of the land use of the hydrographic basin of Montividiu River, it was verified an inversely proportional relationship among the classes, because as the suppression of the native vegetation of the Cerrado occurred, there was an increase in urban areas, industrial, and exposed soil, result of the increasingly anthropic pressure observed in the last years in the state of Goiás (Oliveira & Faria, 2021). This substitution of the vegetation by other uses reduces the shading on watercourses and it affects the quality of the water due to the increase of temperature and effects on the concentration of nutrients and dissolved oxygen (Melo et al., 2020). The reduction of areas of native vegetation of the Cerrado identified in the hydrographic basin of Montividiu River are related to anthropic actions which aim the expansion of farming cultivation and pastures, according to Pizarro (2017). The crops occupy areas increasingly larger of the Cerrado and end up substituting the remaining fragments (Martins, Oliveira & Queiroz Júnior, 2014). About 50% of the Cerrado area is under farming use, reaching about 80% of the native vegetation (Nóbrega et al., 2017). Initially, the modifications of the original vegetation of the Cerrado located in the Southwest of Goiás occurred by the pasture activities and frequent fires (Ab'Sáber & Costa Júnior, 1950), which contributed to transforming Cerradões in Dirty Fields or Clean Fields (Oliveira, 2014). In sequence, public policies contributed so the Cerrado was a highlight in the national farming production (Pires, 2000), revealing a constancy in the changes of land use and cover with conversions among the native vegetation classes of the Cerrado and farming areas (Nóbrega et al., 2017).

The presence of vegetation cover (natural) in the hydrographic basin of Montividiu River reached an inferior rate to 20%, which are located, mainly, in Permanent Preservation Areas (PPA), surrounding the water bodies, or Legal Reserve (LR). The removal of the native vegetation of the Cerrado is associated with the occupation of these areas by agriculture, and the consequent use of pesticides can contaminate the soil and water, being able to cause ecological alterations in the hydrographic basin of Montividiu River, causing grave consequences (many times irreversible) to natural resources and the biological diversity (Lees et al., 2015), as the genetic impoverishment, soil compression and erosion (Pires, 2000), as the decrease of evapotranspiration and increase of the flux of the rivers (Nóbrega et al., 2017).

After the urban areas, agriculture is the second land use that affects the quality of the water the most (Mello et al., 2020). The spatial transformations across the hydrographic basin can contribute to the vulnerability to floods, and, consequently, to the loss of crops and depredation of the property (Caldas et al., 2018), letting the terrain unprotected and subjected to a greater superficial outflow with the probability of an increase in soil loss (Santos & Guerra, 2021) – a characteristic identified in the study by Moura-Bueno et al. (2018), where the quantification of soil and water losses in parcels with natural vegetation was significantly lower while compared to parcels of crops with uncovered soil. The change of the native vegetation to pasture is also an aggressive practice to the environment and occurs due to the need of feeding animals through grazing, being an economic alternative for producers who prefer pasture to the cultivation of lands (Buonocore et al., 2021).

Thus, due to the impacts, it's important to stand out the need for preservation of these PPAs and LRs due to the intensity with which the changes have been occurring in the hydrographic basin (Santos et al., 2020). The degradations can occur naturally, however, they are intensified by the absence of conservationist practices and by the improper use of the land (Vieira et al., 2021), frequently caused by the pressure of the farming and livestock expansion which grow according to the increase in the demand for food (Costa et al., 2019). Therefore, agribusiness must be analyzed in an integrated way to the environmental issues (Brancalion et al., 2016).

The incorrect management of the soil with high erosive potential (predominance of silt and sand) have caused an addition to the exposed soil in the area of the hydrographic basin of Montividiu River, resulting in the intensification of ravines and laminar erosion (Image 4) (Pizarro & Araújo Sobrinho, 2017). The removal of the native vegetation, and, consequently, of the roots, destabilizes the margins of the water bodies, causing erosions (Mello et al., 2020). Furthermore, the areas with greater susceptibility to the production of sediments are located in the Cerrado (Merten & Minella, 2013). Thus, the application of proper management practices and preservation is fundamental to minimize the erosive (Vieira et al., 2021), and sedimentation processes.

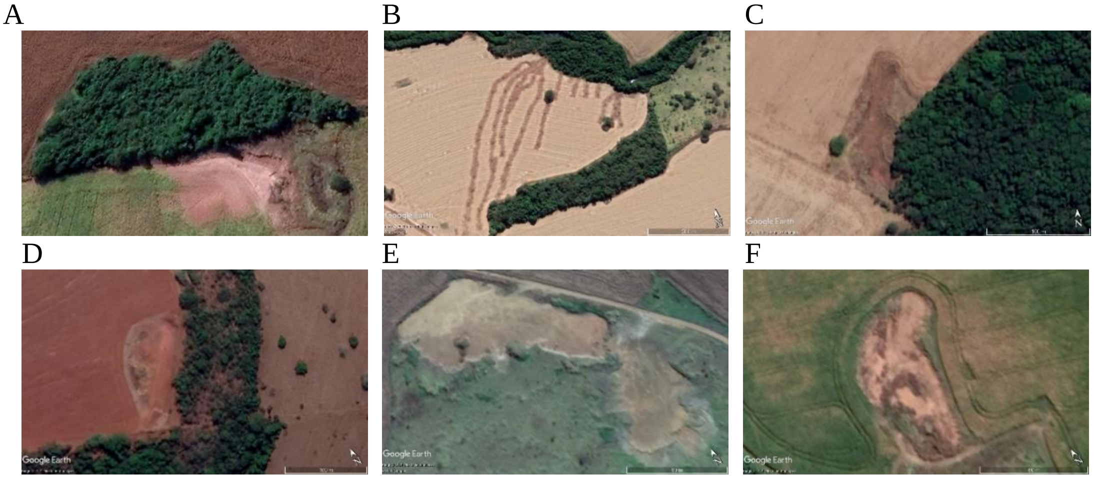


Image 4. Areas with erosion and ravines present in the basin of Montividiu River, Southwest of Goiás state, Brazil.
Source: Images of 2020 from Google Earth Pro.

Thus, these data about erosive processes through the study of land use and cover are important to help the development of policies and methods to accomplish proper management and preservation of the soil and water in the study basin. It's known that the social, environmental, and economic losses with soils and water of low quality are elevated. The accelerated erosive processes reduce the capacity of soil production, elevating production costs and reducing the profitability of farmers. Moreover, the particle carrying from the erosion can arrive at lower parts of the basin, causing the loss of quality of the water of the rivers, lakes, and reservoirs. As consequence, besides the siltation, there's the possible contamination of the water with pesticides and the enrichment of the soil with fertilizers. The pesticides can cause the decrease of aquatic fauna and flora, and the fertilizers can cause the eutrophication of water resources (Pruski, 2009; Dias et al., 2013).

Thus, intending to verify the relation of the variables of the quality of the water with the type of land use and landscape patterns, Shehab et al. (2021) established that the quality of the water is directly related to the configuration of the landscape and the rate of soil cover. The same authors verified the importance of riparian forests to maintain the proper water quality since the low density of the border associated with the use of urban and farming lands is related to the reduction of the quality of the water.

Another identified aspect is the increase of the cultivation of eucalyptus in the area of the hydrographic basin of Montividiu River, which, as the whole Brazilian Middle-west, is influenced by the electric power demand, from the populational and agribusiness expansion, the installation of paper and cellulose companies, as the strategic location of the region, what holds high investments (EMBRAPA, 2015). Souza et al. (2021), in his study developed in the hydrographic basin of Pedras River located in the Middle-west part of Goiás state's territory, verified that de cultivation of eucalyptus emerged in the last decade and it's destined for the production of wood to supply boilers in agro-industrial activities in the region. Alves, Martins & Scopel (2020) identified that the production of eucalyptus cultivated in Rio Verde, a surrounding municipality to Montividiu, is destined to the Agroindustry Cooperative of Rural Producers of the Southwest of Goiás (COMIGO) and Brasil Foods (BRF SA).

As aforesaid, the changes in land use, mainly due to farming activities, mean alterations in the quality of water resources (Gardiman Junior et al., 2018; Mello et al., 2020) and the amount (an increase on the water demand for irrigation), with reduction of water reservations (Buonocore et al., 2021), what can be identified in the hydrographic basin of Montividiu River. The scenery can suffer an even greater influence due to recent alterations in the Environmental License of Goiás, present in the Law no. 20,694-2019, which favors the regularization of irrigation equipment, with the Environmental License no longer being necessary, only an electronic registration for its use (Government of the State of Goiás, 2019).

Knowing that agriculture uses about 70% of the withdrawn water and that irrigation is the main user of water resources, the challenge is to produce food that, at the same time, respects the capacity of support of the hydrographic basins (Rodrigues & Zaccaria, 2020). It's estimated that the water consumption in Brazil will increase 24% in the next 30 years and that the dynamics of the land use and climatic variations will cause even more alterations in the water cycle and the quality of the water (Mello et al., 2020). Thus, the search for water control can occur through the proper water management and supervision by environmental agencies to fulfill the legislation concerning the protection of water resources (Alves, Martins & Scopel, 2020), conciliating the compromises of environmental sustainability with the national and international pressures for the production of food and energy (Sano et al., 2019). Otherwise, the lack of planning and the inefficiency in the supervision of studied the hydrographic basin will result in socio-environmental problems, such as the creation of "favelas" (slums), marginalization, soil loss, siltation, and pollution of the water body, as well as water scarcity – adversities identified at Murucupi River, located in Barcarena in the state of Pará (Brazil) (Furtado et al., 2020).

The management of the Brazilian natural resources is characterized by this inefficiency in the planning of the land use and cover because disconnected public policies are elaborated from different actors/sectors involved in the process, which makes it harder to integrate agendas and results in waste of efforts (Napolitano, 2018). Thus, evaluating the vulnerability coming, among others, the land use and high climatic changes rate are tools that must guide the administrators (Borges et al., 2019; Borges & Loyola, 2020). Thus, there'd be a readjustment of inappropriate laws, to attend to the needs of preservation and sustainability (Howes et al., 2017; Singh et al., 2018; Miola et al., 2019; Resende et al., 2021).

Historically, the development programs of the Public Power and the policies of tax incentives were the ones that consolidated the cultivation of grains in the Cerrado, placing the country as a highlight in the worldwide agri-food system (Pires, 2000). The occupation strategies enabled the modernization of the field and reflected on the migratory intensification, and, consequently, the occupation of the cities (Bastos, Barbosa & Oliveira, 2012), as well as the negative effects in the hydrographic basins.

The confusions identified in the confusion matrixes can be related to the vegetation and its seasonal characteristics (Ponzoni, 2012), because the confusions occurred among the physiognomies of the natural vegetation of the Cerrado, farming area, pasture, and eucalyptus. The high values of the Kappa index come from the high representativity in the development of the maps, demonstrating the quality of the mapping (Vale et al., 2018).

In the face of the information presented in this paper, it's possible to support the administrators to create legal devices and formulate environmental policies and instruments such as the subsidy for improved and sustainable management, as Parente et al. (2021) suggest. According to INPE (2021), the Cerrado, region at which the study basin is located, has the most diverse savannah formation in the world and occupies about 25% of the national territory.

Demonstrating the importance of the land use and cover to manage public policies, Fabbro Neto & Gómez-Martín (2020) analyzed the Water Safety Plan of Caraguatatuba, with the objective of comparing its elaboration steps and respective contents to international practices related to the management of water conflicts with the spatial guidelines, and verified the need of stablishing a legal framework to assure the success of the implementation of the plan, as well as registering the occurrence of extreme water events and incorporate them to the step of diagnoses of the planning system, and preparing multiple progressive sceneries to establish guidelines for the use and occupation of the soil.

Conclusion

The space-time analysis of the land use and cover of the hydrographic basin of Montividiu River emphasized the decrease of the native vegetation of the Cerrado and the increase of areas of exposed soil, urban areas, industrial, rural buildings, and eucalyptus. Meanwhile, the highway class was inert. It was also possible to notice that the areas occupied by agriculture and pasture presented the greatest variations between losses and gains, but they've kept on the rise in the region, is considered a source of development to the local economy.

The withdrawal of the natural vegetation cover can result in soil degradation due to the succession of erosive processes and, consequently, low productivity, silting, and pollution of the studied watercourse. What supports with the addition of areas of exposed soil, also associated with incorrect management of the land, aiming productivity gains. On the other hand, the expansion of eucalyptus areas represents a late attempt to reduce the erosion in degraded areas and seek for balance in biodiversity through reforestation and granting the electric power demand, indicating the need for implementation of environmental recovery projects which handle palliative actions.

The geotechnologies along with the Cross-Tabulation Matrix have allowed us to infer how the changes in the hydrographic basin of Montividiu River can impact this resource. The knowledge about the land use and cover revealed the need for public policies and measures related to the preservation of the flora, fauna, and associated natural resources, as well as environmental services offered. This happened because the OLI sensor has allowed spatializing the main economic activities developed in the basin of Montividiu River in the years of 2013 and 2020, being the time and spatial conditions important to define strategies for the sustainable use of water resources, as well as their restoration or forest preservation.

Besides emphasizing the need for more suitable policies to which the current scenery and future one, aiming the preservation of the hydrographic basin, and the international demands, it's important to emphasize the historical importance of the policies of land use implemented in the region, which contributed to accelerating the occupation and the development of Brazilian Cerrado. Analyzing the programs and impacts of those in space enables to rethink the role of public policies in the territorial development, once they alter social relations, the dynamics of the regional economy, and impact the environment, bringing a new space configuration, due to the insertion of technologies, implementation of enterprises, environmental changes or modifications in people's daily lives.

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