

Spatial organization and land use in Tocantins at the beginning of the 21st century

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Abstract

This article analyzes the spatial organization and land use in the state of Tocantins, between 2006 and 2017, from the regional analysis. Location and specialization indicators were used with the area in hectares occupied in different uses as a variable, according to the Agricultural Census. The results show that the spatial organization of land use in the state in the eastern part has been developing integration between nature and local populations. In the western part, agribusiness (livestock) is expanding. The soybean crop has emerged as an export-based product from Tocantins, and has steadily grown in the planted and harvested areas. The other comparisons including the next agricultural censuses will be able to trace the definitive trend of land use. Especially because, the regional analysis showed a tendency towards redistribution and restructuring that is not consolidated.

Keywords: Indicators. Regional analysis. Agribusiness. Brazil

INTRODUCTION

The State of Tocantins is going through a spatial occupation process revitalizing its economy, especially the agribusiness sector. The state had several occupation frontlines from gold discovery in the 18th century to traditional agricultural activity (19th and 20th centuries). The construction of the Belém-Brasília Highway (BR-153), in the 1950s, linked the future state of Tocantins to the productive national dynamics, demarcating the lands of the region and establishing the integration of northern Goiás to the national market, thus stimulating production agriculture (Oliveira, 2018a; Santos 2020).

Tocantins' agricultural potential is high, as 60% of the state's surface is arable land and more than 25% has production conditions if the technology already available is used. About 430 thousand hectares are used for agricultural activities, mainly in soybeans, fruits, sugarcane, corn, cotton and irrigated rice. Data from IBGE (2019) reveal that soybean, the main agricultural product, presented in 2018, 62% in the main temporary crops' participation in harvested area (Oliveira, 2018b).

According to Lima (2014), the transformations in Tocantins' agrarian organization, from the expansion of soy planting, have attracted modern farmers and hegemonic companies, motivated by land and logistical investments (Ferrovia Norte-Sul). The state's actions provide investments. The Campos Lindos Agricultural Project and the Cerrados Development Program ratify this progress. In the state there is an interest of political actors, businessmen and farmers in defining where the economic activity of agribusiness will be installed in the municipalities, and this is reinforced by the regional development discourse that emphasizes the idea that the activity brings economic growth, the better quality of life and creates better local social conditions.

Given this perspective, this paper's objective was to analyze land use evolution in the State of Tocantins for 2006 and 2017. This objective converges to the understanding of the problem proposed in this study to ascertain the change in land use structure from the political division of the state in 1988. In this sense, the following question arises: Was there a change in the spatial organization of land use in the early 21st century? The answer to this question will be useful for those responsible for land policy and the knowledge of the occupied space's metamorphoses. Therefore, this analysis applies the indicators of location and specialization to analyze changes in the organization of land use. The main limitation of these indicators is to establish cause and effect relationships. They demonstrate spatial trends or regularities in the movement to locate land uses. Thus, the results are not necessarily valid for the future but will indicate the location's situation in a given period. Therefore, they will be useful in regional planning, knowing the degree of concentration of the state's different land uses under analysis.

METHODOLOGY

Specialization and location measures were used to analyze the land use location pattern in Tocantins. These measures provide a framework for analyzing land use in micro-regions in relation to the state of Tocantins. These measures use the relative weight of land use, cancelling the "size" effect of the micro-regions. Regional analysis indicators will provide a relative measure of land use in a micro-region, comparing their "weight" or participation in the state of Tocantins. The different land uses were grouped as presented in the IBGE Agricultural Census (2006 and 2017). There were changes in the conceptual approaches between the Agricultural Census of 2006 and the 2017 Census; it was necessary to make adjustments in the nomenclature of the records in order to unify them: permanent crops, temporary crops, natural pastures, planted pastures, forests or natural forests, forests and/or planted forests, agroforestry systems. This information was organized in a matrix with the distribution of land use among the micro-regions, and the lines show the distribution of land use by mode of each of the micro-regions, T_{ij} = Area used in mode i of the micro-region, as shown in figure 01.

Land uses (ha)	← Estates j →		
Modality (i) ↑ ↓		↑	
		T_{ij}	$\sum_j T_{ij}$
		↓	
		$\sum_i T_{ij}$	$\sum_j \sum_i T_{ij}$

Figura 1. Matriz de Informações Geográfico-Espaciais do Uso das Terras. Fonte: Haddad, 1989; Alves (2012). Source: Haddad, 1989; Alves (2012).

From the information matrix, we have $\sum_j T_{ij}$ = Area used in mode i of all micro-regions; $\sum_i T_{ij}$ = Area used in all modalities of micro-region j ; $\sum_j \sum_i T_{ij}$ = Area used in all modalities in Tocantins. With this set of sums, measures of location and specialization are constructed. The first is the location or locational quotient (QL), which is expressed by equation (01):

$$QL_{ij} = \frac{T_{ij} / \sum_j T_{ij}}{\sum_i T_{ij} / \sum_i \sum_j T_{ij}}$$

The locational quotient can be analyzed from specific modalities or as a whole. When ≥ 1 the proportion of land used in the crop in a specific geographical unit is greater than the proportion of land used in that crop in the geographical reference unit. In addition, ≥ 1 demonstrates the importance of the micro-region in the regional context about the studied use.

In line with the QL, the redistribution coefficient (CRi) relates the percentage distribution of land use in the same modality over two periods. It examines whether a pattern of concentration or spatial dispersion is prevailing for the modality over time. Values close to 0 indicate that there will be no significant changes in the modality's spatial pattern of location. Values close to 01 indicate a significant redistribution—equation (02).

$$CR_i = \frac{\sum_j \left(\left| \frac{T_{ij}^{t1}}{\sum_j T_{ij}} - \frac{T_{ij}^{t2}}{\sum_j T_{ij}} \right| \right)}{2}$$

The location coefficient (CL) relates the percentage distribution of land use among the micro-regions with the percentage distribution of land use in Tocantins. Its calculation is expressed by equation (03):

$$CL = \frac{\sum_j \left(\left| \frac{T_{ij}}{\sum_j T_{ij}} \right| \right) - \left(\frac{\sum_i T_{ij}}{\sum_i \sum_j T_{ij}} \right)}{2}$$

If the location coefficient is equal to zero (0), the use mode *i* will be distributed regionally in the same way as the set of all modes. If the value is equal to (01), it will demonstrate that modality *i* has a more intense regional concentration pattern than the set of all modalities. Thus, results closer to 0 demonstrate a significant dispersion in land use. In contrast, values close to 01 show a significant concentration. For Ferrera de Lima et al. (2006) and Alves (2012) the QL, CL and CR_i indicate land use behaviour in space. The use of these indicators will allow the analysis of the location characteristics based on three elements: i) The location model. In this case, the degree of spatial concentration or dispersion; ii) The model of changes in spatial distributions in land use that are produced in pre-established periods; iii) The degree of spatial redistribution or the stability of the location that characterizes the uses.

The specialization coefficient (CEsp) is a regional measure, through which the land use modalities of a micro-region for Tocantins are compared. Results equal to 0 (zero), the micro-region has an identical composition in the use of Tocantins' lands. On the other hand, coefficients equal to or close to 01 demonstrate a high degree of specialization linked to a given use, that is, it has a land-use structure totally different from that of the state as a whole.

$$CEsp_j = \frac{\sum_i \left(\left| \frac{T_{ij}}{\sum_i T_{ij}} \right| \right) - \left(\frac{\sum_j T_{ij}}{\sum_i \sum_j T_{ij}} \right)}{2}$$

The restructuring coefficient (Cr), equation (05), relates the structure of land use in the region between two periods, base year 0 and year 01, intending to verify the degree of changes in the states' mode of use make up each region. Coefficients equal to zero (0) indicate no changes in the structure of land use in the state, and equal to one (01) demonstrates a very substantial restructuring.

$$Cr = \frac{\sum_i \left(\left| \frac{T_{ij}^{t1}}{\sum_i T_{ij}} \right| \right) - \left(\frac{T_{ij}^{t0}}{\sum_i T_{ij}} \right)}{2}$$

In the case of specialization and restructuring coefficients, they consider each state individually presenting its characteristics and behavior. In this case, they consider the regional effects of trends and types of location. In the case of the Restructuring Coefficient, it will provide elements on the structure of the rural space occupation, in this case, the degree of restructuring or structural stability for the periods under analysis.

Considering that IBGE (2017) reviewed the regional division of Brazil, in order to update the regional framework of the country, it is clear that Immediate Geographic Regions replaced the Micro-regions, therefore, until 2017 it is possible to analyze the data in Micro-regions, as of 2018 this regional division was no longer considered. Figure 02 shows the study area.

The State of Tocantins, created on October 5, 1988, considering the two western and eastern mesoregions and the eight micro-regions: Araguaína, Bico do Papagaio, Gurupi, Miracema do Tocantins, Rio Formoso, Dianópolis, Jalapão and Porto Nacional. It is subdivided into 139 municipalities according to the division adopted by IBGE (2020).

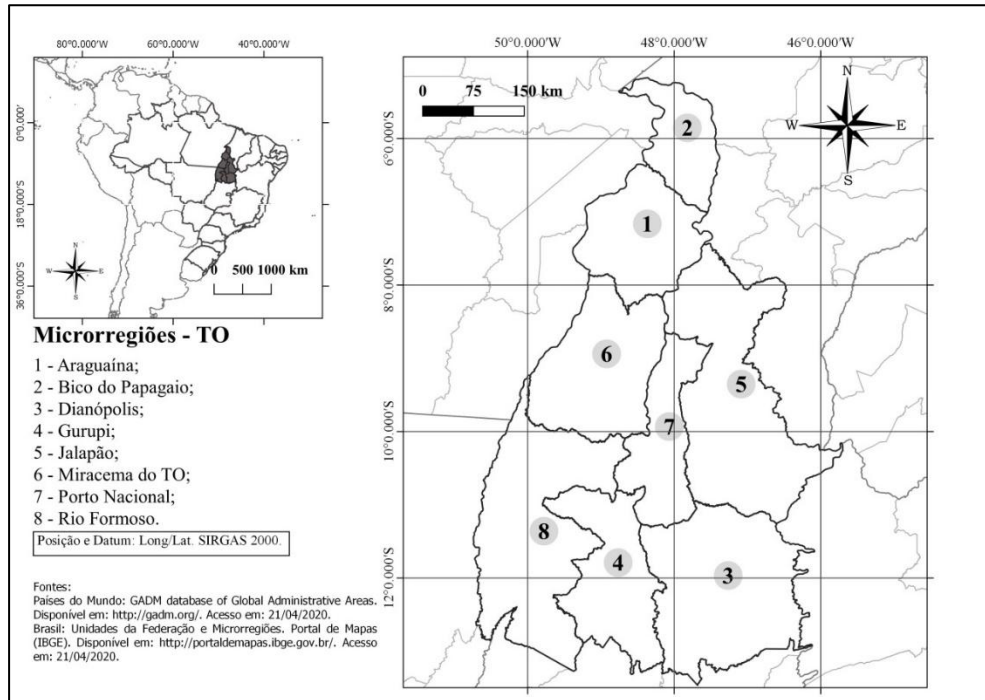


Figure 2. Location of the Study Area. Source: Authors based on - Map portal (IBGE / 2020)

1. RESULTS AND DISCUSSION

The factors that originate space organizations at different times can be identified from the study of the dynamics of land use. These patterns of use and occupation consist of the spatial expression of socioeconomic cycles, as seen in the state of Tocantins, from the mining cycle to agriculture. They also make it possible to understand the spatial organization dynamics resulting from social and economic structures and processes. This can be seen when analyzing the locational quotient of permanent crops, there was a reduction of this stratum in the micro-regions of Araguaína, Bico do Papagaio and Dianópolis, and an improvement in Gurupi and Porto Nacional. The only region that has a significant location for permanent crops in 2006 and managed to maintain this situation in 2017 was the Micro-region of Jalapão. However, despite being one of the regions with the worst socioeconomic indicators in Tocantins (Oliveira, 2019), it is a sparsely populated and which has, besides the Jalapão State Park, several sustainable production initiatives, on the other hand, already suffers the penetration of the advance of temporary crops, notably soybeans.

There is an expansion in the use of land from temporary farming in the micro-regions of Porto Nacional, Jalapão and Formoso do Araguaia, notably in the municipalities of Campos Lindos, Pedro Afonso, Porto Nacional, Formoso do Araguaia, and Lagoa da Confusão, concentrated in the production of soy, corn and rice. Tocantins has emerged on the national scene as a major grain producer. As part of the MATOPIBA region (interface region between the states of Maranhão, Tocantins, Piauí and Bahia), it is responsible for producing approximately 11% of the 115 million tons produced in the 2017/2018 harvest (Conab, 2020).

The amount of soy produced grew 204% between 2009 and 2018, while the planted area grew by 190% in the same period. To get an idea of the strength of soy in the state, we have data from the MDIC (2020), showing that in the first half of 2019 Tocantins exported the equivalent of US \$ 792.3 million, which is still a small share in the Brazilian exports, corresponds to only 0.8% of the country's exports, but that represents an increase of 38.2% in comparison with the same period of 2019. Since soy represents 76% of everything that the state sells abroad, followed by beef with 19%, the main buyer of Tocantins products is China. The proximity of the Jalapão micro-region to the other states that make up MATOPIBA has contributed to the development of grain production, especially soybeans. The region has received significant investments, in addition to research aimed at production under specific edaphoclimatic conditions (Da Cruz, 2018, p. 169).

Since soybeans were the main product of consolidated land use as temporary crops, there was a worsening in the location of this stratum in Bico do Papagaio, which together with Araguaína presented a weak location for 2017, the two micro-regions presented, simultaneously, a significant location for pastures planted in the two periods analyzed, about this region Da Cruz (2018) explains that agricultural production is low, that it does not have favorable geomorphological characteristics for agriculture, because of the high acidity of the soil, requiring the use of a lot of fertilization and nutrient correction, being suitable for cashew, citrus and pasture production.

In view of the need for correction presented by the author, it is hypothesized that this may be the reason for the region to indicate a significant locational quotient for pastures planted in 2006 and 2017.

On the other hand, Gurupi and Porto Nacional appear as an important location for the temporary crop stratum in 2017, the greater specialization of these two regions is evidenced by the presence of a Biodiesel company in Porto Nacional (Zuniga et al, 2015); on the processing capacity, both the companies of Porto Nacional: Granal, Indústria Comércio e Exportação S / A and Pioneer Sementes and a grain processing unit in the city of Cariri do Tocantins, belonging to the company Fazenda Agronegócio, process the grain with solvent, the latter still producing deactivated soybeans (Abiove, 2019). Figure 03 shows the location of land uses in the crop and pasture strata for the state, in the analyzed period.

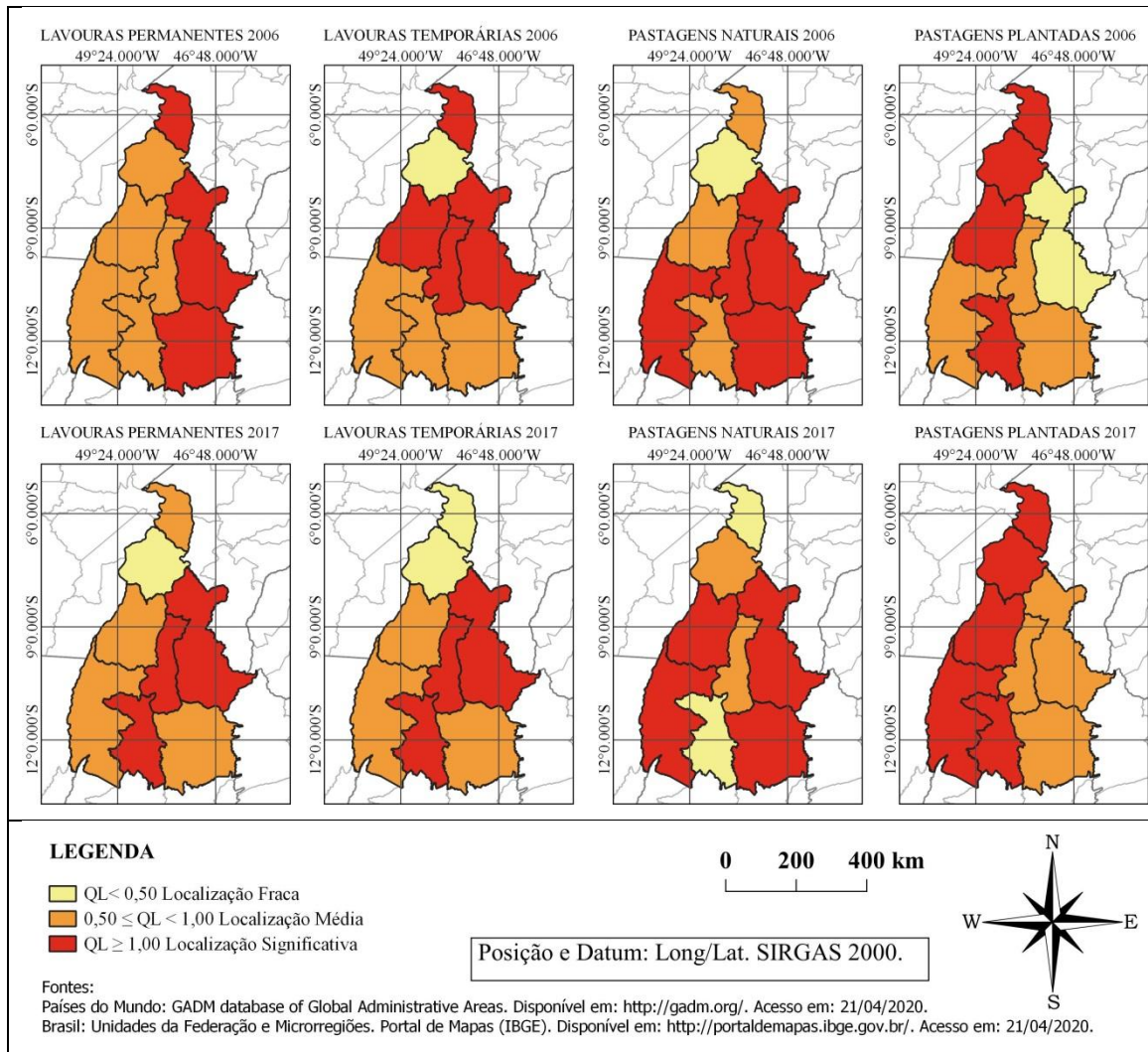


Figure 3. Locational Quotient (QL) of land use in Tocantins (2006 and 2017) Permanent and Temporary Crops, Natural and Planted Pastures. Source: Research Results based on - Portal de Mapa (2020)

Regarding pastures, all regions showed a specialization pattern at the end of the analyzed period in which they are either specialized in natural pastures or planted pastures, with regions specialized in both types of land use, such as Miracema and Rio Formoso. The exception to this pattern is the Micro-region of Porto Nacional, which even lost specialization in natural pastures at the beginning of the analyzed period, for reasons already discussed above, a case of increased specialization in another activity, even within the binomial agriculture/livestock.

There is an advance in the specialization of the strata of pastures planted in the western region of the state, bordering BR 153 and Rio Tocantins, presenting a corridor that may indicate pressure on areas of the Legal Amazon, confirming the current pattern of expansion of agribusiness from the cerrado to the Amazon rainforest. Contrary to the significant location of pastures planted in Tocantins' western region, there is an estimate of weak location for the stratum agroforestry systems, for the same region, which reinforces the hypothesis presented about the advance of livestock in the region.

Regarding the use of land for natural forests or forests, there is a pattern with few variations in the analyzed period, so that the Northwest portion of the state maintained its condition of average location (Bico do Papagaio, Araguaína and Miracema), and the South portion and the Southeast, presenting a significant location, certainly the low demographic density of the state, one

of the lowest in Brazil, 4.98 inhab / km² (IBGE, 2020), contributes to this condition, this does not mean that it has not advanced in land occupation (Figure 04).

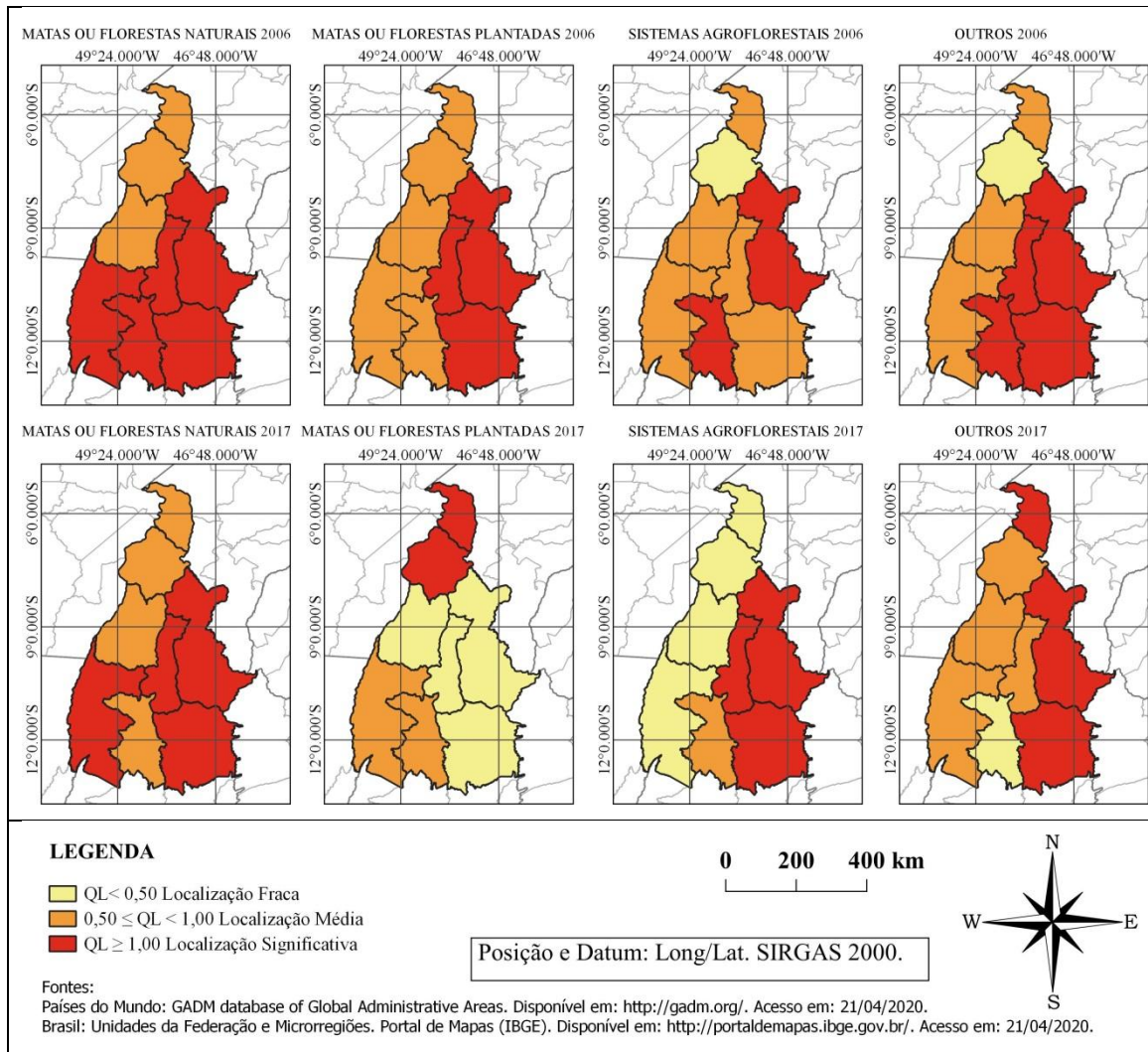


Figure 4. Locational quotient (QL) of land use in Tocantins (2006 and 2017) Natural and planted forests, agroforestry, and others. Source: Research Results based on - Portal de Mapa (2020)

The explanation that is presented is that there was an increase in land occupation, remember that the analyzed data are related to agricultural establishments and not to the total of the state. However, the low demographic density does not produce great pressure on natural forests and forests, allowing that part of the area can still be preserved, keeping the record of this stratum of land use with little variation.

Regarding the use of land for forests or planted forests, there are the biggest changes in terms of QL, Bico do Papagaio and Araguaína started to appear as a significant location in 2017, on the other hand, despite a small improvement in the micro-regions of Rio Formoso and Gurupi, all the others worsened the location for this land use, the explanation goes through the counterpoint of temporary farming, because when observing graphical representations for these two strata, there is an opposition in terms of location specialization, in 2017, possibly related to the soil characteristics discussed previously.

Investments in planted forests have some characteristics that differ considerably from agricultural crops in general, such as the occurrence of most of the costs of forestry operations developed until the cutting age is concentrated in the implantation of the crop, and the return occurs in only a few periods of many years after implantation. Such characteristics can reduce the attractiveness of these investments for producers not used to the productive forest chain (Gomes Junior, 2015, p. 85).

Regarding agroforestry systems, they are cultivated areas with forest species used both in agriculture and in livestock. This land use remained with a significant location in the two periods analyzed only in the Micro-region of Jalapão, since Porto Nacional and Dianópolis improved in 2017, all other micro-regions showed worsening in this type of land use. As it is less intensive than livestock or agriculture, this may have meant the loss of space in the period. Cunha et. al (2008) in his study on the progress of degradation in the cerrado, analyzing the relationship between agricultural exploitation and environmental degradation, identified that the Jorapão Microregion was the one that presented the lowest index of environmental degradation

among the 24 (twenty-four) analyzed. The explanation may lie in the fact that the region is the scene of several preservationist initiatives, seeking to adapt to the presence of local communities and environmental preservation (Oliveira, 2018b, Santos, 2020).

Finally, in the classification (Others), strata are less economically exploited, what calls attention is that these land uses are concentrated to the East of the State. The installation of public research institutions and agricultural development policies is of significant importance in this scenario. Research carried out by Embrapa Pesca e Aquicultura has contributed to productivity gains, mainly in areas that are not favorable to agriculture (Da Cruz, 2018).

Localization, Redistribution, Specialization and Restructuring of Land Use in Tocantins

The Location Coefficient shown in figure 05 showed a homogeneous distribution among land uses in Tocantins' micro-regions. The land use that had the greatest relative dispersion, presenting an intermediate concentration, was the planted forests and / or forests, which confirms the Locational Quotient results, concentrating these strata further to the North of the State in 2017. The most distributed stratum (values close to 0), were natural forests and / or forests.

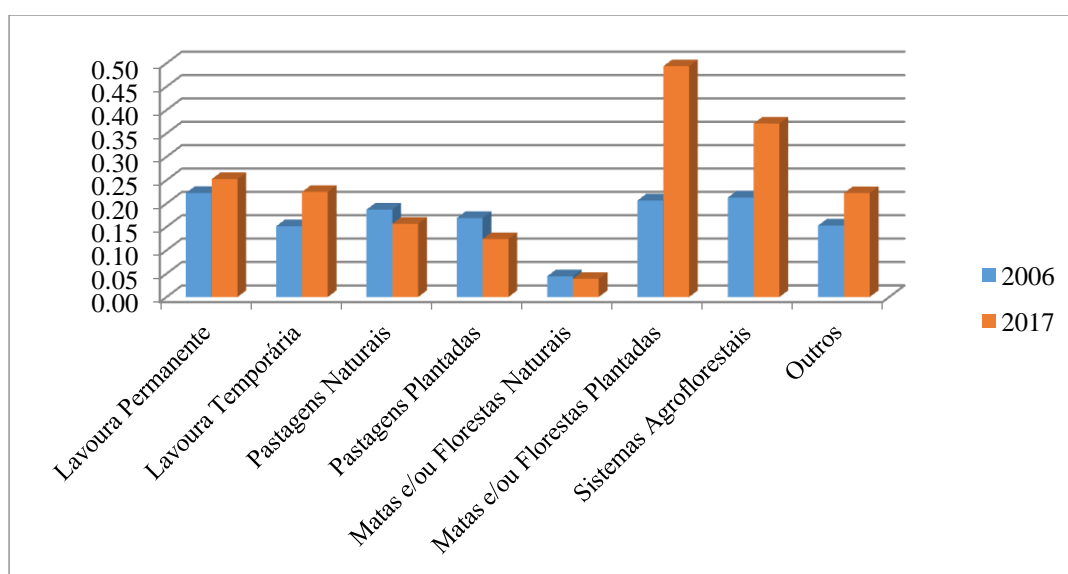


Figure 5. Location coefficient of land use in Tocantins (2006 and 2017). Source: Authors based on - Search Results.

By the pattern of the Location Coefficient, it argues that the crops, pastures, natural forests or forests and the land-use group grouped under the denomination (Others) presumably have a lower tendency to spatial concentration, that is, they are uses of land distributed regionally in a similar way, with pastures reinforcing this trend from 2006 to 2017. Already planted forests or forests and agroforestry systems tend to concentrate regionally, albeit in an intermediate way, because to be classified as concentrated the indicator must be close to the value 1 (hum), which is not the case. Graphically, the meaning of this concentration is evident, in the case of planted forests or forests, occurring in the micro-region of Araguaína and Bico do Papagaio, for agroforestry systems in the micro-regions of Dianópolis, Porto Nacional and Jalapão, as presented by the Locational Quotient.

Figure 06 shows the Spatial Redistribution Coefficient of land use in the State of Tocantins. There were no significant spatial changes in the redistribution of land uses among the micro-regions over the analyzed period, except for areas destined for planted forests or forests, which confirms the results previously discussed, being the only one that exceeded 50% of the possible value for the indicator.

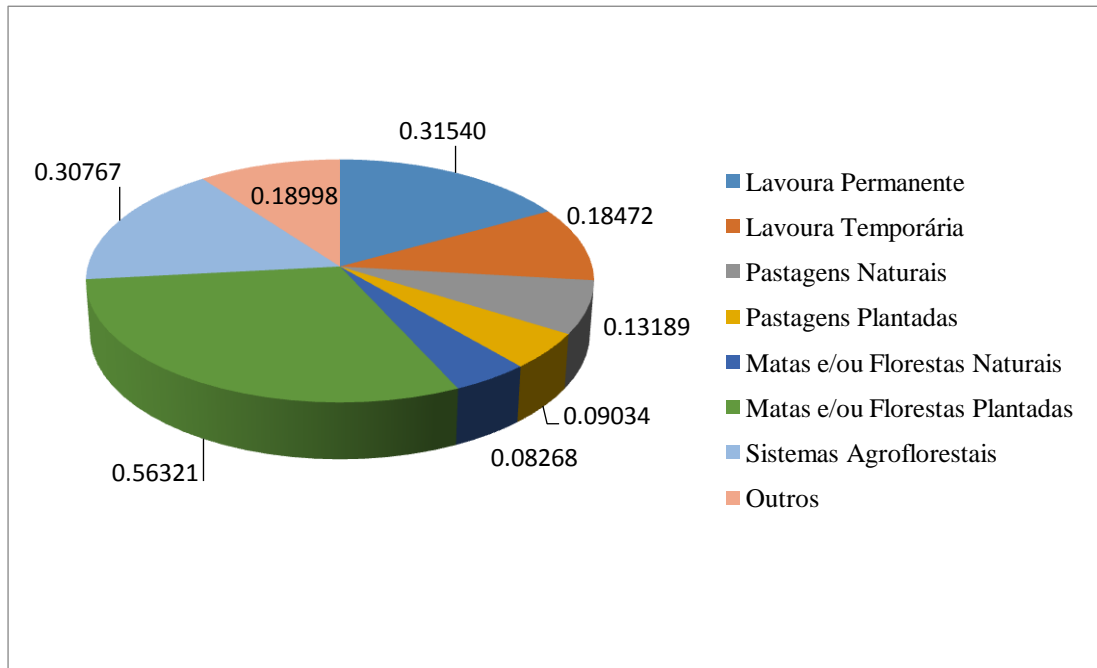


Figure 6. Land Use Redistribution Coefficient in Tocantins (2006 and 2017). Source: Authors based on - Search Results.

Corroborating the QL result, the micro-regions of Araguaína and Bico do Papagaio stand out with strong changes in this redistribution. In 2006, the two regions together had 7,781 hectares of the Forest or Planted Forest stratum, while in 2017 the area corresponded to 23,671 hectares.

Regarding the Restructuring Coefficient, (Figure 07) there were no significant changes in the state, even the micro-regions of Porto Nacional and Dianópolis presenting a restructuring coefficient slightly higher than the others. Therefore, there is no indication that there has been a significant change in the composition of land use in the micro-regions, which suggests that the productive structure in Tocantins is well defined, with agribusiness being the predominant economic bias, this is important to explain the direction of public policies, always focused on the economic fitness of the State (Oliveira, 2018a, Santos, 2020).

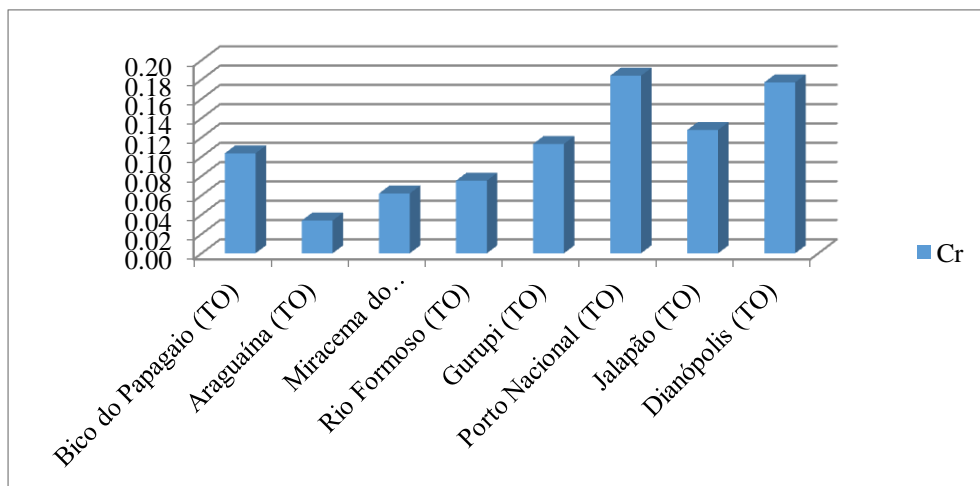


Figure 7. Restructuring coefficient of land use in Tocantins (2006 and 2017). Source: Authors based on - Search Results.

The Southeast region of Tocantins is under the influence of the tropical altitude climate and the lowest rainfall in the state (1200 mm), resulting in lower livestock yields and greater restrictions on rainfed agriculture (Sefaz, 2016). The Dianópolis region has a significant location for the planted pasture strata, which leads to thinking of a livestock economy, thus explaining what may be one reason for the existence of municipalities with incipient economies precarious social indicators in the region.

Figure 08 refers to the Specialization Coefficient and points to a homogeneous behavior between land uses in the micro-regions compared to the reference area. Therefore, there are no regions with specializations other than the specialization of the reference macro-region. If Tocantins has an aptitude for agribusiness, the hypothesis presented is that its micro-regions will have this economic base as a guiding element of their land uses.

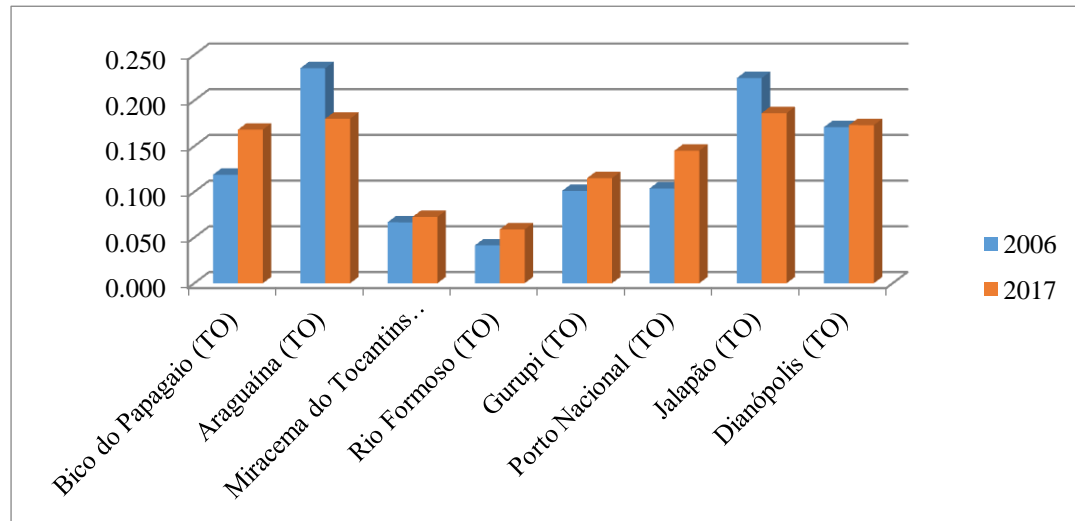


Figure 8. Coefficient of Specialization of land use in Tocantins (2006 and 2017). Source: Authors based on - Search Results.

Since the specialization of any micro-region is not significant, differently from the state, as previously discussed, it is clear that some regions such as Araguaína and Jalapão further reinforced this character of hegemony in 2017.

Yokoyama and Igreja (1992) point out that there have been major changes in the Brazilian land composition, the vector of this transformation being the technological advance, replacing those agricultural products of lesser value with others of greater return per unit area, such as soy. This dynamic is observed in peripheral regions that are in a period of development with economic, demographic and investment changes, as a result of government policies (Church, 2001). "With regard to agrarian dynamics, this process is evidenced by the growth in the number of establishments and the area occupied by agricultural cultivation" (Dal Pai; Ferreira De Lima, 2014, p. 165).

For Da Cruz (2018), agriculture in Tocantins has developed over the years due to improvements in productivity and expansion of area, associated with other factors such as: improvement in transport logistics, expansion of research for production in cerrado areas, increased use of technologies and increased species more adapted to edaphoclimatic conditions. Thus, the changes that occurred in Brazilian territory are also observed in the territory of Tocantins, since the state is linked to the global economy, being part of a regional, national and global network of commodity production for the local and the global.

FINAL CONSIDERATIONS

The article analyzed the spatial organization and land use in Tocantins from 2006 to 2017, using the state's micro-regions. Regional analysis indicators were estimated based on hectares of agricultural establishments for the different land uses defined by IBGE, after making some methodological adjustments. And he used other sources to discuss the central role that temporary farming, notable soybean, plays in this scenario.

The specialization coefficient showed a low value (0.25), which suggests a homogeneous behavior in the allocation of land uses in the micro-regions, different from the reference region. There was also significant locational importance of agroforestry systems in the state's eastern region, where various experiences of integrating nature and local populations have been developed.

In contrast, the western portion of the state presents results compatible with an expansion of agribusiness, especially planted pastures, a fact that would be related to the expansion of livestock, since beef is the second product of the state's export base. The indicators of location, redistribution, restructuring, and specialization presented values well below the unit.

This similarity in the dynamics of land occupation is the result of targeted institutional policies, with the use of technologies as a determining vector. The soybean crop has emerged as an export-based product from Tocantins, and has steadily grown in the planted and harvested areas, it is a fact that there are several criticisms about the income distribution potential of this type of economic base, but it is clear that the growth of the importance of agribusiness in the micro-regions is in agreement with the economic fitness of the State of Tocantins. The other comparisons, including the next agricultural censuses, will be able to trace the definitive trend of land use. Mostly because the regional analysis showed a tendency towards redistribution and restructuring that is not consolidated.

Therefore, it is recommended that both federal and state governments, by means of public policies for the agricultural sector, invest in infrastructure for the flow of production, in new modes, such as Hidrovia and Ferrovia Norte-Sul, which a reality put and irreversible; continue supporting new research for agriculture, mainly soybeans, the flagship of exports from Tocantins and Brazil. There is a need for interconnections of the state highways in Tocantins, connecting the main highway, BR-153, which constitutes Tocantins' artery, facilitating the movement and flow of production to the center-south and north of the country.

It is also recommended to install new grain processing units and expand the storage of agricultural production. They were empowering farmers through extension activities; financing for the acquisition of new machinery and agricultural implements. In addition to these recommendations for Tocantins' agribusiness, the state must strengthen and consolidate agrarian reform projects, and continue to finance family farming, since small producers have an essential role in the production of food for their subsistence and for the local market.

It can be concluded that the use of land for agribusiness activities in Tocantins is in the process of consolidation, as well as its economy. To consolidate agribusiness in Tocantins, still within the recommendations, the organization of producers in a cooperative, agroindustry installation becomes essential. The state must break the barriers of deficiency in the segment of logistics and storage so that it can consolidate this activity. This study does not exhaust the theme discussed here, it suggests for future research other states to be analyzed and that it includes other indicators of the regional analysis. Study on the reduction of labor in the field, observed in the last decades, due to the strong mechanization that this sector has been going through.

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