CADERNO DE CIÊNCIAS AGRÁRIAS
Agrarian Sciences Journal

The spatial dynamics of agriculture in Brazil in 2008 and 2018

Marcio Aloisio da Silva Júnior[1]*; Patrícia de Siqueira Ramos[2]; Lincoln Frias[3]

DOI: https://doi.org/10.35699/2447-6218.2021.35385

Abstract

Given the great influence of agriculture on Brazilian society and economy, it is important to understand the spatial dynamics of different agricultural cultures as a way to identify strategic producing regions, a key information for the development of public policies. Therefore, the purpose of this work is to carry out, through the exploratory analysis of spatial data, a comparative analysis of the spatial dependence of the production of different crops in Brazil, in the years 2008 and 2018. This is done using data from the Municipal Agricultural Production (PAM) by the Brazilian Institute of Geography and Statistics (IBGE) and focusing on the 12 crops with the highest total production values in 2018 (cotton, rice, banana, coffee, sugarcane, beans, tobacco, orange, cassava, corn, soybeans and tomato). The comparative analysis of cultures evidenced the existence of four groups in relation to the spatial dynamics of the high-high groupings in the two years studied. The first group is formed by cultures (cotton, rice, coffee, sugarcane, orange and tobacco) that tend to be concentrated in specific areas of the territory and did not show relevant changes in the clusters between the years under study, while the second group includes crops that expanded their areas between the two years (beans, corn and soybeans). The third group is formed by crops with smaller clusters and more spaced apart among themselves (banana and tomato). Finally, cassava was not included in any of the groups due to its dispersed production throughout the territory and also because it suffered a reduction in some regions.

Keywords: Agricultural Zoning. Exploratory spatial data analysis. Moran's I.

A dinâmica espacial da agricultura no Brasil em 2008 e 2018

Resumo

Dada a grande influência da agricultura na sociedade e na economia brasileira, é importante compreender a dinâmica espacial de diferentes culturas agrícolas para identificar regiões produtoras estratégicas, servindo como subsídio para políticas públicas. Por isso, o objetivo deste trabalho é realizar, por meio da análise exploratória de dados espaciais, uma análise comparativa da dependência espacial da produção de diferentes culturas agrícolas no Brasil, nos anos de 2008 e 2018. São utilizados dados da Produção Agrícola Municipal (PAM) do IBGE, da qual foram selecionadas as 12 culturas com os maiores valores totais da produção em 2018 (algodão, arroz, banana, café, cana-de-açúcar, feijão, fumo, laranja, mandioca, milho, soja e tomate). A análise comparativa das culturas evidenciou a formação de quatro grupos, em relação à dinâmica espacial dos agrupamentos alto-alto nos dois anos estudados. O primeiro grupo é formado pelas culturas que tendem a se concentrar em áreas específicas do território e não apresentaram relevantes alterações nos agrupamentos (algodão, arroz, café, cana-de-açúcar, laranja e fumo), enquanto o segundo grupo engloba as culturas que expandiram suas áreas entre os dois anos (feijão, milho e soja). O terceiro grupo é formado por culturas que apresentaram agrupamentos com menores extensões e mais espaçados entre si (banana e tomate). Por fim, a mandioca não foi incluída em nenhum dos grupos por ter sua produção dispersa em todo o território e por apresentar redução nos agrupamentos em algumas regiões.

[1]Universidade Federal de Alfenas. Alfenas, MG. Brasil.
https://orcid.org/0000-0002-6707-5379
[2]Universidade Federal de Alfenas. Varginha, MG. Brasil.
https://orcid.org/0000-0003-4834-661X
[3]Universidade Federal de Alfenas. Varginha, MG. Brasil.
https://orcid.org/0000-0001-9474-6441
*Autor para correspondência: marcioaloisiojr@gmail.com

Recebido para publicação em 26 de Julho de 2021. Aceito para publicação 22 de novembro de 2021.
e-ISSN: 2447-6218 / ISSN: 2447-6218.

Palavras-chave: Análise exploratória de dados espaciais. I de Moran. Zoneamento agrícola.

Introduction

The influence and importance of agriculture in society comes from crop production for human and animal food and also from its participation in the economic development of countries and regions. The spatial distribution of agricultural crops in certain regions depends on climatic conditions, soil types, topography, among other factors, including those related to public policies (for example, agricultural zoning and agricultural insurance subsidies).

In Brazil, agriculture is one of the main agents of economic development. However, this sector has gone through a series of political changes since 1990, including greater external opening, market deregulation and new public policies for the sector. After that, the sector developed a more competitive structure, both internally and externally (PEROBELLI *et al.*, 2007).

The occurrence of unsatisfactory results in agricultural activity can cause damage to societies. Though, the development of agriculture contributed to reducing the risks of such results, since in addition to being assumed, such risks started to be quantified based on probabilistic calculations (SANTOS; MARTINS, 2016).

An important milestone for the sector in the country began in 1973 with the institution of the Agricultural Activity Guarantee Program (PROAGRO), which began its operations in 1975. The central aim of this initiative was to guarantee the activity of rural producers in cases where the costs invested in their projects were affected by adverse natural phenomena, given that the unpredictability of climate variability is one of the main risks to agricultural activity (CUNHA; ASSAD, 2001).

With the beginning of the Program, it became evident that PROAGRO would have to undergo serious structural and operational changes to maintain itself as an instrument of agricultural policy, given that it had a deficit history throughout its first 22 years of existence (ROSSETI, 2001).

As of the 1996 harvest, the Program underwent important changes in its structure, the main one being the implementation of the Agricultural Zoning. With this, the Program started to be guided by new rules such as not covering the multiplicity of risks and encouraging the use of technologies, including climate risk zoning, the indicated cultivars and direct planting (CUNHA; ASSAD, 2001).

According to Almeida *et al.* (2008), the development of crops in space is heterogeneous as it depends on factors such as different production techniques, climatic conditions, soil types and topography. Furthermore, between different producing regions, the effect of interdependence manifests itself in different ways, including the spatial diffusion of phenomena that influence neighbors and the processes of spatial competition, whether in the expansion of the agricultural frontier or in the formation of agricultural belts.

Spatial analysis comprises a set of techniques capable of measuring properties and relationships according to the location of a given phenomenon. In general, it aims to incorporate space into the analysis (CÂMARA *et al.*, 2004).

The analysis of the dependency structure between the values observed in the different areas of the study is done by the so-called spatial autocorrelation function. It is called autocorrelation because it takes into account the correlation with the variable itself at a different point in space (ANDRADE *et al.*, 2007).

According to Almeida (2012), positive spatial autocorrelation indicates that, in general, regions that present high values for the variable of interest tend to have around them regions that also present high values for this variable (high-high type regions) or that regions with low values tend to be surrounded by regions that also have low values (low-low). On the other hand, negative spatial autocorrelation indicates the dissimilarity between the values of the variable of interest and its location (high-low or low-high).

The purpose of this paper is to carry out, through the exploratory analysis of spatial data, a comparative analysis of the spatial dependence of the production of different crops in Brazil, in the years 2008 and 2018. The remainder of this paper is organized as follows. The next section presents the dataset and the methods in exploratory spatial data analysis. Section 3 contains a description and a discussion of the main findings from the exploratory and spatial analysis. Finally, some conclusions are presented in Section 4.

Material e methods

The present work uses data from the Municipal Agricultural Production of the Brazilian Institute of Geography and Statistics (IBGE), which presents information on 31 crops from temporary crops and 33 crops from permanent crops (IBGE, 2019). The 12 crops with the highest total production values in Brazil, in reais, in 2018 were selected. The Python programming language was used to process the data and apply the methods.

The selected crops are presented in Table 1, ordered according to the total production value in 2018. In addition to this value, the total quantities produced, in tons, in 2008 and 2018 are also present in the table.

Table 1 – Total quantities produced and total values of production of agricultural crops ordered according to the total value of production in the year 2018

crop	total quantity produced[1]		total production value[2]
	2008	2018	2018
Soybeans	59,833,105	117,887,672	127,549,867
Sugarcane	645,300,182	746,828,157	52,238,542
Corn (in grain)	58,933,347	82,288,298	37,644,731
Coffee (in grain total)	2,796,927	3,556,638	22,623,368
Cotton (seed)	3,983,181	4,956,044	12,790,580
Cassava	26,703,039	17,644,733	9,718,965
Orange	18,538,084	16,713,534	9,450,570
Rice (in paddy)	12,061,465	11,749,192	8,650,626
Banana (in bunch)	6,998,150	6,752,171	6,975,536
Tobacco (in leaf)	851,058	762,266	6,510,625
Beans (in grain)	3,416,194	2,915,030	5,693,442
Tomato	3,867,655	4,110,242	5,088,543

[1] Total quantity produced in tons
[2] Total production value in reais in 2018.

To compare the quantities produced by the municipalities in 2008 and 2018, thematic maps constructed according to four ranges of values obtained by the Fisher-Jenks method were used, a method in which the variance within the class is minimized while maximizing the variance between classes. The municipalities that did not present production in the year in question were disregarded. In order to establish a direct comparison between the maps, such intervals were obtained for each crop according to the year 2018, applying this division also to the 2008 data.

The spatial weighting matrix is used as a criterion for its definition of the neighborhood relationship between the municipalities. The contiguity convention adopted was the queen convention, and the normalization of the weighting matrix in relation to the lines was also performed.

Results and discussion

Figure 1 shows the participation of regions in the country in the production of each crop as a percentage, in order to illustrate the proportion of the quantity produced by these regions in 2008 and 2018. It can be seen that certain crops presented most of their products in specific regions of the country, such as cotton in the Midwest, rice and tobacco in the South and coffee, sugarcane and orange in the Southeast. It should be noted that since these are percentage values of the totals produced, changes in the absolute values presented in Table 1 must also be taken into account.

Subsequently, summary measures were obtained on the amount produced (in tons) of Brazilian municipalities. Again, for each agricultural crop, the municipalities that did not have production in the years under study were disregarded. Thus, Table 2 presents the number of producing municipalities and the sample means, minimum values, maximum values and the quartiles of the distribution of production by municipality for each of the selected crops.

It is observed in Table 2 that corn, beans and cassava had the largest number of producing municipalities (over 4,700 municipalities), while the lowest numbers were observed for cotton and tobacco (722 and 925). Data for 2018 are presented in Table 3.

Comparing the statistics between 2008 and 2018, it can be highlighted that, between the years, the five crops with the highest number of producing municipalities in 2008 also had the highest values in the year 2018. However, with the exception of corn, there were changes in the ordering of the numbers of producing municipalities. Regarding the smaller numbers of producers, in addition to the fact that cotton and tobacco crops also presented the lowest values in 2018, these values were even lower than at the beginning of the comparison.

Figure 1 – Percentage of the amount produced, in tons, of crops in each region of the country in 2008 and 2018

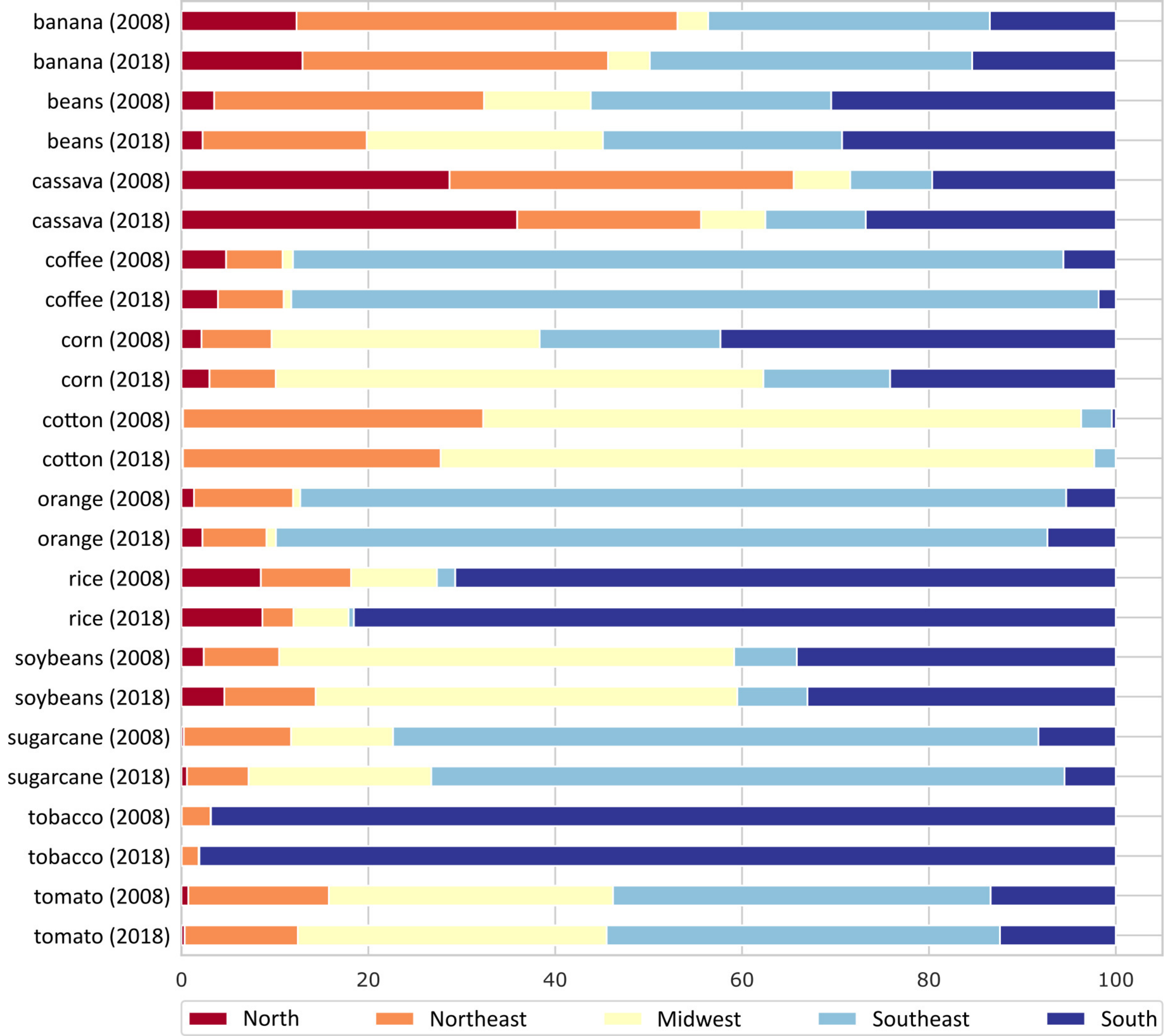


Table 2 – Summary measures of the quantity produced, in tons, of selected agricultural crops in 2008

Crop	n	$\bar{x}$	Min.	q1(25%)	q2(50%)	q3(75%)	Max.
Banana	3,494	2,002.90	2.00	80.00	220.00	834.50	158,400.00
Bean	4,741	730.06	1.00	44.00	136.00	450.00	123,840.00
Cassava	4,726	5,650.24	6.00	400.00	1,362.50	4,477.50	592,000.00
Coffee	1,838	1,521.72	1.00	22.00	124.00	913.75	40,315.00
Corn	5,322	11,073.53	1.00	349.25	1,536.00	7,732.50	997,440.00
Cotton	722	5,516.87	1.00	12.00	54.00	360.00	534,342.00
Orange	3,028	6,122.22	1.00	52.00	165.00	700.00	556,160.00
Rice	3,417	3,529.84	1.00	28.00	148.00	945.00	650,642.00
Soybeans	1,83	32,695.69	1.00	1,024.50	6,240.00	26,415.00	1,794,000.00
Sugarcane	3,727	173,141.99	2.00	834.00	3,600.00	44,730.00	10,260,000.00
Tobacco	925	920.06	1.00	19.00	104.00	612.00	23,650.00
Tomato	1,903	2,032.40	3.00	60.00	200.00	800.00	239,400.00

Table 3 – Summary measures of the quantity produced, in tons, of selected agricultural crops in 2018

Crop	n	$\bar{x}$	Min.	q1(25%)	q2(50%)	q3(75%)	Max.
Banana	3,399	1,986.52	1.00	51.00	160.00	748.00	210,975.00
Bean	4,33	673.22	1.00	24.00	84.00	298.00	63,870.00
Cassava	4,73	3,730.39	1.00	170.00	607.50	2,280.00	373,809.00
Coffe	1,448	2,456.24	1.00	16.00	135.00	1,616.25	82,830.00
Corn	5,069	16,233.64	1.00	185.00	1,108.00	6,840.00	2,851,200.00
Cotton	223	22,224.41	1.00	14.00	390.00	10,482.50	756,891.00
Orange	2,42	6,906.42	1.00	40.00	155.00	902.50	510,000.00
Rice	1,925	6,103.48	1.00	10.00	78.00	720.00	755,486.00
Soybeans	2,318	50,857.49	2.00	1,800.00	10,800.00	43,557.50	2,232,000.00
Sugarcane	3,345	223,267.01	2.00	420.00	1,800.00	75,000.00	8,118,000.00
Tobacco	651	1,170.92	1.00	20.00	110.00	690.50	26,790.00
Tomato	1,788	2,298.79	4.00	58.00	172.50	800.00	356,000.00

In general, it is noted that, between 2008 and 2018, cotton, rice, coffee, sugarcane, tobacco and orange crops had a reduction in the number of producing municipalities, while their average quantities produced increased. On the other hand, the cassava crop had a greater number of producing municipalities and a reduction in the average amount produced in 2018. Corn and tomato crops had higher averages in the last year and a reduction in the number of producing municipalities. In 2018, banana and bean crops presented smaller numbers of producing municipalities and smaller average quantities produced, while soybeans suffered the opposite movement. In both years, there is a large discrepancy between the mean ($\bar{x}$) and median (q2) values for all cultures, indicating that the mean value is highly influenced by high values. This is an early indication that some municipalities have much higher production than others, concentrating most of the production.

To identify the existence or absence of spatial autocorrelation in cultures, the global Moran statistic was used as a first step. The significance of such values was verified by means of the random permutation test, with their respective pseudo-probability values present in the p-value columns of Table 4. The cultures were sorted in descending order, according to the statistical values in 2008.

At a significance level of 5%, all cultures showed spatial autocorrelation in both years, which indicates that the amount produced is spatially autocorrelated in Brazilian municipalities. In addition to that, given the positive signs of the statistics, there is evidence that municipalities with quantities produced above the average tend to be neighbors of municipalities with quantities produced above the average and municipalities with quantities produced below the average, in general, are also neighbors of municipalities with quantities below average. It should be reminded that the closer to 1 the value of the culture statistics, the greater its spatial concentration.

Among the changes in the value of the statistics between the two years, there is an increase in the value for the crops coffee, sugar cane, beans, cassava and corn, and the reduction in the spatial concentration for the crops cotton, rice, banana, tobacco, orange, soybeans and tomato. Here, it is worth noting that the tomato crop had the lowest global spatial autocorrelation statistic in the two years analyzed, having even decreased in 2018.

With these results in hand, a more detailed analysis of the location of spatial regimes in each of the cultures was carried out using thematic maps and LISA maps (local indicators of spatial association). Thus, it was possible to identify the location of spatial clusters and spatial outliers.

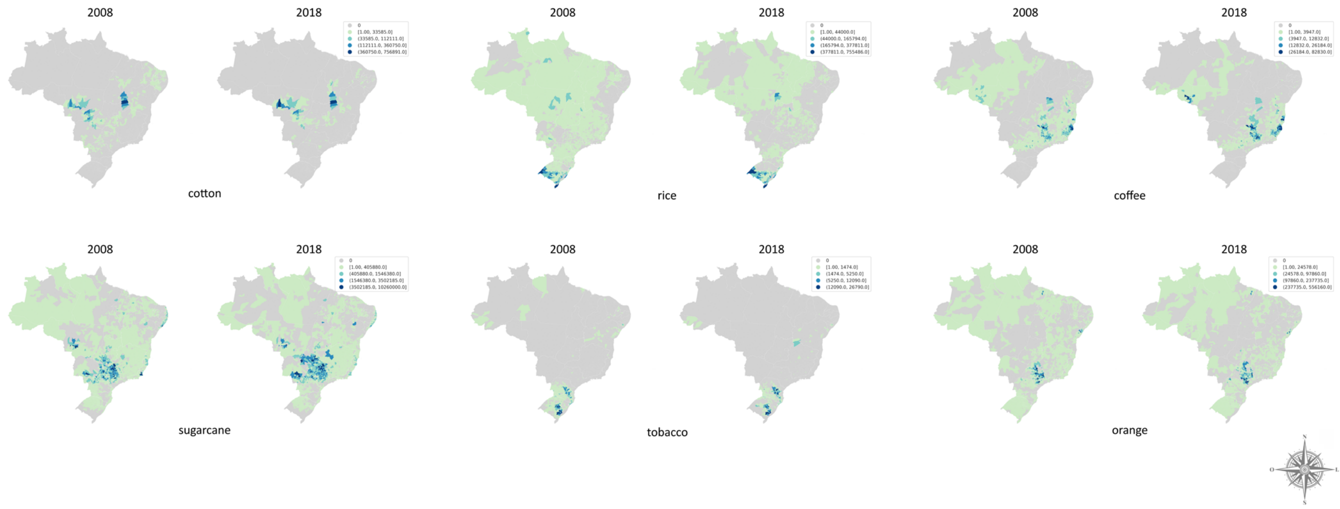
Through the data already presented and the comparison of maps prepared for each of the cultures, it is possible to consider the existence of four groups of cultures according to their spatial dynamics between 2008 and 2018.

The first group is formed by cultures that tend to be concentrated in a few areas, namely: cotton, rice, coffee, sugar cane, orange and tobacco. Such cultures were initially identified by the predominant participation of certain regions in the total quantities produced in the country. In addition, they showed similar behavior in relation to changes in summary measures between 2008 and 2018, namely the reduction in the number of producing municipalities and higher average quantities produced. The thematic maps of the cultures of this group are shown in Figure 2.

Table 4: Global Moran's I for crops in the years 2008 and 2018 and pseudo-p-values

Crops	2008		2018	
	Moran's I	**p-value**	**Moran's I**	**p-value**
Tobacco	0.614	0.001	0.511	0.001
Coffee	0.599	0.001	0.601	0.001
Sugarcane	0.599	0.001	0.621	0.001
Soybeans	0.546	0.001	0.540	0.001
Rice	0.536	0.001	0.498	0.001
Orange	0.501	0.001	0.418	0.001
Corn	0.489	0.001	0.545	0.001
Banana	0.341	0.001	0.281	0.001
Cassava	0.337	0.001	0.413	0.001
Bean	0.305	0.001	0.429	0.001
Cotton	0.266	0.001	0.252	0.001
Tomato	0.150	0.001	0.088	0.002

Figure 2 – Thematic maps of the cultures of the first group for the quantity produced, in tons, in the years 2008 and 2018



The thematic maps show that the municipalities with the largest quantities of crops produced are very concentrated in certain locations, in addition to the complete lack of production of these crops in certain regions of the country. In the case of cotton, municipalities with large quantities produced can be observed in the Center-West and Northeast of the country, while municipalities with the largest quantities of rice and tobacco produced were concentrated mainly in the South.

Coffee had the municipalities with the largest quantities produced in the Southeast region in both years. In the North region, such values were only observed in 2018, due to the increase in the amount produced in municipalities in the state of Rondônia. In the Southeast, the largest municipalities were also concentrated in terms of quantity produced for orange and sugarcane crops, especially in the state of São Paulo.

The LISA maps of the crops in the first group are shown in Figure 3.

The LISA maps of the crops in the first group show high-high clusters in certain locations in the country, but mainly around the municipalities with the largest quantities produced highlighted in the thematic maps. Between the two years, it is noted that the high-high groupings did not have major changes, with the exception of rice crop clusters located in the Midwest and North, which reduced their extension, and sugar cane, which expanded the extent of the cluster in the Southeast.

The second group of crops is formed by beans, corn and soybeans, which expanded their areas between 2008 and 2018 due to increased production in neighboring municipalities of areas that already were major producers and, consequently, the change or significance of their spatial regimes. The thematic maps of the cultures of the second group are shown in Figure 4.

Figure 3 – LISA maps of crops in the first group for the amount produced, in tons, in 2008 and 2018

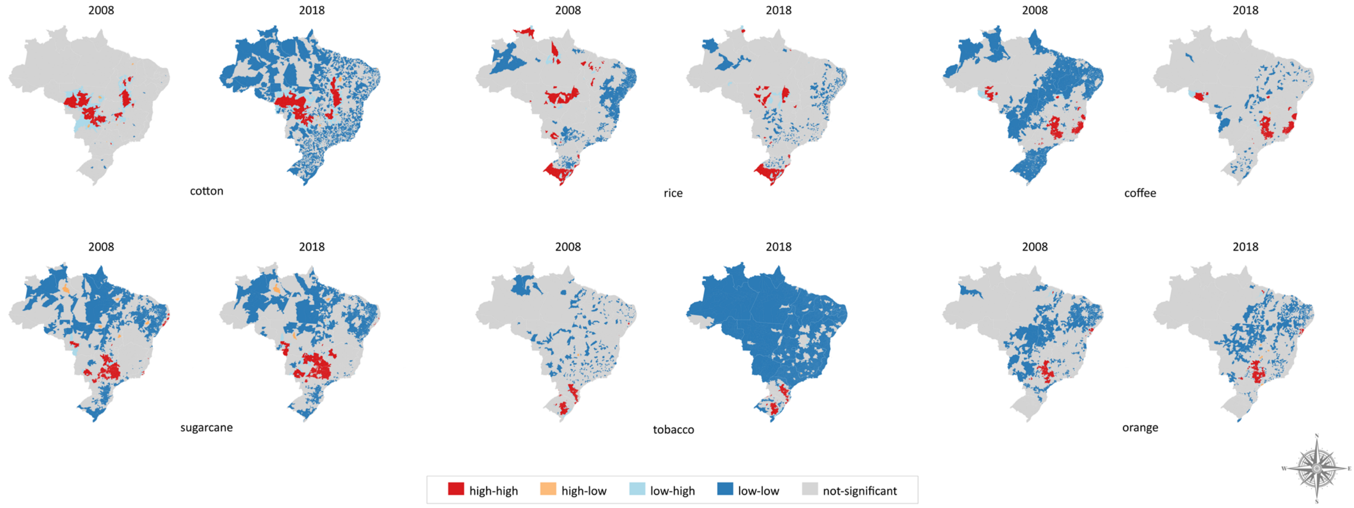
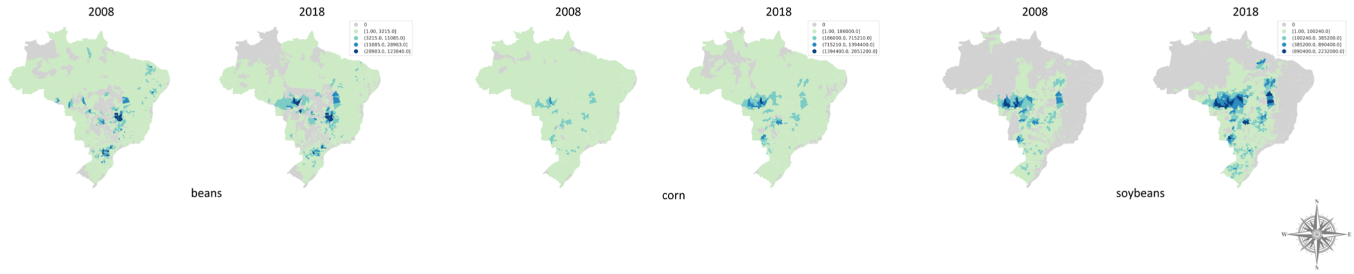
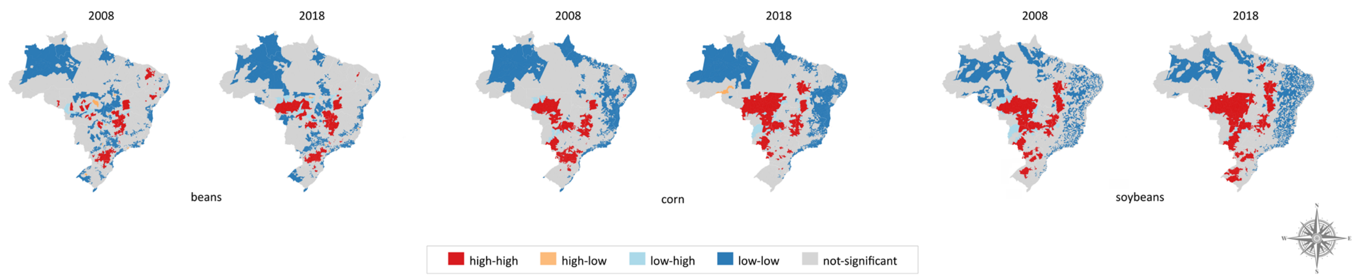


Figure 4 – Thematic maps of the cultures of the second group for the quantity produced, in tons, in the years 2008 and 2018



It can be noted on such maps that the municipalities that produce such crops occupy a greater extension of the territory, not limited to certain regions of the country. It is also observed that for the three crops in the group there was an increase in the amount produced in the vicinity of the municipalities that stood out in 2008. The LISA maps of the crops in the second group are shown in Figure 5.

Figure 5 – LISA maps of crops in the first group for the amount produced, in tons, in 2008 and 2018

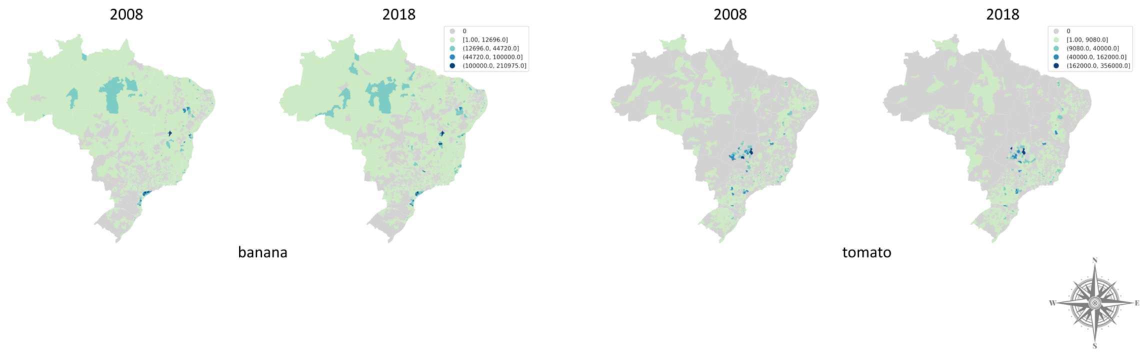


For the cultures of the second group, the expansion of high-high clusters is evident, especially in the Midwest region, and it is important to highlight the changes in the spatial regime of the municipalities from low-high to high-high. Such changes indicate an increase in the level of crop production for municipalities that in 2008 had their produced quantities considered to be different from neighboring municipalities. In addition to the change in the spatial regime, it is worth noting that such expansion was also due to the significance of the spatial regimes of municipalities that in 2008 were considered non-significant.

According to Trentin *et al.* (2018) there were important technological advances in the last 40 years that brought a significant evolution in agriculture, with emphasis on soybean, wich is the main crop in Brazil, standing out for its high production capacity and profitability.

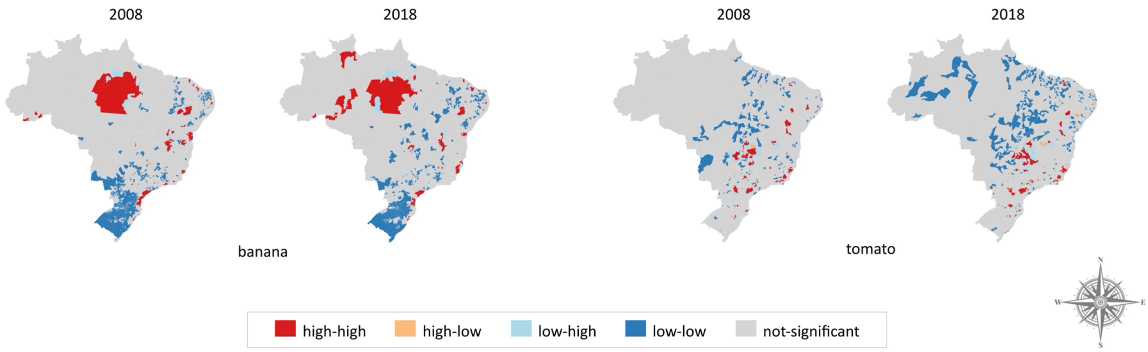
The third is formed by banana and tomato, and the thematic maps of such cultures are presented in Figure 6.

Figure 6 – Thematic maps of the cultures of the third group for the amount produced, in tons, in the years 2008 and 2018



These thematic maps show that the areas containing the municipalities with the largest quantities produced have smaller extensions and are more distant from each other. In 2018, there was an increase in the amount produced in some municipalities, while in others there was a reduction in the amount produced.

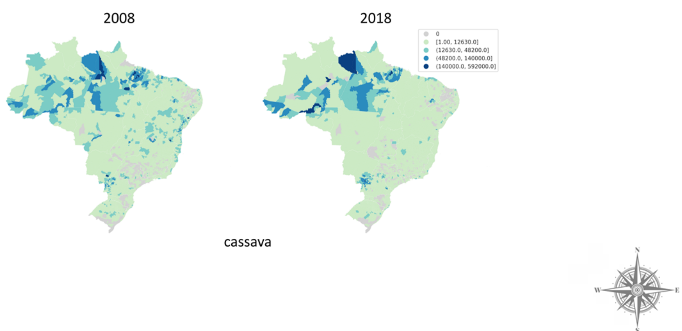
Figure 7 – LISA maps of crops in the third group for the amount produced, in tons, in 2008 and 2018



LISA maps also show the smaller extension and distance between the high-high clusters. In this sense, in relation to the banana crop, it is important to stress that the areas highlighted in the North region present greater extension due to the number of municipalities, but mainly due to their larger area in the region. In addition, the North region was responsible for only about 12% and 13% of the total produced in the country in 2008 and 2018, respectively, as shown in Figure 1.

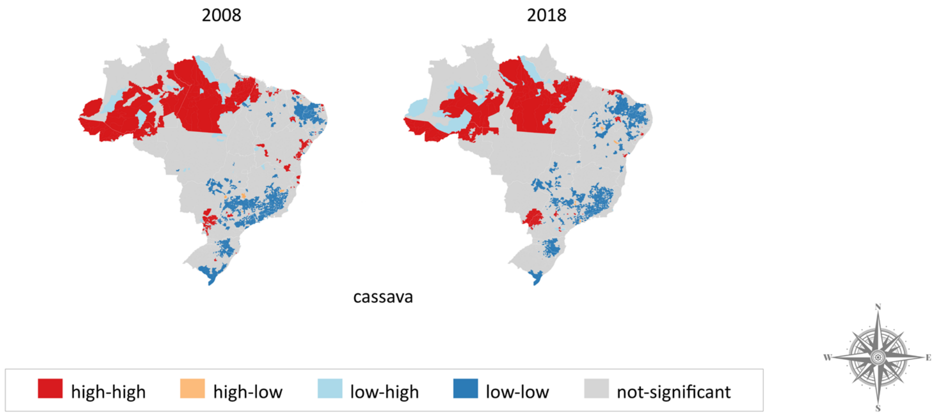
Finally, there is the cassava crop, which, as it does not have characteristics in common with the cultures of the other groups, will have its results presented individually. Its thematic maps are shown in Figure 8.

Figure 8 – Cassava thematic maps for the amount produced, in tons, in 2008 and 2018



The maps show that the municipalities producing cassava are found in almost the entire territory of the country, with a concentration of those with the largest quantities produced in the North region and between the South and Midwest of the country. Between 2008 and 2018, there was a reduction in the amount produced in the Northeast region due to the change in the first range of values in municipalities that in 2008 had higher production. Figure 9 shows the LISA maps for this crop.

Figure 9 – LISA maps of the cassava crop for the amount produced, in tons, in 2008 and 2018



Next, some considerations will be presented in order to identify possible explanations for the main changes observed in the cultures under study.

For rice, it was observed that between 2008 and 2018 there was an increase in the participation of the South region and a reduction in the Midwest and Northeast regions of the country, without major changes in the total quantity produced, which went from 12 tons to 11,7 tons in 2018, as shown in Table 1. To understand these changes, it is necessary to know the different methods of cultivation of the crop in the country.

Rice cultivation in Brazil takes place through two types of production systems: flood-irrigated and highland systems. The first of them is concentrated in the south of the country and in tropical floodplains, especially in the states of Rio Grande do Sul, Santa Catarina, Maranhão, Tocantins and Mato Grosso do Sul. In 2014, these states together accounted for around 85% of rice production in the country. The highland system, on the other hand, represents about 50% of the national area occupied by rice cultivation and is spread throughout the national territory (WANDER; SILVA, 2014).

The participation in the total supply of the highland system has decreased in recent years, as the areas occupied by the crop, mostly involving the states of Goiás, Distrito Federal, Mato Grosso and Tocantins, have given way to crops such as soybeans, corn and sugarcane (WANDER; SILVA, 2014).

As for the common bean crop, the increased share of production in the Midwest region may be related to the fact that it is considered an atypical crop, as it allows for three harvests to be obtained throughout the agricultural year. In the present work, the edible beans crop covers the total production of the three crops.

According to Silva and Wander (2013), concerning the first harvest, the South is traditional in the cultivation of the crop, occupying in the period 2006-2011 the first place in relation to area and production. Then come the Southeast, Midwest, Northeast and North. In relation to this kind of harvest, the authors stress that the Midwest had the highest national productivity among the regions, with evidence that producers have improved varieties of common beans, in addition to high technology.

Concerning the second harvest, in the same period, 2006-2011, there was a reduction in the planted area and, as a result, a reduction in production. However, there is an evolution in yield levels due to the adoption of technologies that enable greater productivity, especially in the states of Paraná, São Paulo, Minas Gerais and Goiás. According to the authors, the highlight of second crop production is also in the South region.

Finally, the third harvest comes from the possibility of using irrigation in times of low rainfall, in addition to the favorable altitudes of some regions, especially in the cerrado region. This harvest occurs mainly in the states of Goiás, Mato Grosso, Tocantins, northwestern Minas Gerais, Espírito Santo, São Paulo and part of Bahia. In the period from 2006 to 2011, significant advances in the level of productivity were observed nationwide, mainly due to increases in the Southeast and Center-West regions.

Thus, the presence and importance of the Southeast and Center-West regions for beans production in its three kinds of harvest should be mentioned, but mainly in the third one, which together with the high productivity of the region could be one of the reasons that justify the increase in its participation in the production of beans in the country between 2008 and 2018.

In the case of corn, which had an increase in the participation of the Center-West region and a reduction in the South and Southeast of the country, one of the possible explanations is presented by Souza *et al.* (2018). According to the authors, the shift over the last four decades of corn production from the South to the North of the country, especially to the Midwest, has been brought about by the increase in demand for the grain and by the availability of cheaper land. In addition, greater growth in terms of production has been observed in the Midwest. However, the South region stands out in terms of productivity.

Conclusion

The analysis of agricultural crops throughout the national territory made it possible to understand certain patterns of spatial association between different crop profiles in the years under study. Thus, were identified those regions that did not show major changes in the production of their municipalities, and also those that were influenced by, or influenced, their neighbors.

The comparative analysis between different cultures allowed the identification of cultures with similar characteristics, either by the concentration of municipalities in certain regions by the expansion of clusters observed from 2008 to 2018 or even by the extent and proximity between the clusters. Furthermore, the comparative analysis of different crops made it possible to analyze not only the effects of interdependence between regions in the same culture, but also the processes of spatial competition between different cultures.

The first group (cotton, rice, coffee, sugar cane, orange and tobacco) has crops that tend to be concentrated in specific areas of the country and did not present major changes between 2008 and 2018. The second group (beans, corn and soybean) has the crops that increased their area between the two years, whereas the third group (banana and tomato) contains those with smaller clusters and with clusters more spaced apart among themselves. In addition, the cassava crop was not included in any of the groups since it has producers throughout the national territory and it presented a reduction in high-high clusters in the North and Northeast regions and an increase in the South and Midwest of the country.

Finally, it should be noted that this paper is limited to the comparison of changes related to crops with greater economic value. Future studies could focus on different categories of cultures and analyze other meaningful variables, such as productivity, in order to enable the analysis of the sector's peculiarities from different points of view.

Financing

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001.

References

Almeida, E. Econometria Espacial Aplicada. Campinas: Alínea, 2012.

Almeida, E.; Perobelli, F.; Ferreira, P. Existe convergência espacial da produtividade agrícola no Brasil? Revista de Economia e Sociologia Rural, v. 46, n. 1, p. 31–52, 2008.

Andrade, A.; Monteiro, A.; Barcellos, C.; Lisboa, E.; Acosta, L. Almeida, M.; Brito, M.; Carvalho, M.; Santos, M.; Cruz, O.; Santos, R.; Flores, R.; Silva, S.; Santos, S.; Correia, V.; Souza, W. Introdução à estatística espacial para a saúde pública. Brasília: Ministério da Saúde, 2007.

Câmara, G.; Monteiro, A.; Fucks, S.; Carvalho, M. Análise espacial e geoprocessamento. In: Druks, S.; Carvalho, M.; Câmara, G.; Monteiro, A. (Ed.). Análise espacial de dados geográficos. Brasília: Embrapa, 2004.

Cunha, G.; Assad, E. Uma visão geral do número especial da RBA sobre zoneamento Agrícola no Brasil. Revista Brasileira de Agrometeorologia, v. 9, n. 3, p. 377–385, 2001.

Instituto Brasileiro de Geografia e Estatística, IBGE. 2019. Produção agrícola municipal. Sistema IBGE de Recuperação Automática - SIDRA, Tabela 5457, 2019. Disponível em: https://sidra.ibge.gov.br/tabela/5457.

Perobelli, F.; Almeida, E.; Alvim, M.; Ferreira, P. Produtividade do setor agrícola brasileiro (1991-2003): uma análise espacial. Nova Economia, v. 17, n.1, p. 65–91, 2007.

Rossetti, L. Zoneamento agrícola em aplicações de crédito e securidade rural no Brasil: aspectos atuariais e de política agrícola. Revista Brasileira de Agrometeorologia, v. 9, n. 3, p. 386–399, 2001.

Santos, W.; Martins, J. O zoneamento agrícola de risco climático e sua contribuição à agricultura brasileira. Revista de Política Agrícola, v. 25, n. 3, p. 73–94, 2016.

Silva, O.; Wander, A. O feijão-comum no Brasil: passado, presente e futuro. Embrapa Arroz e Feijão, 2013.

Souza, A.; Reis, J.; Raymundo, J.; Pinto, R. Estudo da produção de milho no Brasil. South American Development Society Journal, v. 4, n. 11, p. 182, 2018.

Trentin, R.; Modolo, A.; Vargas, T.; Campos, J.; Adami, P.; Baesso, M. Soybean productivity in rhodic hapludox compacted by the action of furrow openers. Acta Scientiarum. Agronomy, v. 40, p. 1-9, 2018.

Wander, A.; Silva, O. Rentabilidade da produção de arroz no Brasil. Embrapa Arroz e Feijão, In: Campos, S.; Torres, D.; Ponchio, A.; Barros, G., Sustentabilidade e sustentação de alimentos: o desafio da rentabilidade na produção. Brasília, DF: Centro de Gestão e Estudos Estratégicos, 2014.