ANALYSIS OF THE SUGARCANE EXPANSION AND LAND USE CHANGES IN SOUTHWEST GOIANIA IN THE YEARS 1985, 1995, 2005, 2010, 2013 AND 2016

ANÁLISE DA EXPANSÃO CANAVIEIRA E AS MUDANÇAS DE USO DO SOLO NO SUDOESTE GOIANO DE 1985 A 2016

ANALYSE DE L'EXPANSION DE LA CANNE À SUCRE ET DU CHANGEMENT DE L'UTILIZATION DES SOLS DANS LE SUD-OUEST DE L' ÉTAT D GOIÁS DE 1985 À 2016

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Abstract

The Southwest Planning Region of Goiás (RPSG) is part of the recent and rapid Brazilian sugarcane expansion in the Center-South of the Brazilian Savannah named Cerrado. The sector's growing created an environment of competition for the best productive areas between agroindustrial complexes in the region, mainly grains and meat. The main evidence of that is found in changes in land use, as sugar cane has been directly and indirectly replacing agricultural, pasture and Cerrado remnant. The influence of this sugarcane expansion on the spatial dynamics of RPSG in 1985, 1995, 2005, 2010, 2013 and 2016, is analyzed considering the previous, concomitant and subsequent period of this expansion. To do so, geotechnologies were applied to analyze the succession and conflicts of uses. The results showed that sugarcane advanced upon the agricultural and livestock areas, but also on the natural ones, in search of the best soils, which is related to the greater profitability of the crop, interfering in the production of food and in the areas of native vegetation.
Keywords: Sugar-energy sector, changes in land use, conflicts of land use.

Resumo

A Região de Planejamento do Sudoeste Goiano (RPSG) se insere na área da recente e rápida expansão sucroenergética brasileira no Centro-Sul do Cerrado a partir dos anos 2000. O avanço do setor criou um ambiente de competição pelas melhores áreas produtivas entre os complexos agroindustriais instalados na região, principalmente o de grãos e o de carne. As maiores evidências disso se encontram nas mudanças de uso do solo, em que a cana-de-açúcar vem substituindo, de forma direta e indireta, áreas de agricultura, pastagens e também de Cerrado remanescente. Com uso de geotecnologias analisou-se a influência dessa expansão canavieira na dinâmica espacial da RPSG, nos anos de 1985, 1995, 2005, 2010, 2013 e 2016, que cobrem o período anterior, concomitante e posterior à essa expansão, considerando os padrões de sucessão de usos. Os resultados mostraram que a cana-de-açúcar avançou sobre as áreas agrícolas e pecuárias, mas também sobre as naturais, em busca dos melhores solos, o que está relacionado à maior rentabilidade da cultura, interferindo na produção de alimentos e nas áreas de vegetação nativa.
Palavras-chave: Setor sucroenergético, mudanças de uso do solo, conflitos de uso do solo.

Résumé

La région de planification du sud-ouest de l´état de Goiás (RPSG) fait partie de la region de l'expansion récente et rapide de la canne à sucre brésilienne au centre-sud du Cerrado. L'avancée du secteur a créé un climat de concurrence pour les meilleures zones de production entre complexes agro-industriels dans la région, principalement occupés para des céréales et de la viande, dont les principales évidences sont les changements d'utilisation des terres, où la canne à sucre a remplacé directement et indirectement les cultures agricoles, les pâturages et des fragments du Cerrado. L'influence de cette expansion sur la dynamique spatiale du RPSG en 1985, 1995, 2005, 2010, 2013 et 2016, couvrant la période précédente, concomitante et ultérieure à cette expansion, a été analysée à l'aide de geotechnologies, en faisant ressortir ceux que la canne à sucre a remplacé et la succession d'utilisations dans le temps. Les résultats ont montré que la canne à sucre a progressée sur les zones agricoles et d'élevage, mais aussi sur les zones naturelles, en recherchant toujours des meilleurs sols, ce qui est lié à la plus grande rentabilité de la culture, où s'ingéré dans la production alimentaire et les zones de végétation. natif.
Mots-clés: bioénergie, changements de l'utilisation des terres, conflits d'utilisation des terres.

Introduction

The global environmental crisis and future projections of oil shortages encourage the search for alternative sources of energy, based on renewable matrices and with lower gas emissions. In this context, the sugarcane biomass, through the sugar and ethanol industry, inserts Brazil, especially the Cerrado areas, in the international context as one of the major producers of this new energy matrix, sugarcane ethanol (Macedo, 2005; Sauer; Pietrafesa, 2012).

Sugarcane production, as a substitute for oil in Brazil, can be characterized in two distinct periods: the first, linked to the process of modernization of agriculture, heavily subsidized by the federal government, linked to the National Alcohol Program (Proálcool). The same was started in the 1970s and closed in the early 1990s, which resulted in a remarkable concentration of planted areas and power plants in the Southeast of the country, especially in the state of São Paulo; the second, corresponds to the current expansion, intensified from the years 2000 linked to the National Agroenergy Program (Castro et al., 2010) and supported by the Agroecological Zoning of Sugarcane (ZAE-Cana) (Manzatto et al., 2009), both supported by legal and financial actions, federal and state that decentralized the production that migrated toward the center-south of the Cerrado biome with an expansion characterized by international capital to meet the internal and external demands of bioenergy (Sauer; Pietrafesa, 2012).

The Cerrado, in the last 40 years, has lost much of its surface to commercial monocultures as well as pastures. For this reason, the advance

of sugarcane has been invading these areas, related to the displacement of pastures to the so-called conservation areas, areas with remnants of native vegetation, which are being transformed into sugarcane crops (Castro et al, 2010; Barbalho et al, 2013). In environmental terms, the expansion of the number of plants in the Cerrado is reflected in the displacement of pastures and agricultural areas to the forest regions and, to their edges, promoting the negative effects of agroindustrial complexes such as loss of soil quality, water quality, human health problems, and the dangers to biodiversity (Houtart, 2010; Silva, A. et al., 2011; Silva, A.; Castro, 2015).

The state of Goiás is one of the largest sugarcane expansions in Brazil. The occupation of the soils in Goiás by sugar cane occurs in the context of a regional concentration, triggering a competitive model among crops, mainly soybeans, within the expansion of the agricultural frontier. This advance of the sector occurs on the dependence of the international market of ethanol, creating a high use of technical capital, through machines, inputs, and financing (Lima; Garcia, 2011). In addition to the intense involvement of technological resources in production, we also seek the best natural resources, reaching the areas of soil with better agricultural ability, increasing the possibilities of a gain in productivity ((Prado; Miziara; Ferreira, M. F., 2012; Barbalho; Silva, A.; Castro, 2013).

To this end, the Planning Region of Southwest Goiania (RPSG) or simply Sudoeste Goiano had its model of development of agricultural production intensified through public policies of modernization, which were induced mainly by the Cerrado Development Program (POLOCENTRO) and by the Japanese-Brazilian Cooperation Program for the Development of the Cerrado (PRODECER), which implemented the technical-economic model brought about by the Green Revolution. This process was structured with the creation of agroindustrial complexes of intense use of the lands, highlighting regionally the complexes of grains, meat, and the sugar-energy.

The recent sugarcane expansion in the Southwest Goiano promoted the dynamics of competition for land use among agroindustrial complexes installed in the region. This process is described in the literature through the advancement of sugarcane on agricultural areas and their displacement, as well as the areas of land stock corresponding mainly to areas of unusable land and remaining forest, which also suffer the effects of annual crops and pastures that are displaced by the sugar-energy sector (Abdala; Ribeiro, 2011).

Thus, the advance of sugarcane in the RPSG triggers the process of land use change, which conflicts with the other agricultural activities of the region, influenced by the physical and socioeconomic context. For Santos (2004), the interpretation of polygons of uses, in a historical succession, portrays the relation of the anthropic activities and the natural environment, demonstrating the impacts and the pressures on the natural systems. The analysis of sugarcane in the context of changes in land use makes it possible to understand the influence of biofuels in the Cerrado.

Therefore, the objective of this study was to analyze the expansion of the sugar-energy sector in the Southwest of Goiania, through the dynamics of land use, evaluating the influence of the changes of use, in relation to the direct and indirect substitution for sugarcane, based on the periods of 1985 and 1995, prior to the recent expansion, and from 2005, 2010, 2013, and 2016, referring to the period of contemporary expansion..

Material and methods

Study area

The Southwest Planning Region of Goiás (RPSG) is located between coordinates 27000/62000 and 784000/814000, in the Southwest portion of the State of Goiás, occupying ~ 18% of the state, about 61,500 km. It has 26 municipalities located in the Cerrado area, with high agricultural production, which stand out as one of the most important in Brazil due to its edafoclimatic and geomorphological characteristics, which have great potential for mechanized agriculture (Figure 1).

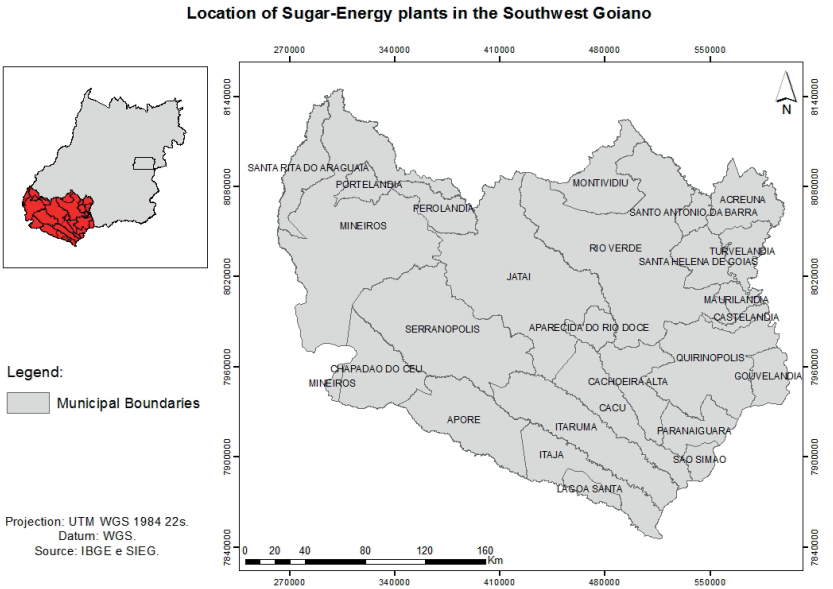

Figure 1 - Location map of the study area and the sugar-energy plants

Source: Organized by the authors from SIFEG and SGEI data (2017).

In recent years, the RPSG has undergone an intense sugarcane advance, being represented, through the increase in the number of processing plants and areas planted with sugar cane. This advance of ethanol production was constituted by three important periods corresponding to the years from 1946 to 1986, with three (03) mills, from 2003 to 2009, with eight (08) mills, and from 2012 to 2017, with five more (05) mills, totaling 16 productive units that were influenced by the National Alcohol Program (Proácool), through the implementation of the National Agroenergy Plan (PNA) and its consolidation in a more recent period (Figure 2).

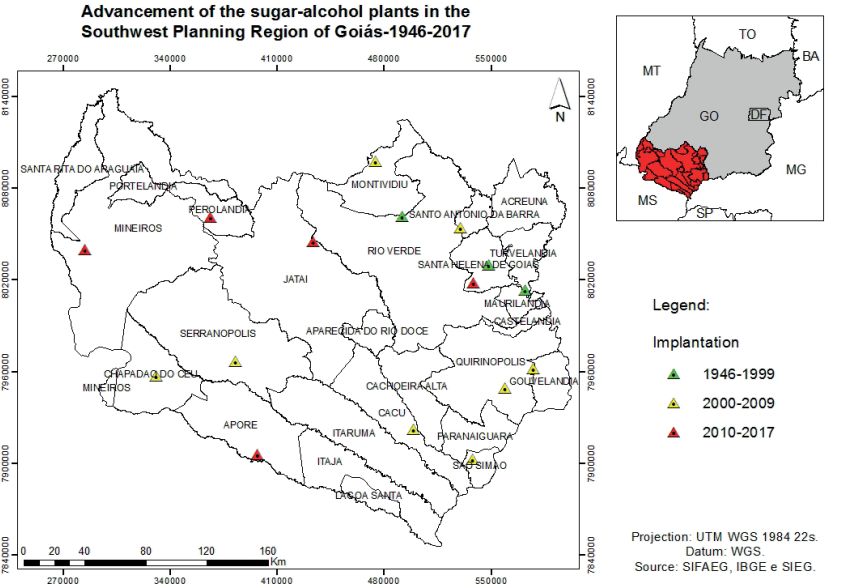

Figure 2 - Advancement of the sugar-alcohol plants in the Southwest Planning Region of Goiás

Source: Organized by the authors from SIFAEG and SGEI data (2017).

In its physical base, the Southwest of Goiás is in areas of sedimentary basins, of the Rivers Araguaia and Paranaíba, with a lithological predominance of basalts and sandstones. In it, the dominance of tabuliform relief, with low slope, associated to the Red Latosols and Red-Yellow Latosols, of medium to high potential for agricultural exploitation prevails (Latrubesse; Carvalho, 2006; Manzatto et al., 2009; Castro et al., 2010).

Remote Sensing and Sugarcane

Remote Sensing is an important tool for agricultural monitoring. It makes it possible to perform temporal analyzes of large areas, with reduced costs, in the face of an integrated relationship with other natural systems remotely. Thus, the use of satellite images for the monitoring of the sugarcane crop is part of these relations, because it is a semi permanent

crop, having a temporality character and occupying large tracts of land (Oliveira; Ferreira; Araújo, 2012). The applications of these techniques for the mapping of sugarcane result in precise analyzes that bring great security to the monitoring of sugarcane expansion (Rudorff; Sugawara, 2007).

Thus, the development of this research was based on the multitemporal mapping of RPSG soil use, with emphasis on the dynamics of land use changes promoted by the expansion of sugarcane. The methodological procedures summarized in an organized way in the flowchart shown in Figure 3, described below, were followed.

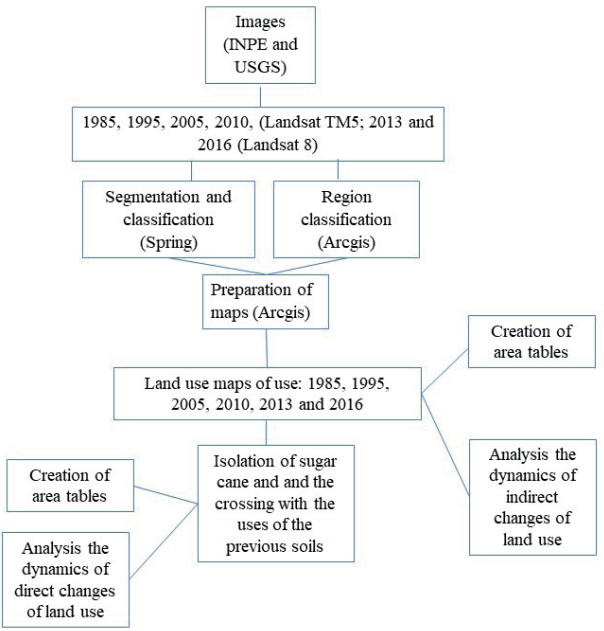

Figure 3 - Flowchart of the steps for the elaboration of the land use maps and the changes of use

Source: Organized by the authors based on the methodological procedures of the research (2017).

Acquisition of Satellite Images

The satellite images used in this research formed the multitemporal database of the dynamics of sugarcane in Southwest Goiano. Landsat TM5 and Landsat 8 images were obtained from the National Institute of Space Research (INPE) and the Unident State Geological Survey (USGLS), with a spatial resolution of 30 meters, corresponding to the years 1985, 1995, 2005, 2010, 2013 and 2016. To mitigate the atmospheric interference, the winter period was chosen to ensure the absence of clouds.

Thus, the formation of the colored compositions of the images in the false RGB color spectrum was performed, corresponding to composition 345 for Landsat TM5 and composition 654 for Landsat 8. The choice of these compositions was based on the spectral response of the sugarcane which presented a great prominence in these bands. After this process, the images went through the geometric correction (georeferencing) and were delimited geographically taking into account each municipality of the study region.

Soil Use Mapping, Classification, and Elaboration

The satellite images went through the process of unsupervised segmentation, which consists of the labeling of the pixels, bringing together the homogeneous characteristics of digital information groups (COUTINHO, 1997). To perform this step, the *Bhattacharya* classifier, available in Spring, was used with the grouping of 55 thematic classes, which were classified in Arcgis, taking into account the spectral behavior of the targets.

The land use mapping, along with the final layout, was also developed in Arcgis, through the adaptation of the classes of the Land Use Manual (IBGE 2013), considering the annual crops, pasture, vegetation, sugarcane, sugar, water and urban area in the scale of 1: 100,000. After the construction of the multitemporal maps, from 1985 to 2016, the table of areas in hectares of the classes of use adopted using the same software with the tool *Xtools*.

Interpolation of Sugarcane Polygons with Pre-Uses

The polygons of the sugarcane areas were isolated and crossed with the land use maps of previous years, using the Arcgis Intersect tool. This process made it possible to analyze the classes of use previous to the sugarcane's advance, generating the succession of use of which sugarcane directly substituted, within a radius of 40 km of the plants, generated by means of the buffer tool. Thus, in these areas, the relation of sugarcane substitution was created for the periods 1985/1995, 1995/2005, 2005/2010, 2010/2013 and 2013/2016. The analysis of indirect use occurred through the variation of the classes of total uses in the Southwest of Goiás. Finally, with Arcto's Xtools tool, a table of areas was generated in hectares of the classes in which sugarcane was substituted.

Results and discussion

The Sugarcane Expansion in the Southwest of Goiás

The multitemporal dynamics of land use considers the evolution of anthropic activities over natural resources, allowing the integration of the analysis of the physical environment with social and economic aspects (Oliveira; Ferreira, 2015). Thus, it was possible to analyze the expansion of sugarcane in relation to the multiple coverages identified in this study.

With the classification of multispectral images of the Landsat TM5 and Landsat 8 satellites, it was possible to map six classes of use present in the study region: agriculture, drainage, urban area, sugarcane, pasture and vegetation, considering the temporal criterion (1985 , 1995, 2005, 2010, 2013 and 2016), making possible the understanding of the spatial distribution of RPSG in the 1: 100,000 scale (Figure 4).

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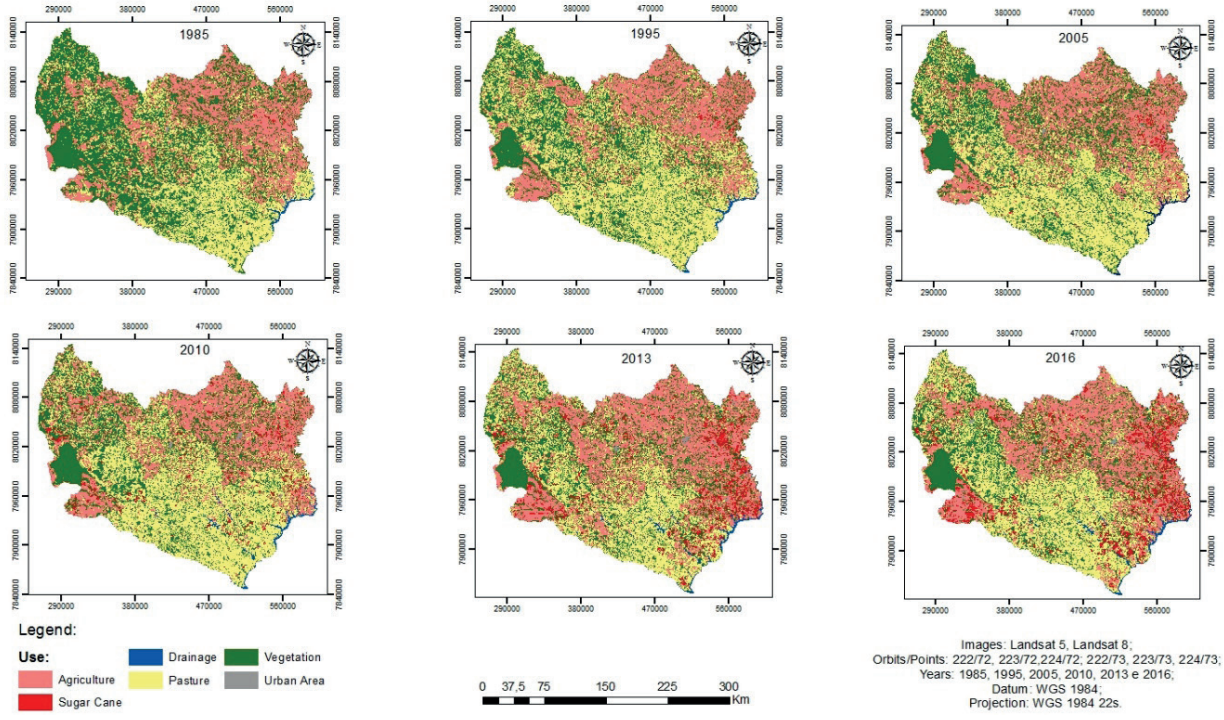

Figure 4 - Land use in the RPSG contemplating in the years of 1985, 1995, 2005, 2010, 2013 and 2016

Source: Created by the authors from the processing of satellite images (2018).

The dynamics of land use in the Southwest of Goiás presented the predominance of four classes of uses: agriculture, vegetation, pasture, and sugarcane. From the year 1985 to the year 2016, agriculture and livestock presented oscillations regarding their production areas, recording progress interspersed with successive setbacks. Sugarcane was in the class of users that reached a constant growth throughout the analyzed period, unlike native vegetation, which presented a constant drop as can be seen in Table 1.

Soil Use	1985	1995	2005	2010	2013	2016
Agriculture	1.835.555,15	1.812.589,49	2.040.221,72	1.951.659,00	2.460.597,17	2.180.902,54
Pasture	1.664.491,28	2.261.631,78	2.045.402,40	2.260.286,49	1.659.564,66	1.853.001,97
Vegetation	2.594.061,05	1.997.667,04	1.954.333,47	1.713.394,99	1.606.437,98	1.574.223,31
Sugar Cane	7.677,88	25.356,45	50.838,37	143.729,53	340.832,82	452.427,80
Water	32.309,10	35.745,82	41.790,27	59.325,11	59.484,53	61.510,44
Urban Area	8.053,95	9.157,83	9.562,19	13.753,30	15.231,25	20.082,34
Total	**6.142.148,41**	**6.142.148,41**	**6.142.148,41**	**6.142.148,41**	**6.142.148,41**	**6.142.148,41**

Table 1 - Soil Use in the Southwest of Goiás from 1985 to 2016

Source: Created by the authors from the land use maps (2017).

In this data scale, the Southwest of Goiás is developed as one of the main agricultural regions of the country. Its productive structure is based on the formation of agro-industrial complexes, which are complete chains of agricultural production, ranging from the production of the raw material, through processing and logistics, to the consumer market. It is possible to understand that it is inserted in the advance of the agricultural frontier, in the context of the modernization of agriculture, occupying areas of greater added value that demand of great investments in technology (Kageyama, et al., 1996; Silva, 1983).

The Southwest of Goiás intensified a consolidated presence of agroindustrial complexes of grains and meat that are currently experiencing frequent expansion of the sugarcane sector. These dynamics can be observed, through temporal successions of land use, in which agriculture and pasture maintained a predominance along with the growth of sugarcane.

In this sense, the public policies of the sector were definitely marked in the region. Proálcool, as stated by Alves, Szmrecsányi (2008), presented in three phases 1975/1979, 1979/1985 and 1990/2000, marked by the expansion of sugarcane production and reduction of sugar production, the creation of autonomous and the supply crises that led to the end of the program; respectively, came the National Agroenergy Plan, which among its objectives, highlights the change in the energy matrix that contributes to the expansion of Brazilian agroenergy production.

Based on the data generated, it is possible to affirm that the sugarcane sector is experiencing extensive expansion, since the first analyzed periods of which there was no record of reductions in planted area in the Southwest of Goiás. The concentration of sugarcane production began before the period of Proálcool, to the east in the municipalities of Santa Helena de Goiás and Turvelândia, and the first processing plants.

Thus, the sector presented a concentration pattern that departed from the eastern region to a radial expansion model. This expansion contributed to the distribution of sugarcane production to the east/south axis and to the west of the RPSG (Figure 5). The rapid advance registered, since the implementation of the PNA, emphasized the sugar cane culture as one of the main agents inducing the substitution of commercial crop areas, mainly grain production and native vegetation areas, interfering directly and indirectly in the Cerrado.

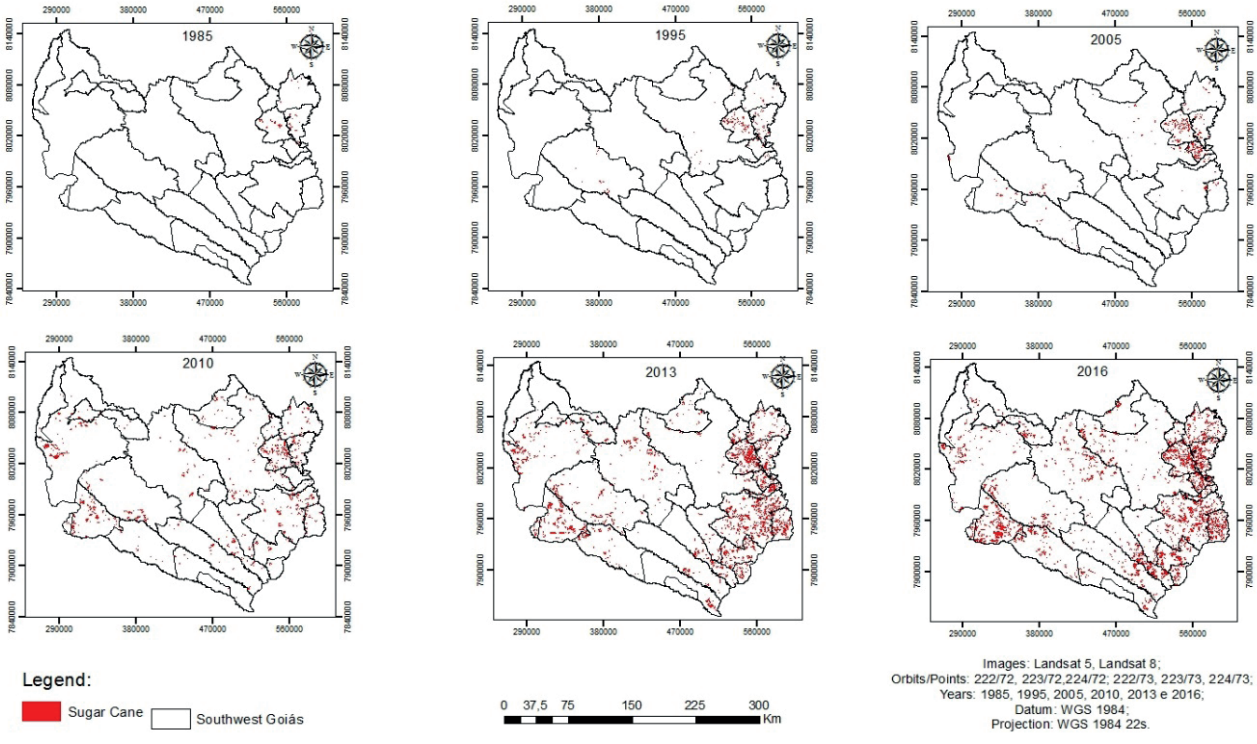

Figure 5 - Expansion of sugarcane production in Southwest Goiás -1985 to 2016

Source: Created by the authors from the processing of satellite images (2017).

Given this intense growth of sugarcane production, Abdala and Ribeiro (2011) have shown that the sugarcane industry has advanced over other agroindustrial complexes in Goiás. This scenario creates an environment of productive competition between sugarcane, grains, livestock, around the areas of the Cerrado.

Sugarcane and the Dynamics of Soil Usage Changes

Land use changes are part of a set of changes related to the temporal succession of the polygonal classes of the physical and anthropogenic bases of nature. These changes represent transitions that are related to technological levels, where practices with little or no technology standard, such as pasture and native vegetation, are the place for those with the greatest use of techniques, such as commercial agriculture, including the sugar-energy sector, with the latter adding a higher technological level.

The process of changes in land use in the face of the dynamics of the expansion of sugarcane serves, more intensely, a directed increase within the 40 km radius of the mills. This context becomes important since this distance brings the viability of the logistics system from the transport of the raw material to the processing units. In these areas, the dynamics of sugarcane expansion become more conflicting in relation to the dispute with other categories of land use, including native vegetation. Thus, the multicronological analyzes of the direct substitutions of sugarcane, within the reach of influence of the plants, revealed the search for the best cultivation areas as observed in Figure 6.

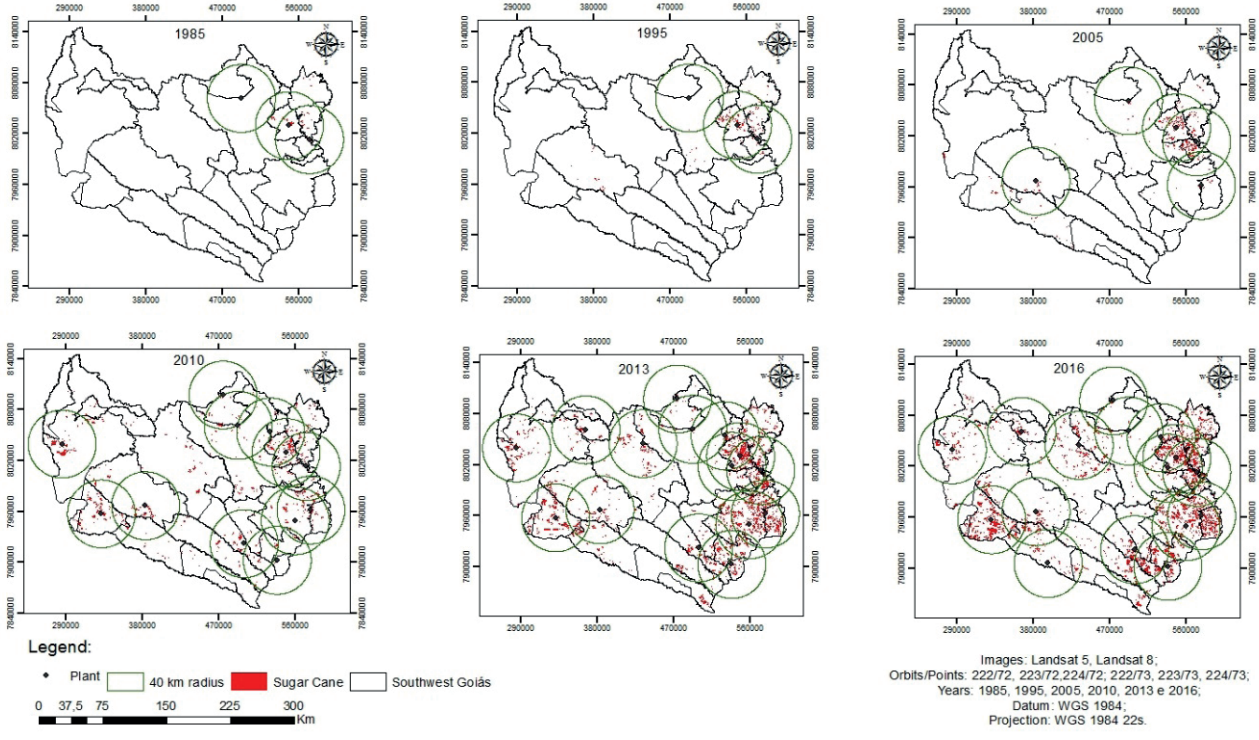

Figure 6 – Sugar cane expansion within the areas of logistic feasibility

Source: Created by the authors from the satellite image processing, location of the plants according to SIFEG and the cartographic base of the SGEI (2018).

The expansion of sugarcane showed that its development in the RPSG occurred on agricultural areas already consolidated to the east, moving to pasture areas in the west. This process is related, with an edaphic selectivity that the sugar-energy sector seeks, to the better productive conditions that are found in Red Latosols and Red-Yellow Latosols, due to their better agricultural aptitude (Trindade, 2014).

The inclusion of biofuels in the PNA created the official discourse that sugarcane would advance on pasture areas, mainly degraded areas, preserving the food producing areas and the remnants of the Cerrado (Sauer; Pietrafesa, 2012). Detailed studies on these dynamics, carried out by Castro et. al (2010), showed that the conversion of agriculture and pasture areas is part of a competition context that includes remnants of vegetation and the best soils. The structured discourse on the advancement of sugarcane on degraded pasture areas has proved to be conflicting, as there is a real dispute between agricultural land, regardless of its use and occupation.

Figure 7 shows the changes induced directly by sugarcane, within the analyzed period of this research. It should be noted that the sugarcane advance has been changing the agricultural and natural pattern of Southwest Goiás

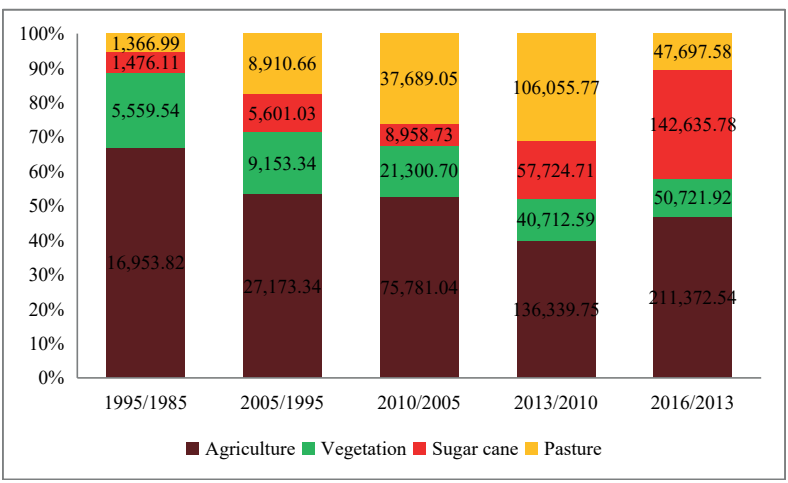

Figure 7 - Effect of substitution for sugarcane in Southwest Goiás (1985 to 2016)

Source: Created by the authors from the land use maps (2017).

Thus, the analyzed period of direct substitution of sugarcane, from 1995/1985, showed that its occupation occurred mainly on the agricultural areas (16,953.82 ha), followed by the substitution of vegetation areas (5.559,54 ha). The sugarcane advance was also identified for its own areas (1,476.11 ha), a fact that can be explained by the maintenance of sugarcane already installed, and, to a lesser extent, pasture areas (1.366,99 ha).

The 2005/1995 decennium maintained the same pattern of the previous period, with sugarcane advancing mainly in the areas of agriculture (27.173,34 ha) and of Cerrado (9.153,34 ha). The sugarcane expansion was sequenced, over the pasture areas (8.910,66 ha) and in the maintenance areas of existing sugarcane plantations (5.601,03 ha).

It is important to note that the direct substitution of sugar cane shows that changes in land use in the two quinquennia analyzed correspond to the political model of sugarcane expansion during the direct and transitory access of Próalcool. This model, in turn, presented a pattern of substitution that prioritized agricultural areas and native vegetation. According to studies conducted by Vaz, Steckelberg, Pietrafesa (2015), the scenario of sugarcane expansion has been replacing these areas of food production and preservation, having pastures as an intermediary agent.

Thus, the analysis of sugarcane expansion between 2010/2005, the PNA's period of operation, showed changes in its substitution pattern, since its progress occurred in the agricultural areas (75.781,04 ha) followed by livestock or pasture areas (37.689,05 ha), by native vegetation (21.300,70 ha) and by sugar cane (8.958,73 ha).

As pointed out by Barbalho, Silva and Castro (2013), despite the efforts of the PNA, the sugar and ethanol sector continues to advance to the agricultural areas, proving that the sector is in a territorial dispute with the grain production areas, entering into contradiction with the agroenergy public policies that, in their official text, prioritized that this recent expansion of sugar cane would occur in areas of degraded pastures while leaving the environmental control of the soils.

The changes in land use in relation to the expansion of sugarcane between 2013/2010 occurred, once again, mainly on the agricultural areas (136.339,75), followed by the pasture areas (106.055,77 ha), by sugarcane (57.724,71 ha) and by vegetation (40.712,59 ha). According to Silva and Miziara (2011), this can be explained by the fact that the sugarcane advance occurs in grain areas and, secondarily, in the pasture areas,

differing from the official discourse. In this period, it is interesting to stay in the areas that already harbored sugarcane, reducing its advance to the Cerrado areas, registering, for the first time, effective results regarding the reduction of deforestation in these natural areas.

According to the above information, the last two quinquennies showed that the pattern of sugarcane expansion in the RPSG was influenced exclusively by the new sectoral policy, the PNA. However, despite the advance of pastures, sugar cane has replaced large areas of grain production, contradicting the prospects of a sustainable expansion in disharmony with biodiversity, foreseen in the Agroecological Zoning of Cana (Manzatto et. al, 2009).

The last analyzed period, between 2016/2013, showed that the sugarcane also advanced on the agricultural areas (211.372,54 ha) followed by sugarcane (142.635,78 ha) and in the areas of vegetation (50.721,92 ha) and pastures (47.697,58 ha). This substantial advance on agricultural areas and the expansion of already existing sugarcane plantations emphasizes the selectivity of the installation of the sugarcane agroindustrial complex since the sector is inserted in a high technological standard of agricultural production (Silva; Miziara, 2011). On the other hand, the permanence of the advance over the other classes of land use shows the criteria of land prices, which may also be associated with the scarcity of higher capacity pedological resources.

Thus, the conventions of land use identified by the direct influence of sugarcane showed that it has been replacing, with greater intensity, the agricultural areas. This occurs under the watch of the PNA that does not avoid the old practices of the sector, preventing an advance within a new conservationist reality and rehabilitating degraded areas.

Also evident in the southwest of Goiás are the indirect changes in land use, that is, the systematic model of the dynamics that preceded sugarcane, and which integrates the re-direction of the other classes of uses that influence the new sugarcane advances as a whole. In this perspective, according to Figure 8, the dynamics of the indirect changes provided by sugarcane.

The pasture areas were the most advanced classes of use on the Cerrado, succeeded by the intense agricultural advance on the pasture and vegetation areas. The growing increase of sugar cane has replaced the agricultural areas, comprised by regions that require less investment

for production. It also replaced the pasture and vegetation areas with edaphic conditions for the production of the raw material for ethanol/sugar, representing the sugarcane influence in the dynamics of the other classes of uses in the Southwest of Goiás.

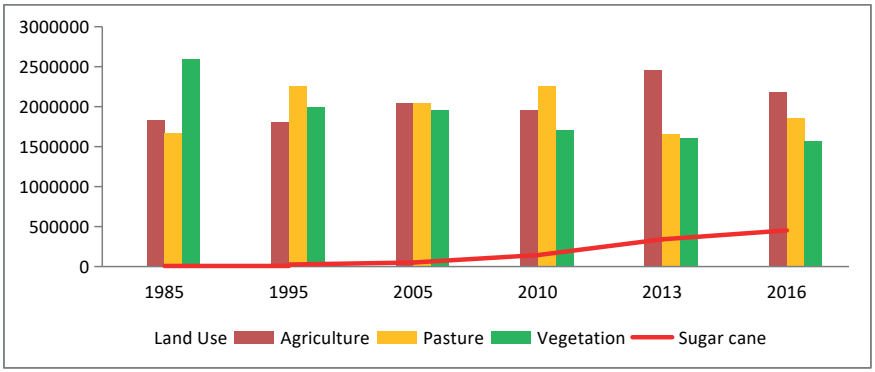

Figure 8 - Dynamics of land use changes in the Southwest of Goiás (1985 to 2016).

Source: Organized by the authors from the land use maps of Southwest Goiás (2017).

Conclusions

Between 1985 and 2016, RPSG showed important characteristics in the pattern of agricultural frontier dynamics through the sugar-energy advance. The influence exerted by sugarcane on land use triggered a gradual process of changes from a production model of greater technological involvement, in which the production of ethanol and sugar evolved over the areas with lower technology use.

It is possible to conclude that the sugar-alcohol expansion in the Southwest of Goiás, within its direct influence, promoted the territorial competition between agroindustrial complexes already consolidated, mainly grain (agriculture) and meat (pasture). Thus, it was possible to observe that sugar cane mainly occupied areas of agriculture already formed, having as a pattern of advance the regions with the highest edaphic potential. The analysis of the changes of indirect uses suggests that the pastures gave place to the productive means of greater profitability and, in this perspective, they advanced on the native vegetation areas, expanding the agricultural frontier.

The results of this research allowed to deduce that the effects of the expansion of sugarcane in the Cerrado are in conflict with the environmental guidelines of the National Plan of Agroenergy. The analysis of sugarcane production in southwest Goiás indicates the influence on food production and biodiversity, characterized from its progress, mainly on the agricultural areas and the native vegetation areas.

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Authors' contributions

All the authors contributed jointly in the development of the research. The author Silas Pereira Trindade was responsible for the theoretical-conceptual development and for the acquisition and processing of data and analysis; the second author Karla Maria Silva de Faria also contributed to the theoretical-conceptual development and data analysis; and the third author Selma Simões de Castro was responsible for the orientation of the research and the activity of contributing to the scientific and intellectual discussions of data interpretation and revision of the presented text, maps, and graphs.

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