

The Agribusiness of Sugarcane and Its Expansion in the State of Goiás

Mateus R. Oliveira¹, Antônio Pasqualetto^{1,2}, Jeferson de C. Vieira¹ & Sergio D. de Castro¹

¹ School of Law, Business and Communication, Pontifícia Universidade Católica de Goiás, Goiânia, Goiás, Brazil

² Federal Institute of Goiás [IFG], Goiânia, Goiás, Brazil

Correspondence: Antônio Pasqualetto, School of Law, Business and Communication, Pontifícia Universidade Católica de Goiás, Goiânia, Goiás, Av. Fued José Sebba, 1184. Jardim Goiás. CEP 74805-100, Brazil. Tel: 55-62-3946-3086. E-mail: profpasqualetto@gmail.com

Received: August 30, 2022

Accepted: September 30, 2022

Online Published: October 9, 2022

doi:10.5430/ijba.v13n5p61

URL: <https://doi.org/10.5430/ijba.v13n5p61>

The research is financed by Research Support Foundation of the State of Goiás [FAPEG]

Abstract

Sugarcane is an important crop in Brazil. The objective of this work was to evaluate the expansion areas, especially in the state of Goiás, in order to contribute to the understanding of sugarcane agribusiness. In the methodology used, data were obtained from IBGE and from ÚNICA and other sources, from 1980 to 2020. The results showed that in the *Cerrado*, especially in the states of Goiás and Mato Grosso do Sul, there has been an expansion of sugarcane areas since the end of the last century, but that it was optimized in the mid-2000s. These are located predominantly in the southern region of Goiás, particularly in the southwest micro regions; Quirinópolis, Meia Ponte and Vale do Rio dos Bois. One fact to highlight is that the expansion occurs preferably in areas of grain cultivation and supplementary pasture, in fertile soils and with the use of technology.

Keywords: sugarcane sector, occupation, Midwest

1. Introduction

In Brazil, the production of sugarcane is mainly intended for its conversion to sugar and ethanol, but other products and by-products are also obtained (artisanal cachaça, sweets and fodder to feed animals), and are largely produced by small producers.

In terms of planted area, the state of Goiás is second in the ranking with 971,600 hectares of the largest sugarcane producers in the country, behind the state of São Paulo in first place, Minas Gerais in third and the state of Mato Grosso do Sul, fourth. Monocrop production in these four states totals more than 547.8 million tons, with the state of Goiás alone responsible for the production of 74.1 million tons (*Companhia Nacional de Abastecimento [CONAB]*, 2021).

The areas of expansion of sugarcane as the only crop in the *Cerrado* of Goiás encompasses a mobility paradigm formed by the flows of goods, capital and workers.

The objective of this study was to analyze the expansion of sugarcane cultivation in Brazil, with special emphasis on the agroindustry of sugarcane production in the state of Goiás during the period between 1980 and 2020.

The methodology is based on data surveys and qualitative and quantitative information. For this reason, the advance of sugarcane cultivation areas was analyzed, as well as the installation of mills and sugarcane production.

The structure of this article is composed of an Introduction where the problem is addressed and the objectives are defined, a **Literature** review with the “**Contextualization of sugarcane expansion in Brazil**”, **Methodology** where the research procedures are defined. Finally, the chapter on **Results and Discussion** is divided into topics, the first addressing the “**Screening of scientific articles**” and the second “**Expansion of sugarcane in the state of Goiás**” while the third concerns “**Sugarcane and grain crops in Goiás**”. Finally, the **Conclusion and References** consulted for the development of this study are provided.

1.1 Literature Review

Contextualization of sugarcane expansion in Brazil

Much of Brazil's history intersects with the history of sugarcane (*Saccharum spp*) in the country, marked by relevant facts about the expansion of the sugar-energy sector (Matos & Marafon, 2020). The emergence of the crop begins practically with the colonial history of the country. It was disseminated from the year 1532 in the captaincies of São Vicente (today São Paulo), Pernambuco, Paraíba do Sul (today northern Fluminense) and then to the other states. By the sixteenth and seventeenth centuries, it was considered the main wealth of the country (Cardoso, 2006).

The combination of climate, soil for sugarcane cultivation determines crop productivity. In Brazil, sugarcane is produced in almost the entire country, with quantities reaching thousands of reais, mainly in the southeast region. In addition to resistance to herbivores and diseases, productivity is directly related to the selection of suitable varieties, precipitation, temperature and physical, chemical and biological soil properties; but agricultural planning is ultimately fundamental for high crop productivity (Nocelli, Zambon, Silva & Morini, 2017).

To achieve maximum productivity, it is necessary to adapt crop management with the knowledge of the growth patterns of each variety and environmental characteristics so that the maximum development stage coincides with periods of greater water availability and solar radiation (Keating, Robertson, Michow & Huth, 1999; Stone, Sorensen & Jamieson, 1999).

Brazil has two different harvests, from April to November in the Central-South region and from September to March in the Northeast region, enabling the production of ethanol for most of the year (Nocelli et al., 2017).

In Brazil, sugarcane is mainly intended for the production of sugar and ethanol, but other products are also obtained, such as artisanal cachaça, sweets and fodder to feed animals, which are largely produced by small farmers (Pereira & Barreto, 2020).

The affirmation of the alcohol industry as of national interest occurred in 1942, being accompanied by demands for government incentives, which were attended to only in 1975, with the institution of the National Alcohol Program – *PROÁLCOOL*, as a response in 1975 by the Brazilian government to the 1973 oil and sugar crisis. This was a federal program to encourage the production of alcohol for use as automotive fuel, which generated the expansion of sugarcane cultivation in the form of monoculture (Bardalho, Silva & Castro, 2013).

While the expansion of the consequent agricultural frontier in the South-Southeast towards the center of the country, the Southeast region, in particular the state of São Paulo, transformed agricultural and livestock areas, already consolidated with the production of grains, cotton and livestock, to the monoculture of sugarcane. This conversion was only plausible because of the application of substantial incentives through the federal program called *Proálcool* (1975-1979) (Castro, Abdala, Silva & Bôrges, 2010).

Table 1 shows the data on sugarcane milling and sugar and alcohol production in the Central-South Region, North-Northeast Region and the sum showing the evolution between the 1980 and 2020 harvests in Brazil.

Table 1. Sugarcane milling and sugar and ethanol production in the main producing regions of Brazil

Harvest		Ethanol (m ³)				Total
		Sugarcane (thousand tons)	Sugar (thousand tons)	Anhydrous	Hydrated	
1980/1981	Central-South Region	83,432	5,253	1,823	1,233	3,056
	North - Northeast Region	40,248	3,001	283	368	650
	Brazil	123,681	8,254	2,105	1,601	3,706
1985 / 1986	Central-South Region	163,37	4,834	2,813	6,986	9,799
	North - Northeast Region	59,804	3,199	383	1,647	2,030
	Brazil	223,178	8,033	3,196	8,633	11,829
1990-1991	Central-South Region	170,195	4,509	1,088	8,620	9,708
	North - Northeast Region	52,235	2,857	199	1,608	1,807

	Brazil	222,429	7,365	1,287	10,229	11,515
1995/1996	Central-South Region	204,383	10,185	2,588	8,256	10,844
	North - Northeast Region	44,547	3,328	421	1,346	1,767
	Brazil	248,930	13,513	3,009	9,602	12,611
2000/2001	Central-South Region	207,099	12,643	4,802	4,262	9,064
	North - Northeast Region	49,718	3,554	818	709	1,527
	Brazil	256,818	16,198	5,621	4,971	10,592
2005/2006	Central-South Region	336,783	22,015	7,275	7,036	14,311
	North - Northeast Region	48,345	3,808	791	718	1,509
	Brazil	385,129	25,823	8,067	7,754	15,821
2010 / 2011	Central-South Region	556,945	33,501	7,413	17,971	25,385
	North - Northeast Region	63,464	4,505	910	1,082	1,992
	Brazil	620,409	38,006	8,323	19,053	27,370
2015/2016	Central-South Region	617,709	31,221	10,643	17,581	28,225
	North - Northeast Region	49,115	2,616	1,017	991	2,008
	Brazil	666,824	33,837	11,661	18,572	30,232
2020/2021	Central-South Region	605,462	38,465	9,688	20,675	30,363
	North - Northeast Region	51,970	3,038	959	1,181	2,140
	Brazil	657,433	41,503	10,647	21,856	32,503

Description: Data obtained by UNICA related to sugarcane milling and sugar and ethanol production in the main producing regions of Brazil (Central-South Region and North-Northeast Region) in the periods 1980, 1985, 1990, 1995, 2000, 2005, 2010, 2015 and 2020.

Table 2 shows the data for planted areas and harvested areas of sugarcane in the Central-South Region, North-Northeast Region and the total for the country, showing the evolution between the 1980 harvests when expansion began, until the year 2018. Unlike Table 1, it was not possible to obtain the date for the 2020 harvest. However, the increase is evident in the areas of cane culture over the decades, where remarkable progress has occurred since the turn of the century.

Table 2. Planted area X Sugarcane harvested area in the main producing regions of Brazil

Harvest		Cultivated Area (hectare)	Harvested area (hectare)
1980	Central-South Region	1,725,728	1,725,728
	North - Northeast Region	1,042,786	1,042,786
	Brazil	2,768,514	2,768,514
1985	Central-South Region	2,735,042	2,735,042
	North - Northeast Region	1,349,816	1,349,816
	Brazil	4,084,858	4,084,858
1990	Central-South Region	2,810,895	2,780,054
	North - Northeast Region	1,511,404	1,492,548
	Brazil	4,322,299	4,272,602
1995	Central-South Region	3,309,951	3,298,415

	North - Northeast Region	1,328,330	1,260,647
	Brazil	4,638,281	4,559,062
2000	Central-South Region	3,729,995	3,727,228
	North - Northeast Region	1,149,846	1,077,283
	Brazil	4,879,841	4,804,511
2005	Central-South Region	4,663,630	4,660,039
	North - Northeast Region	1,151,521	1,145,479
	Brazil	5,815,151	5,805,518
2010	Central-South Region	7,895,289	7,810,665
	North - Northeast Region	1,269,467	1,266,041
	Brazil	9,164,756	9,076,706
2015	Central-South Region	9,072,407	9,013,536
	North - Northeast Region	1,107,420	1,097,840
	Brazil	10,179,827	10,111,376
2018	Central-South Region	9,131,832	9,116,563
	North - Northeast Region	931,907	925,636
	Brazil	10,063,739	10,042,199

Description: Data obtained by UNICA related to the harvested areas and planted areas (hectares) of sugarcane in the main producing regions of Brazil (Central-South Region and North-Northeast Region) in the periods of 1980, 1985, 1990, 1995, 2000, 2005, 2010, 2015 and 2018.

In the Central-South region, production expansion occurs mainly through the increase in cultivated area (area factor), *"since in this region there is a large area of degraded pasture that can be converted for use in sugarcane cultivation"* (Bittencourt & Gomes, 2014).

Noting that for the Central-South region there was a greater expansion both in planted area and in sugarcane production, the factors related to favoring the relief for mechanization, availability of land, credits for the implementation of plants/distilleries mainly in the state of Goiás, may be related to this growth. Thus, the production of sugarcane in the country, stimulated mainly by the four states with the highest productivity presents an evolution anchored mainly by *"public policies of incentives for investments, technological development, contribution to production and export that ensure an important role in the development of a national agribusiness"* (Alves, Franco, Zanetti & Góes, 2021).

Traditionally the industry was centralized in the Northeast of Brazil, which has supported the tradition of large sugar mills since the colonial period, but now the sugarcane culture has expanded to the Center-South of the country. With the obtaining of State subsidies, and the support of institutions such as the Institute of Sugar and Alcohol (IAA), and with a political base together with the federal government, the sugarcane agribusiness has developed substantially since the mid-1980s (Castro et al., 2010).

At the end of the 1980s, the *Proálcool* Program began to lose its effectiveness and consequently the programs of incentives and tax benefits for producers no longer had the importance or the relevance they had when they were first created (Silva, Leão & Pasqualetto, 2015).

The expansion is primarily based on the model of incorporation of areas by leasing and acquiring land by the mills, the use of intermediaries that induced the expansion, and by suppliers, inserted in a radius of action that highlights the cost-benefit ratio of the transportation of the harvested sugarcane to the mills. This relationship differs from one state to another, depending on the logistics. This model, initially a vertical integration model, gradually became horizontal during the two subsequent decades, with the development of industrial complexes (Castro et al., 2010).

Thus it was, until the advent of a new crisis in the late 1980s, called neoliberalism. This new world order progressed throughout the 1990s, demanding a global macroeconomic adjustment, leading to the deregulation of the

sugar-energy sector (Bray, Ferreira & Ruas, 2000).

This period was responsible for the extinction of public regulatory institutions, such as the Sugar and Alcohol Institute (IAA) in March 1990, determining the end of tax and credit subsidies, dismantling the public policies designated for the sector. *Proálcool* was finally extinguished in 1991, but other policies remained, disjointed and conflicting with each other, becoming the source of conflicts between the production centers, while the search for solutions to recover economic stability continued. These issues characterized this period (Castro et al., 2010).

This program had been created to reduce dependence on oil imports (Kohlhepp, 2010) and brought important innovations to the country's bioethanol production, the production of plant genetics and adapted seeds, technologies used by plants and wineries and the development of the automotive industry (Rodrigues & Ortiz, 2006).

In addition, the confrontation became evident, either between the producers within the same geographical block or between the two blocks that became consolidated in the process: the Northeast and the Center-South. The state of Goiás did not demonstrate visible development in the sector during this phase of expansion of *Proálcool* and even later, to the detriment of certain factors, it became the target of agricultural frontier extensions, especially in grains, cotton, rice and cattle (Castro et al., 2010).

However, from the 1980s on, sugarcane production began to expand in the state, but it was only after the end of the 1990s that the expansion became evident. It intensified at the beginning of the present century, due to the need for diversification in the energy matrix. This was caused by environmental impacts resulting from the model previously adopted, based on fossil fuels (Castro et al., 2010).

Since the 1980s, most scientists around the world have issued a new warning: global warming is closely related to issues such as the burning of fossil fuels. At the same time, oil prices have risen sharply, contributing to the introduction of biofuels worldwide - bioethanol among them, which has had at least two main consequences: helping to reduce greenhouse gas emissions and partially replacing oil (Leite & Leal, 2007).

2. Method

The State of Goiás occupies an area of 340,106 km² and is located in the Midwest region of the country. The state has a privileged geographical position, bordered to the north with the state of Tocantins, to the south with Minas Gerais and Mato Grosso do Sul, to the east with Bahia and Minas Gerais and to the west with Mato Grosso (Figure 1). The state has 246 municipalities and a population of 6.921 million inhabitants (Instituto Mauro Borges [IMB], 2022).

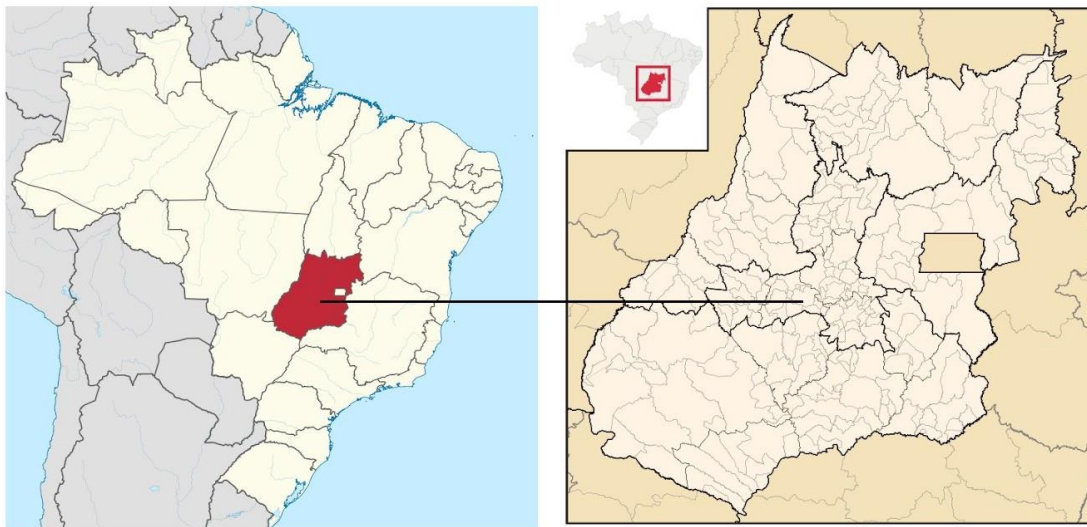


Figure 1. Location of the State of Goiás on the map of Brazil

Description: Map of Brazil highlighting the State of Goiás and next to it, the map of the State.

The methodology for this study comprised qualitative and quantitative research of an exploratory nature. Initially, the method used was a literature review. Therefore, questions of interest, databases to be analyzed, combinations of keywords, and inclusion and exclusion criteria of articles were previously determined for further evaluation, synthesis and interpretation of the data. Thus, quality research was sought, or in other words, knowledge was sought on a given subject but which is only possible when studies that are relevant and available (Galvão & Pereira, 2014), support it.

The question of interest was - How to understand the transformations resulting from the expansion of sugarcane agribusiness over the years in Brazil and Goiás. To answer this question, a search was carried out in January 2022 and the data was updated in July 2022, in order to contemplate all articles published so far, on two scientific research platforms: SciELO and in the journals of *Capes* (The Brazilian Federal Agency for Support and Evaluation of Graduate Education).

The review was directed to research in Brazil; therefore, the platforms used aimed to ensure that studies published in regional journals were included in the analysis. In addition, in order to obtain a significant number of articles and thus provide a better diagnosis, a specific period was delimited for the search, to between the years 2000 and 2020 and in the updating of the data a new period was delimited between 2010 and 2021.

For the localization of articles, the following combination of keywords linked by Boolean operators “AND” and “OR” was used: (“sugarcane” OR “expansion” OR “sugarcane occupation” OR agriculture) AND (“sugarcane expansion” OR “Goiás”) AND (Brazil). The combination of keywords, Boolean operators, quotation marks and parentheses were used as a search process in order to limit information and ensure greater search accuracy.

Subsequently, the articles were sorted and registered in a spreadsheet for analysis. The aspects observed in this section were: year of publication, author, journal, field of research and reasons for inclusion or exclusion of the article. The titles, abstracts and keywords were read and analyzed from the record of the most general information in the articles. This first step aimed to ensure that the articles met the inclusion criteria. These criteria were defined to refine the search for articles dedicated to clearly discussing the relationship between the expansion of sugarcane agribusiness and territorial occupation. As for the exclusion criteria, studies conducted outside Brazil, review articles and articles that were not available in full text in PDF format were not evaluated. After the first screening, the articles were read in full, which meant that certain studies could not be included because they did not meet the inclusion criteria. Thus, the list of checks was based on the following points: (i) the expansion of sugarcane in Brazil and; (ii) the expansion of sugarcane in Goiás.

At the same time, quantitative research was carried out, with data collection in agencies such as IBGE, IMB and UNICA for the following variables: production (tons) and productivity (tons/ha), planted areas (ha), thus analyzing the expansion of sugarcane in the state of Goiás and in Brazil, through a survey of the main agroindustries in the state of Goiás.

1. IBGE – The Brazilian Institute for Geography and Statistics –

Available at <https://ibge.gov.br/>

2. IMB – The Mauro Borges Institute for Statistics and Socio-economic Studies.

Available at <https://www.imb.go.gov.br/>

3. UNICA - Union of the Sugarcane Industry, cane observatory.

Available at: <https://observatoriodacana.com.br/>.

The research was carried out in 2022, but the data for the period from 1980 to 2020 (total period) were analyzed every five years: 1980, 1985, 1990, 1995, 2000, 2005, 2010, 2015 and 2020. This analysis was completed from the 1980s when the explosion of coproduction occurred in the country. It is worth highlighting, as it was done during the research, that the 1990s was the period that witnessed the opening of Brazilian commerce and a period where the availability of rural credit was low. The middle of that decade saw the process of dismantling of the interventionist government institutions and instruments that had guided Brazilian agricultural policy. It was also the time of the implementation of the Real Plan. The first decade of the new millennium was marked by the arrival of large projects in the sugar-energy sector and the arrival of flex-fuel cars in the national market. This has boosted production in the sector, and by the abundance of cheap capital and new entrants in the sector, who have managed to invest driven by the prospect of good profit margins for ethanol within the country and abroad (Bittencourt & Gomes, 2014).

3. Results and Discussion

3.1 Screening of Scientific Articles

Of the total articles that made up the final database (Figure 2), 16 articles were included in the SciELO database and 28 articles from the Capes journals database, making a total of 44 scientific articles taken from different journals.

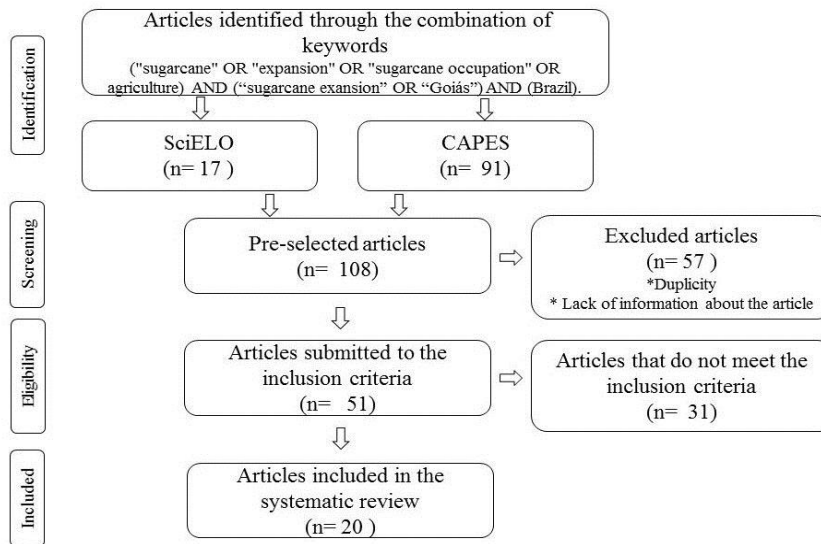


Figure 2. Flowchart with the research methodology used

Description: Flowchart of research and screening of articles obtained in SciELO research platforms and *Capes* journals until 2022.

The periodical *Campo-Território* presented the largest number of publications (13%) followed by *Boletim Goiano de Geografia* (9%), *Field Crops Research* (9%) and others with (4%) only one publication (Figure 3).

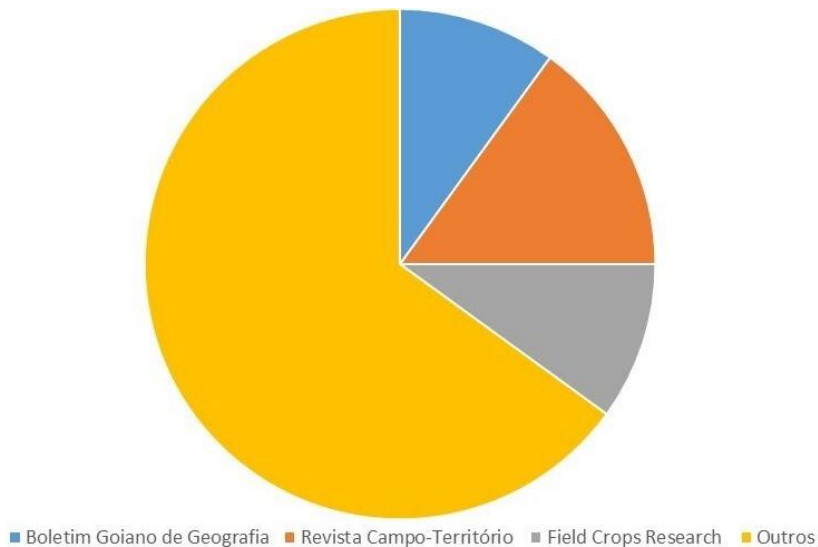


Figure 3. Periodicals of publications of selected articles – Database

Description: Among the journals selected from the SciELO research platforms and *Capes* journals, we noticed a division among the scientific journals that most appear in the database.

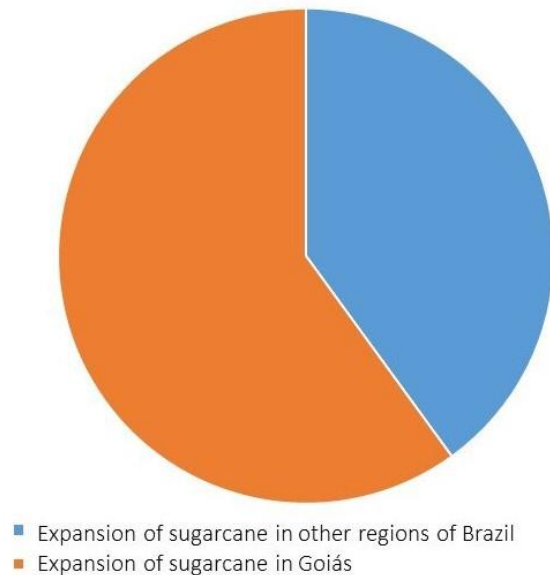


Figure 4. Periodicals of selected articles published – division of themes

Description: Among the journals selected from the SciELO research platforms and *Capes* journals, there is a division between articles that address the themes of sugarcane expansion in Brazil and Goiás according to searches in the databases.

Among the articles that are part of the database, only 20 are part of the discussion found in this research (Table 3), considering 77% address the expansion of sugarcane in the state of Goiás and 23% address the expansion of sugarcane in other Brazilian regions (Figure 4).

Table 3. Database used for the formulation of the discussion

Year	Author	Periodical
2021	ALVES, L. Q.; FRANCO, P. N.; ZANETTI, W. A. L.; GÓES, B. C.	<i>Revista Brasileira de Engenharia de Biosistemas</i>
2020	LUCENA, R. A. F.; DEMARTELAERE, A. C. F.; PRESTON, H. A. F.; PRESTON, W.; FEITOSA, S. dos. S. F.; FERREIRA, A. dos. S.; SILVA, H. F. da; SANTOS, J. J. M. dos.	Brazilian Journal of Development
2020	MATOS, P.F. de; MARAFON, G. J.	<i>Revista Campo-Território</i>
2020	NEVES, P. D. M.; MENDONÇA, M. R.	<i>Revue Franco-brésilienne De Géographie</i>
2020	PEREIRA, L.A.G.; BARRETO, J.B.	<i>Revista Campo-Territorial</i>
2018	MESQUITA, F. C.; FURTADO, A. T.	<i>GEOgraphia</i>
2018	RODRIGUES, H. S. M. C.; CASTRO. S.S.	<i>Geografia</i>
2016	MESQUITA, F. C.	<i>Revista Campo-Território</i>
2016	RIBEIRO, N. V.; FERREIRA, L. G.; FERREIRA, N. C.	<i>Revista Brasileira de Cartografia</i>
2015	SILVA, A. A.; CASTRO, S. S.	<i>Ateliê Geográfico</i>
2015	SILVA, L. I. da; LEÃO, C.; PASQUALETTO, A.	<i>Baru</i>
2014	BITTENCOURT, G. M.; GOMES, M. F. M.	<i>Redes</i>

2014	FRANCO, I. O.	<i>Boletim Goiano de Geografia,</i>
2013	BARDALHO, M. G da Silva; SILVA, A.A; CASTRO, S. S.	<i>Revista Brasileira de Ciências Ambientais</i>
2011	SILVA, A. A.; MIZIARA, F.	<i>Pesquisa Agropecuária Tropical</i>
2010	CASTRO, S. S. de; ABDALA, K.; SILVA, A. A.; BÔRGES, S. V. M.	<i>Boletim Goiano de Geografia</i>
2010	KOHLHEPP, G	<i>Estudos Avancados</i>
2007	LEITE, R.C.C.; LEAL, M.R.L.V.	<i>Novos Estudos – CEBRAP</i>
1999	KEATING, B.A.; ROBERTSON, M.J.; MUCHOW, R.C.; HUTH, N.I.	Field Crops Research
1999	STONE, P.J.; SORENSEN, I.B.; JAMIESON, P.D.	Field Crops Research

Description: Data bank created for research methodology with the periodicals used in producing this article, divided by year, authors and scientific periodical

3.2 Sugar Cane Expansion in State of Goiás

In the *Cerrado* of Goiás, the lands became the target of expansion of the agricultural frontier in the 1970s, based on the change in the technical basis of agriculture, commonly known as the modernization of agriculture, inspired by the Green Revolution, which was based on the intensive use of agricultural inputs and machinery. This transformation favored the change in the paradigm of the potential use of *Cerrado* soils, hitherto considered poor and unsuitable for cultivation (Rodrigues & Castro, 2018).

The expansion in the state of Goiás, according to Silva & Miziara (2011) would have occurred at two different times. At first, on a smaller scale, it started in the areas historically occupied by grain crops, located on the south-north axis, and still very much associated with *Proálcool*, which covered the central mesoregions and part of the south of the state. In a second moment, more recently and intensely, it occurred specifically in the southern region of the state, which reproduced the Agricultural Border Expansion itinerary of the 1980s, when the soybean commodity was introduced.

Table 4 lists the agro-industries registered with the Syndicate for the Ethanol Manufacturing Industry of the State of Goiás – SIFAEG.

Table 4. Agroindustry's registered with the Syndicate for the Fabrication of Ethanol in the state of Goiás in 2020

	Power Plant	Address	Municipality
1	Aguape íAgroenergia S.A	Rod. GO 164, Km 02, Gleba B da Faz. Pateiros - Zona Rural	S ão Sim ão
2	BOM Sucesso Agroind ústrias S.A	Rodovia GO 210, Km 335.1 - Zona Rural	Goiatuba
3	BP Bioenergia Tropical S.A	Takayuki Maeda Highway (GO 410) – Km 51 – Zona Rural	Ed éa
4	BP Bioenergia Itumbiara S.A	Rodovia Municipal Itumbiara/Cachoeira Dourada, Km 18, Fazenda Jandaia (Gleba B) - Zona Rural	Itumbiara
5	BRENCO - Usina Morro Vermelho	Rod. GO 341 – Km 67, right 13 Km - Zona Rural	Mineiros
6	BRENCO - Usina Pearol ândia	Rodovia BR 364, Km 256 - Zona Rural	Perol ândia
7	Ca çu Com ércio E Ind. De Açúcar E Álcool Ltda	Rod. Municipality Vicentin ópolis/Porteir ão, Km 10 - Zona Rural	Vicentin ópolis
8	CBB - Companhia Bioenerg ética Brasileira Ltda	Rodovia BR 020, Km 160, Fazenda preludo - Zona Rural	Vila Boa

9	CEM - Central Energética Morrinhos S.A	Rod. BR 153 – Km 646 – Faz. Samambaia - Zona Rural	Morrinhos
10	Centro Álcool S.A	Rodovia GO 222, Km 3 - Zona Rural	INHUMAS
11	Cerradinho Bioenergia S.A	Rod. GO 050 – Km 11 + 950 mts – Faz. Âncora - Zona Rural	Chapadão do Ceu
12	Cooperativa Agroindustrial De Rubiataba Ltda	Rodovia GO 434 – Km 24 - Zona Rural	Rubiataba
13	Crv Industrial Ltda	Rodovia Carmo do Rio Verde/Rubiataba – Km 2,5 - Zona Rural	Carmo do rio verde
14	Denusa Destilaria Nova União S.A	Rodovia BR 060 – Km 274 - Zona Rural	Jandaia
15	Eber Bio-Energia E Agricultura Ltda	Rod. GO 070, Km 030, 3 Km à esquerda - Zona Rural	MONTES CLAROS, GOIÁS - GO
16	Energética Serranópolis Ltda	Rodovia GO 184 – Km 65 – Fazenda Bonito - Zona Rural	Serranópolis
17	Goiás Bioenergia S.A	Rodovia GO 210 – Km 99 – Acesso à esquerda – Fazenda Ouro Fino - Zona Rural	Porteirão
18	Goiasa Goiatuba Alcool Ltda	Rodovia GO 040 – Km 194 – Acesso 7 km à direita - Zona Rural	Goiatuba
19	JALLES MACHADO S/A	Rodovia GO 080 – km 185 – Faz. São Pedro - Rural Area	GOIANÉSIA
20	Jalles Machado S.A - Otávio Lage Unit	: Rodovia GO 338 – Km 33 à esquerda 3 Km - Zona Rural	GOIANÉSIA
21	Lasa Lago Azul S.A	BR 050 – Km 148- Fazenda Lago Azul - Zona Rural	Ipameri
22.	Nardini Agroindustrial Ltda	Rodovia GO 184 – Km 133 – Fazenda S. Francisco - Zona Rural	Aporé
23	Raizen Centroeste Açúcar E Alcool Ltda	Rodovia GO 050, Km 328.5 - Zona Rural	Jatá
24	RIO CLARO AGROINDUSTRIAL S/A	Rod. BR 364 – Km 61, Fazenda Santo Antônio - Zona Rural	Caçu
25	São Martinho S.A	Rod. GO 164, Km 131.5, Faz. Boa Vista - Rural Area	Quirinópolis
26	SJC Bioenergia S.A – Rio Dourado Unit	Rod. GO 206, Km 25, Faz. Boa Vista - Rural Area	EGP Cachoeira Dourada
27	SJC Bioenergia S.A – Unidade São Francisco	GO 206, Km 18, Faz. São Francisco - Zona Rural	Quirinópolis
28.	Uruguai Açúcar E Álcool Ltda	Estrada UR-4, s/n – Km 13 – Distrito de Água Branca - Zona Rural	Uruguai
29	Usina Goianésia S.A	Rod. GO 428 – Km 12 – Faz. São Carlos - Zona Rural	GOIANÉSIA
30	Usina Nova Gália Ltda	Rod. GO 333 – Km 79, Sentido Rio Verde - Jandaia – Zona Rural	Paraúna
31	Usina Rio Verde Ltda - Decal	Rodovia GO 174, Km 32 – Faz. Alvorada - Zona Rural	Rio Verde
32	Usina Santa Helena De Açúcar E Álcool S.A	Rod. Municipality Turvelândia, GO 210, Km 06 - Zona Rural	Santa Helena de Goiás

Description: Data obtained by the Syndicate for the Ethanol Manufacturing Industry of the State of Goiás – SIFAEG with the list of registered agroindustries. Table divided with the name of the plant and location (address and city).

Figure 5 shows the micro regions of the State of Goiás, according to the classification of the Brazilian Institute of Geography and Statistics – IBGE. The micro regions are formed by a group of municipalities that corresponds to the lowest administrative level in Brazil. The location of each agribusiness listed above and belonging to SIFAEG were inserted in them.

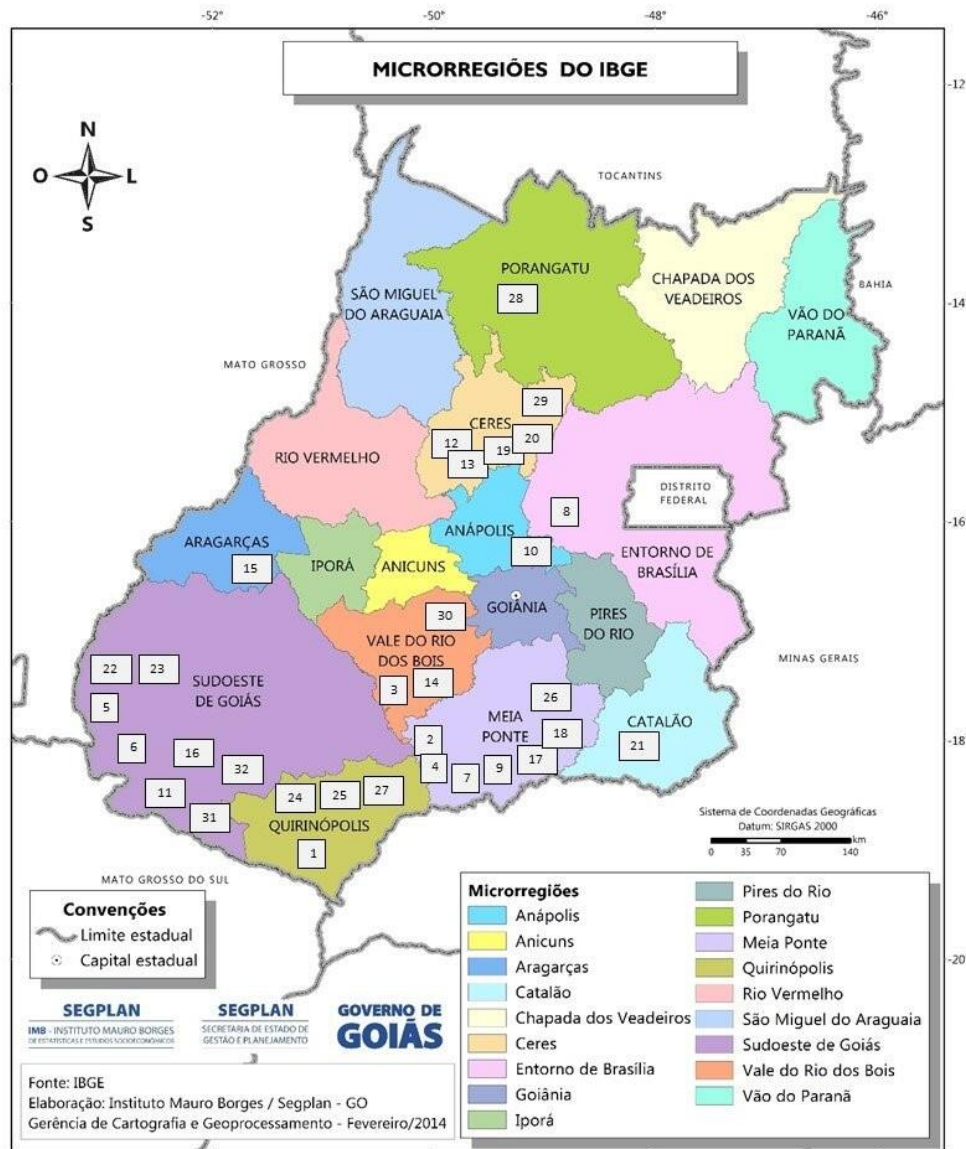


Figure 5. Map of the State of Goiás with the subdivisions of the micro regions

Description: Obtained by IBGE and prepared by the IMB. The map of the State of Goiás and its micro-regions, locating the agro-industries registered in the Syndicate for the Ethanol Manufacturing Industry of the State of Goiás – SIFAEG.

In the state of Goiás, sugarcane cultivation areas are widespread in 112 municipalities, which are comprised of the Geographical micro regions defined by IBGE, according to the last census (IBGE, 2020).

In Goiás, the need for investment in this area is high, as many factories were installed in areas of the interior of the state with little traffic and, in some cases, with unpaved roads. In this case, the role of the state government, through the Highway program, created in 2011, for the improvement of road sections in municipalities with mills and

sugarcane production is notorious. This relationship is seen, for example, in the reconstruction of 65 km of the GO-164 section connecting Quirinópolis and Paranaiguara and 68.2 km of the GO-206 section between Quirinópolis and Caçu, and finally the paving of the GO-206 highway, 60 km long, which connects Chapadão do Cáu to the GO-184 highway (Mesquita & Furtado, 2018).

Thus, with these high investments in technology and infrastructure, the harvesting of sugarcane is carried out mechanically. Thus, sugarcane has become one of the main segments within the state's economy, and its culture has contributed to the entry of several processing industries, which has generated new jobs and adds value to primary production (Silva et al., 2015).

Table 5 shows the area cultivated with sugarcane by micro region in Goiás, 2014/2015 and 2019/2020 harvests, exemplifying the areas available for harvest, divided into sugar cane stalks, renovation, expansion and areas under renovation, totalling the cultivated area. Unfortunately, it was not possible to obtain segmented data every five years from 1980 to 2020.

Table 5. Area cultivated with sugarcane by micro region of the State of Goiás – 2014/2015 and 2019/2020 harvests

Micro region	Available for harvest											
	Stalks (hectare)		Renovation (hectares)		Expansion (hectares)		Total Hectares		Renovation (hectares)		Total Cultivated (hectares)	
	2014/2015	2019/2020	2014/2015	2019/2020	2014/2015	2019/2020	2014/2015	2019/2020	2014/2015	2019/2020	2014/2015	2019/2020
Anápolis	11,912	8,542	2,243	731	1,044	206	15,199	9,479	1,304	2,823	16,503	12,301
Anicuns	15,623	11,183	2,525	520	272	332	18,420	12,036	1,919	2,482	20,338	14,517
Aragarças	-	0	-	0	-	0	-	0	-	0	-	0
Catalão	5,120	7,905	722	467	460	29	6,302	8,400	368	600	6,670	9,001
Ceres.	103,253	96,720	13,660	12,987	6,056	3,738	122,968	113,446	5,837	15,971	128,805	129,419
Chapada Dos Veaderos	-	0	-	0	-	0	-	0	-	0	-	0
Entorno De Brasília	22,715	25,968	3,651	2,455	2,250	615	28,616	29,037	4,935	3,970	33,550	33,007
Goiânia	669	553	239	38	203	0	1,111	591	0	748	1,111	1,339
Iporá	-	0	-	0	-	0	-	0	-	0	-	0
Ituiutaba	9,817	0	187	0	3,221	0	13,225	360	488	0	13,713	0
Meia Ponte	146,979	192,915	17,033	19,921	24,349	13,173	188,1	226,008	25,174	47,232	213,535	273,238
Pires Do Rio	-	0	-	0	-	0	-	0	-	0	-	0
Porangatu	5,028	0	36	0	1,575	0	6,639	0	151	0	6,789	0
Quirinópolis	145,061	179,528	13,750	15,870	31,656	6,692	190,466	202,089	16,738	34,457	207,204	236,546
Ribeirão Preto	5,578	0	562	0	1,121	0	7,262	0	896	0	8,158	0
Rio Vermelho	694	306	0	4	0	0	694	310	0	417	694	726
São Miguel Do Araguaia	-	0	-	0	-	0	-	0	-	0	-	0
Serra Do Pereiro	0	0	0	0	604	0	604	0	0	0	604	0

Southwest of Goiás	213,235	239,881	14,978	18,930	28,167	23,003	256,380	281,813	17,278	40,978	273,659	322,792
Vale Do Rio Dos Bois	77,813	\$94,608	9,125	11,826	10,501	10,674	97,439	117,111	9,305	19,338	106,744	136,448
Vão Do Paraná	18	0	0	0	0	0	0	0	0	0	18	0
Total	660,262	858,109	78,711	81,294	111,479	58,462	953,686	1,000,320	84,393	169,016	1,038,095	1,169,334

Description: Data obtained by ÚNICA relative to the area cultivated (hectares) with sugarcane by micro region in Goiás, in the 2014/2015 and 2019/2020 harvests, in the areas available for harvest, divided into: Stalks, renovation, expansion and areas under renovation.

The expansion of the sugarcane planting area is due to the increase in the capacity of the production units and the installation of new units. As such, there is a strong tendency to value land prices in regions close to the mills and, consequently, in addition to the expansion trend in sugarcane production into traditional pasture areas, it means that the displacement of grain production, such as soybeans and corn and permanent crops may be affected (Stupiello, 2005).

Table 6 shows data on sugarcane milling and sugar and ethanol production in the State of Goiás, thus demonstrating the increase in crop production between the 1980 and 2020 harvests.

Table 6. Milling of sugarcane and production of sugar and ethanol in the State of Goiás

Harvest	Sugarcane (thousand tons)	Sugar (thousand tons)	Ethanol (m ³)		Total
			Anhydrous	Hydrated	
1980/1981	311	21	4	6	9
1985 / 1986	4,188	12	50	256	307
1990-1991	4,258	42	17	274	291
1995/1996	6,330	226	38	328	366
2000/2001	7,208	397	143	176	318
2005/2006	14,560	750	375	354	729
2010 / 2011	46,613	1,805	662	2,233	2,895
2015/2016	73,522	1,892	1,314	3,375	4,689
2020/2021	74,011	2,319	1,186	4,055	5,241

Description: Data obtained by ÚNICA related to sugarcane milling and sugar production (tons) and ethanol (cubic meters) in the State of Goiás during the 1980, 1985, 1990, 1995, 2000, 2005, 2010, 2015 and 2020 harvests.

In the state of Goiás, as the crops are newer than those of the state of São Paulo, the mills are supplied especially with these for the production of ethanol and cogeneration of electricity. This explains the large ethanol production between the 1995/1996 and 2014/2015 harvests (Neves & Mendonça, 2020).

The *Cerrado* biome contains extensive areas under geo-environmental conditions suitable for intensive agriculture and livestock, which is historically extensive and dominant in spatial form. During the 1960s and 1970s, for this and other geopolitical reasons, the *Cerrado* was the target of expansion of the new agricultural frontier (Castro et al., 2010).

Thus, in Goiás, as well as expansion areas in the regions of the Triângulo Mineiro, Mato Grosso and Mato Grosso do Sul, advantages for new plants arose, such as: the possibility of occupying larger extensions of land with lower costs compared to the state of São Paulo. These advantages also included greater viability in building mills with a larger capacity for production; the opportunity to start operations with harvesting and planting in a mechanized manner;

and being able to enjoy tax incentives offered by the State Government. Thus, in parallel, the areas of expansion of the sugarcane agribusiness were privileged with investments from the National Bank for Economic and Social Development (BNDES) (Mesquita, 2016).

In Goiás, the sugarcane agribusiness found an enormous ease in its territorialization through studies with the help of the State with programs and policies, as well as with flexibility for its structuring, production and marketing (Neves & Mendonça, 2020).

Unlike other crops - for example, soybeans, whose grain can be stored for a long time (under certain technical conditions) or transported over long distances for industrial processing without significant loss of properties - the proximity of the production mill is of fundamental importance for sugarcane. This leads to the creation of a framework for aggressive occupation, which invariably results in the emergence of large areas under the monoculture regime and the prevailing locational rigidity of the land structure of the regions (Franco, 2014).

3.3 Sugarcane and Grain Crops in Goiás

Changes in the form of agricultural use and occupation of land need to be considered from different perspectives, even on a scale, because the insertion of some elements can change the entire agro system. Thus, the changes caused by the replacement of cultures, considered as modifying agents of the landscape and the different elements that compose it, tend to affect it (Silva & Castro, 2015).

Agriculture is considered the sum of temporary and permanent crops. Table 7 shows production data for the main grain and sugarcane crops in the State of Goiás (Silva et al., 2015).

Table 7. Agricultural production (tons) in the State of Goiás in the period from 1980 to 2020

Product	1980	1985	1990	1995	2000	2005	2010	2015	2020
Soy	455,794	1,356,240	1,258,440	2,146,926	4,092,934	6,983,860	7,252,926	8,606,210	12,837,120
Corn	1,751,507	1,690,770	1,848,350	3,449,308	3,659,475	2,855,538	4,689,453	9,512,503	11,838,775
Rice	1,455,400	1,116,312	307,770	419,871	294,629	374,627	221,419	108,938	144,419
Beans	36,622	75,256	118,960	132,350	200,415	280,461	288,816	289,463	351,454
Sorghum	803	8,730	8,740	58,106	287,502	510,869	611,665	898,123	1,173,014
<i>Sugarcane</i>	<i>1,218,325</i>	<i>6,025,090</i>	<i>6,896,320</i>	<i>7,690,407</i>	<i>10,162,959</i>	<i>15,642,125</i>	<i>48,000,163</i>	<i>72,066,835</i>	<i>76,480,368</i>

Description: Data obtained by IBGE and IMB regarding agricultural production (tons) in the State of Goiás in the period 1980, 1985, 1990, 1995, 2000, 2005, 2010, 2015 and 2020 with the main crops of grains (soybeans, corn, rice, beans, sorghum) in comparison with sugarcane.

Table 8 shows the area harvested from these same agricultural products, with emphasis on the reduction of the areas planted with rice and beans and the expansion of the others, especially soybeans and sugarcane.

Table 8. Harvested area (hectares) of agricultural products in the State of Goiás

Product	1980	1985	1990	1995	2000	2005	2010	2015	2020
Soy	246,066	734,210	972,430	1,121,511	1,491,066	2,663,380	2,445,600	3,260,025	3,574,230
Corn	803,268	734,120	873,650	881,954	839,844	614,709	860,041	1,401,843	1,731,660
Rice	1,186,728	860,774	296,070	263,068	150,334	184,950	90,382	25,258	28,461
Beans	160,547	198,239	180,770	133,915	112,179	118,242	118,948	122,797	133,779
Sorghum	460	6,400	5,410	32,479	175,850	276,065	245,308	243,974	360,543
<i>Sugarcane</i>	<i>20,664</i>	<i>90,010</i>	<i>97,950</i>	<i>104,498</i>	<i>139,186</i>	<i>196,596</i>	<i>578,666</i>	<i>930,052</i>	<i>937,619</i>

Description: Data obtained by IBGE and IMB regarding agricultural production (tons) in the State of Goiás in the period 1980, 1985, 1990, 1995, 2000, 2005, 2010, 2015 and 2020 for the main crops of grains (soybeans, corn, rice, beans, sorghum) in comparison with sugarcane.

The expansion of crops such as soybeans is intrinsically related to the international consumer market and competitive advantages, especially linked to the favorable value of the US dollar for exportation. As for sugarcane, the demand for alternative fuels, demand for new areas in addition to São Paulo and climates more favorable for soils, combined with government strategies and good productivity has enabled a greater presence of sugarcane in the territories of Goiás state.

According to what has been presented, it is clear that the State of Goiás has become part of a national context with an agricultural standard that encourages the consolidation of a modern and entrepreneurial agriculture, with close links to the national and international markets. These facts reinforce the importance of Goiás as a strong region in attracting regional, national and international agro-industrial capital (Silva et al., 2015).

In short, micro regional studies better clarify what statistics have already allowed us to assume for the South Region of Goiás - the replacement of agricultural land by sugarcane fields and land for pasture since 2000 -, but also clarified the key to the indications that the reduction of pastures does not always mean transforming it into sugarcane (Castro et al., 2010).

The *Cerrado* region of Goiás, characterized as the new sugarcane frontier, has undergone a phase of adaptation to the culture because of the new climatic and productive conditions of the region. Investments in increasing average productivity should continue, so that the pattern of increase in sugarcane production will result, from technological growth (productivity factor) and not from extensive land use (Bittencourt & Gomes, 2014).

3.4 Conclusion

The sugarcane crop in Brazil focused on ethanol production shows a recent expansion towards the north of the *Cerrado*, especially in the states of Goiás and Mato Grosso do Sul. As a result, the expansion of the Central-South block has been consolidated and configured, stemming from the implementation phase of *Proálcool*, in the 1970s, when these states, together with the state of Mato Grosso, were bordering the process. The new expansion has privileged lands with different characteristics, thus tripling the areas of cultivation. The mills and industrial complexes have begun to organize themselves by validating the *Cerrado* as a center for the generation of commodities for export. Thus, it managed to aggregate a greater value for its products that, supported by the domestic market, has consolidated and grown continuously.

In the mid-2000s, there was a consistent substitution of annual crop areas, thus revealing intensive competition for land. This is in spite of the dominant political discourses which had indicated degraded pastures as a priority for the expansion of sugarcane.

During this time, the expansion of sugarcane cultivation areas has revealed an almost simultaneous process of agro industrial installation from the first plantations, which is manifested in strategic planning for this industry.

With this expansion of the sugar-energy sector, there has been a reorganization of land use in the south-central region of the *Cerrado*, particularly in the south of the state, although sugarcane has no significant participation in the cultivation area in the country, in the south-central region or even in Goiás. Thus, it is important to note that the territorialization of the sugar-energy sector is not only an agrarian control mechanism, but also a social one, which causes transformations in all spatial dynamics and organization.

The expansion of sugarcane agro-industry in Goiás is a phenomenon capable of promoting spatiality's and territorialities, in order to seek greater profitability and/or productivity stimulated by the use of new technologies and the intensification of land use distinguishing this expansion from the frontier of sugarcane production in the state.

Thus, the State of Goiás has become one of the main centers, of national prominence, for grain production and the attraction of agro-industrial capital. From a new pattern of agricultural development, Goiás has stood out in recent decades as a region that shows strong expansion in all its forms of production.

Over the last few years, the sugarcane agribusiness has undergone a strong expansion, having provided a symbol of progress and development of the state and the country it has a fundamental role in the Brazilian economy.

Despite the growth, however, there are few bibliographies, information and data on the changes that the insertion of this culture occurs in the environment and in the development of some cities, since this fact reduces the decision-making process and the creation of public policies oriented to the new reality of urban environments, which receive plants and can receive a large number of people with the migration of workers. Therefore, it is necessary to exercise some caution in the cost-benefit analysis regarding the implementation of sugarcane in a given region.

References

- Alves, L. Q., Franco, P. N., Zanetti, W. A. L., & Góes, B. C. (2021). Performance of sugarcane culture production in the main producing states. *Revista Brasileira de Engenharia de Biosistemas*, 15(2), 303-317. <https://doi.org/10.18011/bioeng2021v15n2p303-317>
- Bardalho, M. G. Da Silva, Silva, A. A., & Castro, S. S. de. (2013). A expansão da área de cultivo da cana-de-açúcar na região sul do estado de Goiás de 2001 a 2011. *Revista Brasileira de Ciências Ambientais*, 29, 98-110, São Paulo. Retrieved from http://rbciamb.com.br/index.php/Publicacoes_RBCIAMB/article/view/282
- Bittencourt, G. M., & Gomes, M. F. M. (2014). Fontes de crescimento da produção de cana-de-açúcar no Sudeste e centro-oeste do Brasil. *Redes*, 19(2), 182-201. <https://doi.org/10.17058/redes.v19i2.3173>
- Bray, S. C., Ferreira, E. R., & Ruas, D. G. G. (2000). *As polífitas da agroindústria canavieira e o PROÁLCOOL no Brasil*. Marília: Unesp – Marília- Publicações.
- Cardoso, B. O. (2013). *Avaliação da sustentabilidade de sistemas de produção da cana-de-açúcar no estado de São Paulo: uma proposta metodológica e de modelo conceitual*. (Dissertação de Mestrado). São Carlos: UFSCar. Retrieved from <https://repositorio.ufscar.br/handle/ufscar/7024>
- Castro, S. S. De., Abdala, K., Silva, A. A., & Bôrges, S. V. M. (2010). A expansão da cana-de-açúcar no cerrado e no estado de Goiás: elementos para uma análise espacial do processo. *Boletim Goiano de Geografia*, 30(1), 171-191. <https://doi.org/10.5216/bgg.V30i1.11203>
- CONAB. Companhia Nacional de Abastecimento. (2021). *Acompanhamento da safra brasileira de cana-de-açúcar*. v. 7 – Safra 2020/2021, n. 4 – Quarto levantamento, Brasília, pp. 1-57.
- Franco, I. O. (2014). Expansão da cana-de-açúcar na microrregião sudoeste de Goiás: análise espacial das mudanças do uso e cobertura do solo nos anos de 2001, 2006 e 2011. *Boletim Goiano de Geografia*, Goiânia, 34(3), 481-499. <https://doi.org/10.5216/bgg.v34i3.33860>
- Galvão, T. F., & Pereira, M. G. (2014). Revisões sistemáticas da literatura: passos para sua elaboração. *Epidemiol. Serv. Saúde*, 23(1), 183-184. <https://doi.org/10.5123/S1679-49742014000100018>
- IBGE – Instituto Brasileiro De Geografia e Estatística. Retrieved from <https://www.ibge.gov.br/>
- IMB – Instituto Mauro Borges De Estatísticas e Estudos Socioeconômicos. Retrieved from <https://www.imb.go.gov.br/>
- Keating, B. A., Robertson, M. J., Muchow, R. C., & Huth, N. I. (1999). Modelling sugarcane production systems I: development and performance of the sugarcane module. *Field Crops Research*, 61(3), 253-271. [https://doi.org/10.1016/S0378-4290\(98\)00167-1](https://doi.org/10.1016/S0378-4290(98)00167-1)
- Kohlhepp, G. (2010). Análise da situação da produção de etanol e biodiesel no Brasil. *Estudos Avançados*, 24(68), 223-253. <https://doi.org/10.1590/S0103-40142010000100017>
- Leite, R. C. C., & Leal, M. R. L. V. (2007). O biocombustível no Brasil. *Novos Estudos - CEBRAP*, 78, 15-21. <https://doi.org/10.1590/S0101-33002007000200003>
- Lucena, R. A. F., Demartelaere, A. C. F., Preston, H. A. F., Preston, W., Feitosa, S. Dos. S. F., Ferreira, A. Dos. S., ... Santos, J. J. M. Dos. (2020). Levantamento da estrutura do solo em função da colheita mecanizada em diferentes estádios da cana-de-açúcar em áreas de produção no município de Pureza-RN. *Brazilian Journal of Development*, 6(9), 64881-64892. <https://doi.org/10.34117/bjdv6n9-066>
- Matos, P. F. de, & Marafon, G. J. (2020). Dinâmica territorial do setor sucroenergético em Santa Vitória, Minas Gerais. *Revista Campo-Território*, 15(37), 1-18. <https://doi.org/10.14393/RCT153701>
- Mesquita, F. C. (2016). Evolução do aprendizado na expansão da cana-de-açúcar para Goiás: o papel dos centros de pesquisa. *Revista Campo-Território*, 11(22). <https://doi.org/10.14393/RCT112216>
- Mesquita, F. C., & Furtado, A. T. (2018). Globalização e relações territoriais na agricultura: particularidades na expansão da soja e da cana-de-açúcar no Estado de Goiás. *GEOgraphia*, 20(43), 71-85. <https://doi.org/10.22409/GEOgraphia2018.v20i43.a27212>
- Neves, P. D. M., & Mendonça, M. R. (2020). Expansão do agronegócio canavieiro no sul goiano e os efeitos na produção de alimento. *Confins. Revue Franco-brésilienne De Géographie*, 44. <https://doi.org/10.4000/confins.26199>

- Nocelli, R. C. F., Zambon, V., Silva, O. G. M. Da, & Morini, M. S. C. (2017). Histórico da cana-de-açúcar no Brasil: contribuições e importância econômica. In C. S. Fontanetti, & O. C. Bueno (Eds.), *Cana-de-açúcar e seus impactos: uma visão acadêmica* (Canal 6, p. 275, 2017). Bauru, SP.
- Pereira, L. A. G., & Barreto, J. B. (2020). Geografia das exportações de açúcar e de etanol no estado de Minas Gerais. *Revista Campo-Territorial*, 15(36), 230-258. <https://doi.org/10.14393/RCT153609>
- Ribeiro, N. V., Ferreira, L. G., & Ferreira, N. C. (2016). Avaliação da expansão do cultivo da cana-de-açúcar no bioma cerrado por meio de modelagem dinâmica da paisagem. *Revista Brasileira de Cartografia*, 68(1). Retrieved from <https://seer.ufu.br/index.php/revistabrasileiracartografia/article/view/44468>
- Rodrigues, D., & Ortiz, L. (2006). *Em direção à sustentabilidade da produção de etanol de cana-de-açúcar no Brasil*. Porto Alegre: Núcleo Amigos da Terra, p. 37.
- Rodrigues, H. S. M. C., & Castro, S. S. (2018). A expansão da cana-de-açúcar e a aptidão agrícola das terras da microrregião do Vale do Rio dos Bois - GO. *Geografia*, 43(2), 237-253. <https://doi.org/10.5016/geografia.v43i2.13703>
- Silva, A. A., & Castro, S. S. (2015). Transformações no uso da terra e na estrutura de solos no Cerrado em áreas de expansão da cana-de-açúcar: o caso da microrregião de Quirinópolis, Goiás. *Ateliê Geográfico*, 9(2), 114-135. <http://doi.org/10.5216/bgg.v30i1.11203>
- Silva, A. A., & Miziara, F. (2011). Avanço do setor sucroalcooleiro e expansão da fronteira agrícola em Goiás. *Pesquisa Agropecuária Tropical*, 41(3), 399-407. Retrieved from <https://revistas.ufg.br/pat/article/view/11054>
- Silva, L. I. da, Leão, C., & Pasqualetto, A. (2015). Área de ocupação da cana-de-açúcar no estado de Goiás e o efeito substituído em relação a outras culturas de abastecimento alimentar (2003-2012). *Baru*, 1(1), 21-35. <https://doi.org/10.18224/baru.v1i1.4603>
- Stone, P. J., Sorensen, I. B., & Jamieson, P. D. (1999). Effect of soil temperature on phenology, canopy development, biomass and yield of maize in a cool-temperature climate. *Field Crops Research*, 63(2), 169-178. [https://doi.org/10.1016/S0378-4290\(99\)00033-7](https://doi.org/10.1016/S0378-4290(99)00033-7)
- Stupiello, J. P. (2005). A expansão canavieira no Brasil. In *II Simpósio de tecnologia de produção de cana-de-açúcar*. Piracicaba: Unipress Disc Records do Brasil, 2005. 1 CD-ROM.
- ÚNICA. União Da Indústria de Cana-de-Açúcar. Observatório da Cana. Retrieved from <https://observatoriodacana.com.br/>

Copyrights

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).