


Permanences and changes in the production structure of agriculture in Parana, 2006-2017

Permanências e mudanças na estrutura produtiva da agropecuária paranaense, 2006-2017

Marina Silva da Cunha¹ 

¹Programa de Pós-graduação em Ciências Econômicas (PCE), Universidade Estadual de Maringá (UEM), Maringá (PR), Brasil.
E-mail: mscunha@uem.br

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Abstract: The objective of this work is to analyze the dynamics of changes in the productive structure of agriculture in the State of Paraná, based on information from the 2006 and 2017 Agricultural Censuses. Multivariate analyzes, factorial and cluster, were used to characterize temporal changes and spatial, considering twenty indicators of the modernization of agriculture associated with land use, technology and capitalization, labor and condition of the producer and establishments. The research results show significant transformations in agriculture in the State of Paraná, but still favoring the country's traditional trends, with expansion of agriculture for export and reduction of family farming, which still absorbs the largest share of occupation in rural areas.

Keywords: agricultural modernization, household farmers, factor analyse, Paraná.

Resumo: Este trabalho tem como objetivo analisar a dinâmica das mudanças na estrutura produtiva da agropecuária do Estado do Paraná a partir das informações dos Censos Agropecuários de 2006 e 2017. Foram utilizadas as análises multivariadas, fatorial e *cluster*, para caracterizar as mudanças temporais e espaciais, considerando vinte indicadores da modernização da agropecuária associados ao uso da terra, tecnificação e capitalização, mão de obra e condição do produtor e dos estabelecimentos. Os resultados da pesquisa evidenciam transformações significativas na agropecuária do Estado do Paraná, mas que ainda privilegiam as tradicionais tendências do país, com expansão da agropecuária voltada para exportação e redução da agricultura familiar, a qual ainda absorve a maior parcela da ocupação no meio rural.

Palavras-chave: modernização agropecuária, agricultura familiar, análise fatorial, Paraná.

1 Introduction

Since the last decades of the 20th century, technological intensification and changes in work relations in the countryside have been referred to as the modernization of agriculture. These transformations have had a number of impacts on Brazil's rural socio-economic dynamics, such as the consolidation of large-scale agricultural commodity production, the intensification of rural-urban migration and new ways of organizing production, consumption and occupation in rural areas (Mattei, 2015).

The rural population that is unable to keep up with technological innovations, especially in family farming, moves to urban centers, which do not have the necessary infrastructure to adequately cater for this migratory flow (Guanziroli & Caram, 2000). In fact, the proportion of the population living in urban poverty and extreme poverty increased between 1981 and 2005, although in rural areas these measures were reduced during this period (Cunha, 2017)¹.

¹ In urban areas, the proportion of extreme poverty varied from 0.148 to 0.156 from 1981 to 2005, while poverty increased from 0.352 to 0.369. In turn, in rural areas, while extreme poverty reduced from 0.397 to 0.309, poverty decreased from 0.715 to 0.625 (Cunha, 2017).



In rural areas, from 1992 to 2005, the reduction in poverty can be explained by the reduction in inequality and the growth in income, the main source of which was the increase in social security and pensions (Helfand et al., 2009). In turn, considering employment in the agricultural sector in relation to the total in the country, there was a reduction from 16.3% in 1995 to 8.2% in 2019 (Hoffmann & Jesus, 2020).

Following a national trend, the population residing in rural areas in Paraná has reduced according to information from the 2000 and 2010 Demographic Census, falling from 18.6% to 14.7%. Thus, despite the growth of the population of the State of Paraná from 9,563,458 to 10,444,526, in the first decade of the century, there was a reduction in rural areas from 1,777,374 to 1,531,834, indicating continuity of the urbanization process. At the beginning of the 21st century, the agricultural sector in the State of Paraná represented around 10% of value added, while in 2002 it reached 11.08%, in 2019, it corresponded to 8.4% of the total value. However, it is not possible to say that there is a downward trend in the economic importance of the sector, since this lowest value had already been obtained in 2006 (Instituto Paranaense de Desenvolvimento Econômico e Social, 2023). In fact, for Rolim (2011), since the mid-1970s, especially with the advent of frost that severely penalized coffee growing, there has been the formation of two Paraná's, one Agrobusiness and the other Urban, whose dynamics orbit around the agricultural and urban-industrial economic activities, respectively.

In the State of Paraná, the agricultural sector is also highlighted in foreign trade, with an increase above that recorded in the other segments in the export list. The state's exports, which in 2000 were equal to US\$4,379,504, in 2020 reached US\$16,255,783. Of this total, basic products, such as grains and meat, represented 37.94% at the beginning of the period and 55.65% at the end (Instituto Paranaense de Desenvolvimento Econômico e Social, 2022).

In this context, this work aims to analyze the changes in the productive structure of agriculture in Paraná from 2006 to 2017, based on information from the Agricultural Censuses of the Brazilian Institute of Geography and Statistics. Twenty indicators related to land structure, the use of technology and capitalization, land use, the condition of labor, producers and establishments were considered, using a multivariate approach, that is, factorial and group analyses.

Thus, the research aims to contribute to the identification of the heterogeneity of agricultural production structure in the municipalities of Paraná and its dynamics from 2006 to 2017, assisting in the formulation of more targeted public policies addressing local demands and fostering a more sustainable development process.

This study is organized into four sections, in addition to this introduction. The next section presents the theoretical and empirical framework to provide the foundation for the discussed theme. Section three introduces the selected indicators for the research, as well as the methods used. Subsequently, in the fourth section, the obtained results are presented and discussed. Finally, the last section is dedicated to concluding remarks.

2 Theoretical and Empirical Framework

In economic literature, the productive structure of a society would initially be based on rural areas or the primary sector. Subsequently, the secondary sector would play the biggest role, attracting capital and labor from the countryside. In turn, with economic growth, the tertiary sector would assume the role of absorbing the largest proportion of product, income and employment. In this process, the primary and secondary sectors would still maintain the expansion of their productive capacity through technological progress.

Although this decline in agriculture in national wealth is typical of the process of economic growth, it cannot be deduced that rural spaces are not relevant. In fact, the conventional functions of rural areas as suppliers of raw materials and labor for economic growth have become less important. However, in addition to their biodiversity, the forms of life in these places are increasingly valued, which represents a potential contribution to the development process (Abramovay, 2009).

In this context, the modernization of Brazilian agriculture is inserted based on intense transformations in rural areas, associated with accelerated urbanization and the expansion of the population in a more vulnerable situation, since the last decades of the 20th century. This modernization was also called painful by Graziano da Silva (1982), as it occurred slowly, with advances and retreats, without completely carrying out the expropriation of labor or the transformation of the production process and, for the most part, supported by the state.

The reduction in employment in rural areas is associated with three phenomena. The first phenomenon is the increase in pendular mobility, commuting between urban and rural areas for work. Another aspect is the change in family arrangements, particularly affecting women and children, who seek productive engagement outside of agriculture. Finally, a third factor is the shift from rural spaces to non-agricultural activities, such as leisure, tourism, environmental preservation, and hosting businesses (Mattei, 2015).

In the national empirical literature on the modernization of agriculture, one of the pioneering works is highlighted, namely Hoffmann (1992a). In this study, indicators of the modernization of Brazilian agriculture were analyzed, considering 157 homogeneous microregions with data from Agricultural Censuses in the years 1975 and 1980. The study successfully identified the intensity of the modernization process in the analyzed microregions.

There are also more recent studies characterizing these transformations in the Brazilian rural environment. Concha et al. (2013) analyzed changes in municipalities in Rio Grande do Sul based on information from the Agricultural Census of 2006 and the Demographic Census of 2010. Additionally, the study compared findings with Schneider & Waquil (2001), who had addressed the same theme but considered data from the Agricultural Census 1995/1996 and the Population Count of 1996. The results identified greater regional and productive diversity, highlighting the need for increased attention from public policies aimed at improving the living conditions of the rural population. The authors pointed out that the reduction in employment in rural areas and the pursuit of new opportunities in urban areas create pressure on the labor market and city infrastructure. Considering indicators for the year 1995/1996 and multivariate analyses, Cunha & Parré (2001) characterized agriculture in the Southern Region and highlighted significant spatial heterogeneities.

In the analysis of family farming, Guanzirolí et al. (2012), considering the Agricultural Censuses of 1995/96 and 2006, showed substantial heterogeneity among these farmers. They also emphasized the modest technical assistance received, ranging from 16.7% to 20.9% during this period. Despite the lower productivity of family farming compared to large-scale farming, the authors found intensive use of land due to its scarcity, being heavily exploited.

Pinto & Coronel (2015), using information from the Agricultural Census of 2006 for Rio Grande do Sul, constructed an Agricultural Modernization Index and observed that, despite low disparity between the analyzed mesoregions, the Southwest and Metropolitan regions had a higher inclination towards modernization. Lobão & Staduto (2020) also constructed an Agricultural Modernization Index with 2006 Census data for the Amazon region, identifying the northern and western regions with lower levels of modernization and the southern and eastern regions with better results.

In turn, using data from the Agricultural Censuses of 2006 and 2017, Silva et al. (2020) analyzed labor and land productivities in coffee cultivation in the state of Bahia. They observed a decline in the workforce and intensive use of capital and land, with significant differences in productivity among the Cerrado, Atlantic, and Plateau regions. Despite the reduction in employment, the authors highlighted the importance of family coffee farming, particularly in the Plateau region.

Lima et al. (2022) examined the modernization of agriculture in the Northeast region using information from the 2017 Agricultural Census. Similarly, they created an Agricultural Modernization Index, indicating that approximately 88.4% of the analyzed municipalities had low agricultural propensity. Considering the latest Census, Batista et al. (2023) analyzed agricultural modernization in the MATOPIBA region and identified better performance in Tocantins and Maranhão compared to Piauí and Bahia. Alcantara & Bacha (2023) conducted an analysis considering the Agricultural Censuses of 2006 and 2017 for 137 Brazilian microregions, finding that the modernization of agriculture still occurs heterogeneously throughout the national territory.

In the empirical literature regarding the state of Paraná, several studies have aimed to characterize regional differences in the productive structure of agriculture, particularly based on Agricultural Censuses. Fuentes Llanillo (1994) characterized the productive structure into eight distinct zones using data from the 1980 Agricultural Census and soil agricultural aptitude information. Fuentes Llanillo et al. (1993), considering data from the 1985 Agricultural Census, provided a new characterization of municipalities in the state of Paraná and identified eight homogeneous regions. Focusing on the northern region of the state, Cunha & Del Grossi (1993), using information from the Agricultural Censuses of 1970, 1980, and 1985, observed the substitution of permanent crops, especially coffee cultivation, by temporary crops, pastures, and increased inequality in land distribution and hired labor.

In another study, Cunha & Chilante (2001), based on data from the 1995/96 Agricultural Census, characterized agriculture in Paraná, identifying eight homogeneous regions. The northernmost region stood out for its temporary crops, higher technological advancement, greater inequality in land distribution, while another region to the south was less capitalized, had lower land inequality, and featured dairy and pig farming. Incorporating soil natural fertility and mechanization possibilities, Fuentes Llanillo et al. (2006) identified ten homogeneous regions in Paraná, also using data from the 1995/96 Agricultural Census. Considering indicators for the year 2000, Melo & Parré (2007) showed that, despite the production and competitiveness of the sector, the rural population's standard of living in the state is highly heterogeneous, with a significant number of municipalities having a low level of rural development.

While theoretical literature describes agricultural transformations as a phenomenon of economic development that occurred intensively in the country, empirical studies have sought to understand these changes, notably through Agricultural Censuses. In this context, the present study aims to contribute to this literature by characterizing the dynamics of this process in the municipalities of Paraná, based on an analysis of the two most recent Agricultural Censuses.

3 Methodology

3.1 Data

This study relies on information from the IBGE Agricultural Censuses of 2006 and 2017. Twenty indicators were selected to characterize the productive structure of agriculture in the 399 municipalities of Paraná. These indicators pertain to land structure, technology and capitalization usage, land use, labor, and the condition of producers and establishments, as outlined in Chart 1.

Chart 1. Factor analysis indicators

Variable	Description
Land Structure	
Gini	Gini Index
Technology and capitalization	
Tractors	Proportion of farms with a tractor
Service	Proportion of farms with access to technical assistance
Lime	Proportion of establishments using limestone
Fertilizers	Proportion of establishments using fertilizers and correctives
Pesticides	Proportion of establishments using pesticides
Production value	Production value per area farmed
Land use	
Temporary farming	Proportion of area under temporary crops per total occupied area
Planted forests	Proportion of area with planted forests per total occupied area
Cattle	Cattle and buffalo by area farmed
Milk	Milk per area farmed
Corn and beans	Proportion of area under corn and beans per area farmed
Soybeans	Proportion of soybean area per area farmed
Labor	
Temporary	Proportion of HES from temporary labor
Family	Proportion of family labor HES
Female	Proportion of HES of female labor
Producer and establishments	
Cooperative members	Proportion of establishments in cooperatives
Family Farming	Proportion of establishments in family farming
Producer	Proportion of establishments with female producers
Qualified	Proportion of producers with complete secondary education or more

Source: Research data.

In this study, the cultivated area is defined as the sum of temporary crops, permanent crops, planted pastures, natural pastures, and planted forests. On the other hand, the occupied area includes, in addition to the cultivated area, natural forests at rest and unused. Labor was quantified considering the man equivalent, which treats individuals under fourteen years old as half of an individual aged fourteen or older. Monetary values were adjusted, considering 2017 as the base year and using the General Price Index (IGP/DI) from the Getúlio Vargas Foundation.

According to Hoffmann & Jesus (2020), since 1975, the concepts of establishments in Agricultural Censuses have been similar. However, in 2017, non-contiguous areas within a municipality exploited by the producer were considered part of the same establishment, whereas in the previous Census, areas not in the same sector were considered separately, in another establishment.

According to Del Grossi et al. (2019), between 2006 and 2017, a significant portion of producers ceased to be classified as part of family farming, particularly due to income earned outside of agricultural establishments. Among the minimum requirements set for identification as family farming were: an area of up to four fiscal modules; the use of at least half of the family workforce; a family income equivalent to at least half of the enterprise or establishment; and the management being family-oriented. These requirements in 2017 are similar to those in place in 2006².

² Law No. 11,326, dated July 24, 2006 (Brasil, 2006), and Decree No. 9,064, dated May 31, 2017 (Brasil, 2017). For further details, refer to Nascimento et al. (2022).

From the twenty indicators, we aimed to characterize changes in the productive structure of agriculture and capture the process of agricultural modernization in the state of Paraná from 2006 to 2017, employing a multivariate approach, as described below.

3.2 Methods

In this study, based on the previously described indicators, factor analysis and cluster analysis were employed. Factor analysis was conducted using the principal components method, which involves constructing linear combinations of indicators to explain the maximum variance of the original variables (Hoffmann, 1992b, 2016; Hair et al., 2009).

To analyze the dynamics of the transformation process in the productive structure of agriculture in each municipality in Paraná, factor analysis was performed by grouping the two years. Thus, the indicators were calculated for each municipality in 2006 and 2017, resulting in a matrix with dimensions 798×20 .

Considering the number of indicators (k), there are $k-1$ possible factors. However, the selection of the main factors occurs among those whose characteristic root is greater than one, as suggested by Kaiser's criterion (Kaiser, 1974). The definition of the number of main factors seeks to select the highest proportion of variance from the original indicators.

To assess the adequacy of each indicator in factor analysis, the Kaiser-Meyer-Olkin (KMO) criterion was employed, ranging from zero to one, with values closer to one indicating better performance. Values below 0.50 are inadequate, between 0.50 and 0.69 are low, between 0.70 and 0.79 are moderate, between 0.80 and 0.89 are good, and between 0.90 and 1.00 are excellent. Additionally, the likelihood ratio (LR) test, similar to the Bartlett test, was used, with the null hypothesis assuming that correlations between variables are equal to zero. Therefore, if the null hypothesis is rejected, factor analysis can be applied. Furthermore, the communality related to each variable is presented, indicating how much of the variance of the respective indicator is captured by the set of factors.

To obtain a better interpretation of the factors, Varimax rotation was used, which maintains orthogonality between the original factors. Besides preserving the proportion of the total explained variance, this procedure enhances the association of each factor with its correlated variables.

After factor analysis, cluster analysis, or "clustering," was employed using the simple arithmetic mean method, which involves grouping observations with similar factor values, forming homogeneous groups. In this study, the observations are the municipalities in Paraná, thus forming homogeneous regions, not necessarily contiguous.

3.3 Descriptive analysis

Table 1 shows the average values of the indicators used in the multivariate analysis, as well as the percentage change over the period. While in 2006 there were 371,063 agricultural establishments in the state of Paraná, by 2017, this number had reduced to 305,154. Regarding the total occupied area, Census data also showed a reduction from 15,391,782 hectares to 14,741,967. However, this process is not recent, as in 1975, there were 478,453 establishments and a total occupied area of 15,630,962 hectares (Instituto Brasileiro de Geografia e Estatística, 2023).

In Paraná, small-scale farming played a significant role in its colonization. However, in the first half of the 1970s, there was a noticeable increase in land distribution inequality.

Initially, colonization occurred along the coast and central areas during the mining, mate, and timber cycles. In the early 20th century, the occupation of the northern region can be considered an expansion of coffee cultivation from the state of São Paulo, emphasizing a direction guided by private colonization companies with official support. During the same period, the southern occupation was carried out by residents of Santa Catarina and Rio Grande do Sul (Graziano da Silva, 1982). According to Boni & Cunha (2002), from 1970 to 1995/96, there was an increase in land ownership concentration in Paraná associated with the modernization of agriculture, with consequences for the rural population and rural-urban migration.

Table 1. Average and percentage variation of multivariate analysis indicators for municipalities, Paraná, 2006 and 2017

Variable	2006	2017	Variation
Land Structure			
Gini	0.73	0.75	3.58
Technology and capitalization			
Tractors	36.16	35.32	-2.32
Technical assistance	47.96	48.60	1.32
Lime	39.29	29.90	-23.91
Fertilizers	58.83	67.94	15.50
Pesticides	55.93	63.81	14.09
Production value	306.52	479.55	56.45
Land use			
Temporary farming	39.62	47.17	19.06
Planted forests	12.59	21.10	67.67
Cattle and buffalo	79.84	75.04	-6.01
Milk	17.04	29.95	75.77
Corn and beans	18.04	22.67	25.71
Soybeans	25.13	32.35	28.71
Labor			
Temporary	10.12	15.77	55.92
Family	76.95	72.71	-5.51
Female	29.03	23.47	-19.15
Producer and establishments			
Cooperative	29.29	38.51	31.46
Family Farming	78.85	71.10	-9.82
Producer	9.05	12.99	43.61
Qualified	19.49	32.78	68.15

Source: Basic data from the Agricultural Census, 2006 and 2017.

Therefore, between 2006 and 2017, there was an increase in land inequality, with the average area in the state rising from 41.48 hectares to 48.31. These changes in land use are reflected in the land structure indicator, which shows an increase in the Gini inequality index over the period studied, from 0.73 to 0.75.

Among the indicators for the use of technology and capitalization, there was a not very significant reduction in the proportion of establishments with tractors, although there was a 23.9% reduction in the use of limestone. It should be noted that, despite the reduction in agricultural establishments with tractors, the number of tractors increased from 2006 (113,718) to 2017 (166,393) in the state, according to information from the Agricultural Census, suggesting an intensification in the use of agricultural implements in a portion of establishments.

There is also an expansion in the number of establishments using fertilizers and pesticides. Technical assistance, despite showing a modest increase, still reaches just under 50% of agricultural establishments.

There was a significant increase in the value of agricultural production per area farmed of more than 50% over the period. However, the Agricultural Censuses also show a reduction in the proportion of establishments with access to finance, which fell on average from 36.83% to 26.69% in the municipalities of Paraná, indicating that less than 30% of establishments have this access.

With regard to land use, the indicators used suggest an expansion of temporary crops, planted forests and livestock in the state. With regard to temporary crops, there has been an increase in corn, bean and soybean areas. In the case of livestock, there has been an increase in dairy farming.

The number of people employed in the agricultural sector has historically been falling in Brazil, and this is no different in Paraná. According to Fleischfresser (1988), between the 1940s and 1970s, the state's rural population increased, but between 1970 and 1980 there was a negative balance. According to information from the Agricultural Census, in 2006 there were 1,117,098 people employed in the sector and, in 2017, around 846,642, while in 1975 there were 2,079,174.

At the same time, the indicators show an increase in the proportion of temporary labor and a reduction in family labor. It should be noted that, despite the drop, the family workforce still accounts for 72.7% of the state's total. In addition to the family and temporary workforce, there are permanent employees, partners and those in other conditions, who showed some stability among those employed in rural areas, at around 13% in the two years analyzed. Still with regard to the workforce, there was a lower rate of female employment in rural areas.

With regard to the characteristics of producers and agricultural establishments, there has been an increase in establishments associated with cooperatives. In turn, despite the 9.8% drop in family farming in the state, it still represents 71.1% of agricultural establishments. Considering the number of family workers employed, the importance of this segment in Paraná's agricultural sector stands out. Furthermore, the participation of women in economic activities is also reflected in the agricultural sector, with an increase from 9% to 13% of all agricultural producers from 2006 to 2017. Finally, the qualification of rural producers has also improved, with an increase from 19.5% to 32.8% of establishments with producers with secondary education or more.

In the next section, we look at the municipalities in the state of Paraná to see in which localities these indicators stand out the most, considering factor and group analyses.

4 Results and discussions

The first results of the factor analysis indicated four factors with characteristic roots greater than one, which were selected to continue the study³. According to Table 2, these main factors explain 96.7% of the total variance of the twenty variables, which represents a satisfactory proportion explained. The K-M-O test was 0.8375, indicating a good fit between the variables. In turn, the LR test was significant at the 1% level, which is favorable to the use of factor analysis.

³ The four characteristic roots greater than one were equal to 5,95464, 3,58889, 1,55236 and 1,24930.

The communalities, which represent the proportion explained by the factors of each variable, are generally above 50%, with only two exceptions, the value of production and the use of limestone, which remained in the analysis to better characterize the technology and capitalization dimension. Furthermore, these two variables had an individual K-M-O value of over 0.85, contributing to a better characterization of the structure of agriculture in the state of Paraná.

Considering the factor loadings, Factor 1 (F1) is identified with the intensive adoption of technology and temporary crops, especially soybeans. The second Factor (F2) can be associated with family farming, female labor, less land inequality and rural producer qualifications. The third factor (F3) correlates with planted forests, establishments with female producers and low pesticide use. Finally, the fourth Factor (F4) is directly related to beef and dairy farming, with a negative Gini index, which indicates less land inequality.

Table 2. Factor analysis results for 20 indicators and 4 factors, Paraná, 2006 and 2017

Variable	F1	F2	F3	F4	Communality
Gini	-0.406	-0.454	0.218	-0.414	0.590
Tractors	0.649	-0.236	-0.162	-0.198	0.543
Service	0.818	-0.129	-0.268	0.066	0.762
Lime	0.441	-0.062	-0.430	-0.241	0.441
Fertilizers	0.828	0.104	0.004	-0.020	0.697
Pesticides	0.120	0.376	-0.694	-0.184	0.671
Production value	0.438	0.007	0.287	0.092	0.283
Temporary crops	0.883	-0.134	-0.101	-0.138	0.827
Planted forests	-0.188	0.162	0.623	-0.260	0.517
Cattle and buffalo	-0.504	0.116	-0.088	0.719	0.793
Milk	0.213	0.223	0.246	0.587	0.500
Corn and beans	0.771	0.029	-0.003	-0.033	0.596
Soybeans	0.820	-0.027	-0.049	-0.099	0.685
Permanent workforce	0.037	-0.750	0.072	-0.118	0.583
Family labor	-0.015	0.825	0.121	0.122	0.711
Female labor	-0.189	0.729	0.113	0.090	0.587
Cooperative	0.745	-0.231	-0.171	0.252	0.701
Family farming	0.032	0.739	-0.175	0.119	0.591
Female producer	-0.330	-0.083	0.614	-0.096	0.502
Qualified producer	0.316	-0.787	0.181	0.121	0.767
Variance explained (%)	43.27	27.76	14.62	11.07	

Source: Basic data from the Agricultural Census, 2006 and 2017.

To characterize the changes in agriculture in Paraná, ten groups were selected in the cluster analysis. Table 3 shows the average values obtained for each factor, which allows each group of municipalities to be distinguished. In turn, the dynamics of the changes that took place in the agricultural sector from 2006 to 2017 can be seen in Table 4 and Figure 1. Among the results, five of the most significant changes can be highlighted.

Firstly, there are the changes in groups one and three between 2006 and 2017, which indicate a reduction in family farming associated with the expansion of beef and dairy farming. In group one, there is a greater negative value for the first factor and a positive value for the latter, indicating a location with a more significant presence of beef and dairy farming.

This same characteristic is also observed in group three, but the negative value of the first factor is more intense and the positive value of the last is lower, suggesting less exploitation of temporary crops and livestock in group three. In addition, when factors two and three are considered, there is a lower presence of family farming and areas with planted and productive forests in group one.

Table 3. Factor values for the selected regions in the group analysis, Paraná, 2006 and 2017

Regions	F1	F2	F3	F4
1	-0.826	-0.383	0.138	0.942
2	1.081	0.100	-1.118	-0.655
3	-1.128	0.533	-0.496	0.140
4	-0.128	-1.771	0.158	0.044
5	-0.848	-0.009	1.524	-1.097
6	1.274	-0.476	0.483	-0.087
7	0.302	1.223	-0.714	0.623
8	-0.050	0.738	0.303	-0.781
9	-0.395	-0.617	-1.047	-0.161
10	0.695	0.588	1.024	1.699

Source: Basic data from the Agricultural Census, 2006 and 2017.

Table 4 shows that group three was more present in 2006, with 91 municipalities. In 2017, there was only one municipality, Cândido de Abreu, in the central region of the state, which can be better seen in Figure 1, in light blue. On the other hand, group one, in dark blue, with only fifteen municipalities in 2006, expanded to 71 municipalities in 2017, further north in the state and also in the Central region. A total of 49 municipalities that were in group three in 2006 moved to group one in 2017. Therefore, in these municipalities, the expansion of beef and dairy cattle, as well as planted forests and producers, as well as a reduction in the use of pesticides and family farming stand out.

A second set of transformations occurs between groups two and six, with greater use of land for temporary crops, more technification and a lower proportion of family farming. In Figure 1, groups two and six are identified with the colors light green and dark green, respectively. These changes reflect the greater use of land for temporary crops, with more technology and capitalization and a reduction in family farming.

In both groups, the positive value for the first factor stands out, which is even more intensive in group six. However, while group two has the highest negative value for factor three, group six has a positive factor three. Furthermore, while group two is more present in 2006, with 80 municipalities, and only one in 2017, Iracema do Norte, in group six there is only one municipality in 2006, Porecatu, and 100 municipalities in 2017. Almost all of the municipalities in group two in 2006 are in group six in 2017, with a total of 70.

The dynamic between groups four and nine is the third result worth highlighting, which also indicates a reduction in family farming and, to a modest extent, the presence of planted forests, beef and dairy cattle. Group four shows a negative value for factor two, indicating a low presence of family farming. Group nine also shows a negative value for factor two, but to a lesser extent. In fact, group nine shows negative values for all the factors analyzed, especially for factors three and two, which are associated with planted forests, the presence of female producers and family farming.

However, while group four expanded from two to 68 municipalities, group nine was absent in 2017. From a total of 73 municipalities belonging to group nine in 2006, the largest proportion (43) is in group four in 2017. In Figure 1, group nine is in lighter yellow and group two in darker yellow. Therefore, these changes signal a reduction in family farming, especially in the north of the state.

Table 4. Number of municipalities in the homogeneous groups of the cluster analysis, Paraná, 2006 and 2017

Group	2006		2017	
	Municipality	(%)	Municipality	(%)
1	15	1.75	71	4.51
2	80	10.03	1	11.78
3	91	15.79	1	6.77
4	2	9.27	68	9.02
5	13	17.54	53	10.78
6	1	1.75	100	10.28
7	66	3.26	1	12.53
8	58	12.78	50	12.78
9	73	18.55	0	11.53
10	0	9.27	54	10.03
Total	399	100	399	100

Source: Basic data from the 2006 and 2017 Agricultural Censuses.

Another change that stands out is between regions five and eight, where it is possible to highlight the expansion of planted forests, the presence of female producers and the appearance of family farming in a more significant way only in group eight. In region five, there was a positive value only for factor three, associated with planted forests, the presence of female producers and the low use of pesticides. Group eight shows similar characteristics, with the exception of factor two, which changes sign, indicating a greater presence of family farming in these locations and low producer qualifications.

While group eight remained with almost the same number of municipalities in 2006 and 2017, with a reduction from 58 to 50, group five expanded from 13 to 53 municipalities, respectively. Among the municipalities that were in group eight in 2006, 20 of them migrated to group five, while only 30 remained in group eight, indicating that there were other changes in the productive structure of the other municipalities. In Figure 1, groups five, in dark magenta, and eight, in light magenta, can be seen more in the Central-South, Metropolitan and Coastal Regions of the state.

Finally, the changes between the municipalities in groups seven and ten stand out. In Figure 1, group seven can be seen in a lighter shade of red, while group ten in a darker red, in the southernmost part of the state of Paraná. In group seven, only the third factor has a negative sign, but the highlight is the value and intensity of factor two, indicating the presence of family farming. In group ten, all four factors have positive values, including factor three, but it is factors three and four that have the greatest intensity, indicating the importance of planted forests and livestock in these municipalities. The positive values in group ten suggest greater heterogeneity in the agricultural exploitation of these municipalities.

The reduction in group seven from 66 municipalities in 2006 to just one municipality in 2017 and, on the other hand, the increase in municipalities in group ten, which was not present in 2006, but has 54 municipalities in 2017. It should be noted that 49 municipalities that were in group seven in 2006 are in group ten in 2017, i.e. almost all of this group.

In the results of this study, the main aspect that deserves to be highlighted in the dynamics of the modernization of agriculture in the state of Paraná is the continued expansion of temporary crops to the detriment of family farming. However, despite the evidence suggesting important transformations in the productive structure of agriculture in the state of Paraná, 53 municipalities remained in the same group in 2006 and 2017⁴.

⁴ The number of municipalities that remained in each group is in brackets: group 1 (1), group 2 (1), group 3 (1), group 4 (1), group 5 (12), group 6 (7), group 7 (1) and group 8 (30).

A second aspect, linked to the first and to the reduction in family farming, is the use of family labor. It is worth mentioning that family farming is associated with reduced technical guidance and lower qualifications for rural producers. Furthermore, family farming is less associated with cooperatives, unlike establishments that typically produce for export, such as soy, corn and timber.

Despite this predominant characterization of family farming, there is great diversity in these establishments. In fact, Souza et al. (2019) show a high disparity in the use of technology in family farming, higher in the South and Southeast and lower in the North and Northeast. In the state of Paraná, the highest rates were found in the West Paranaense, West Central Paranaense, Southeast Paranaense and North Central Paranaense regions.

Furthermore, according to Aquino et al. (2018), there are important differences between family farming and that of employers or agribusiness, especially considering information from the 2006 Demographic Census. In addition, the authors highlighted a significant heterogeneity in family farming, with a large proportion of poor and extremely poor producers, despite some progress, with difficulty in accessing credit and low capitalization. According to Del Grossi et al. (2019), from 2006 to 2017, there was a change in the income profile of rural families, with an increase in pluriactivity, which disqualified a significant proportion of poor families from family farming in 2017. In turn, Nascimento et al. (2022) confirm this downward trend in family farming, especially in the southern region of the country.

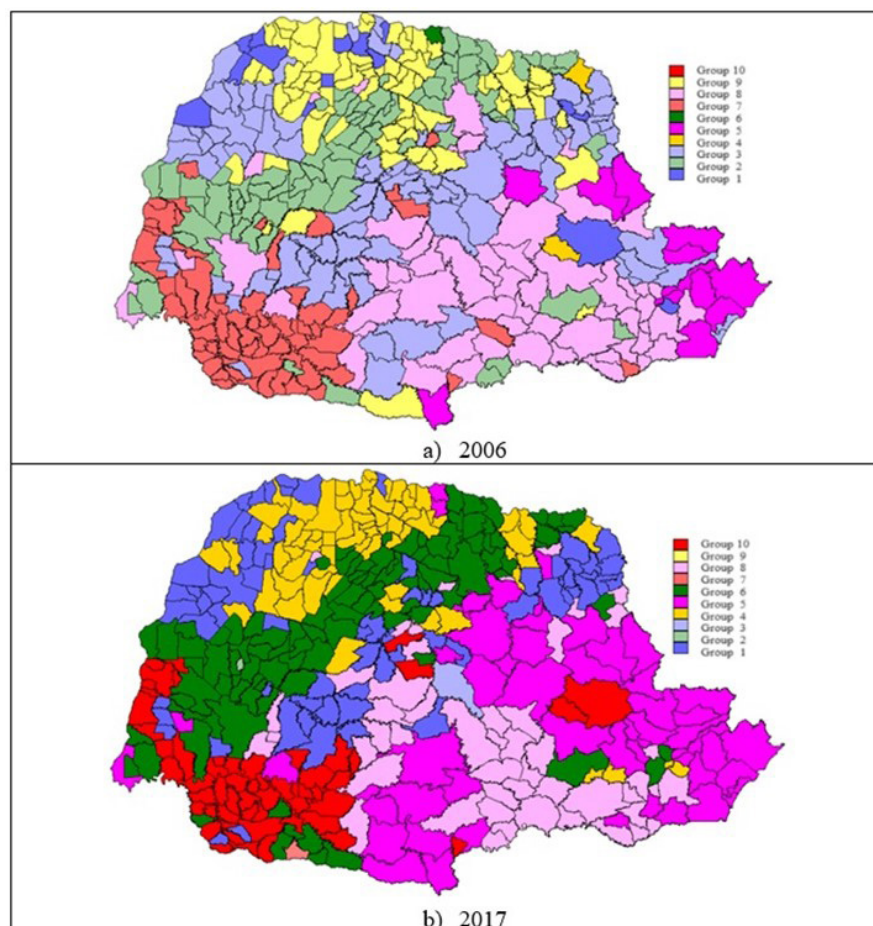


Figure 1. Dynamics of changes in agriculture in Paraná, 2006 and 2017.
Source: Basic data from the 2006 and 2017 Agricultural Censuses.

Another piece of evidence related to export-oriented agriculture is the expansion of planted forests, especially in the central region of the state of Paraná. These results are in line with the expansion of paper and especially pulp exports in the state. Of particular note in this region is the installation and expansion of Klabin's Puma unit, which began in 2014 in the municipality of Ortigueira.

The greater inequality in the distribution of land is also a national phenomenon, according to information from the 2006 and 2017 Agricultural Censuses. In Brazil, the Gini index went from 0.865 to 0.866 and, in Paraná, from 0.777 to 0.793, respectively. In Paraná, among the determinants of this increase can be cited the expansion of planted forests, represented by the increase in homogeneous group five in Figure 1, which includes, for example, the municipalities of Ortigueira, Mauá da Serra, Imbaú, União da Vitória and Ponta Grossa.

There is also a greater presence of women as rural producers, which is in line with their greater participation in economic activities in recent decades. However, the greater presence of women, especially in group five, may be associated with poverty and a lower level of socio-economic development, which deserves greater attention from public policies. This region includes Vale do Ribeira, one of the poorest regions in the state of Paraná, made up of seven municipalities, which were in group five in 2017⁵.

According to Perin et al. (2021), women's participation as producers was boosted by their inclusion in the Food Acquisition Program (PPA) regulations in 2011, with Resolution 44 and Decree 7.775/2012. The authors analyzed the trajectory of the PPA, from its implementation in 2003 until 2019, and observed that until 2008, there was a period of learning and organization, in a second moment, from 2009 until 2013, significant results were observed with greater protagonism of the Supply Company (Conab) and the Ministry of Social Development and Fight against Hunger (MDS). However, from 2014 to 2019, the program continued to decline. The Bolsa Família Program has also contributed to the increase in the number of women as reference persons in agricultural establishments, since it prioritizes women as those responsible for receiving the benefit, as discussed by Bartholo et al. (2019). This evidence corroborates the results of this study, which point to a reduction in family farming and greater participation by women as producers.

In fact, although this study identified ten homogeneous regions, the complexity and diversity of the production structure deserves more detailed attention. In this respect, Telles et al. (2008) identified five production systems for dairy farming in the state of Paraná, despite the predominance of family farming. This result corroborates the relationship identified in this study in factor four (F4), in which family farming has a positive relationship, although not a very high one. In this study, the authors analyzed the Children's Milk Program, which began in May 2003 and was carried out through social purchases by the Paraná Supply Centers (CEASA/PR), especially small plants, which collected milk from local producers. The initial focus of the program was the municipalities with the lowest Human Development Index and the authors found that there were benefits both for the producers, especially family farmers, and for the population served. Still considering livestock, pig and poultry farming are also prominent in the interior of the state, especially in the southern and western regions.

⁵ According to the Instituto Paranaense de Desenvolvimento Econômico e Social (2021), the municipalities in the Ribeira Valley had low or medium-low performance in 2019. While the municipalities of Adrianópolis (0.690), Cerro Azul (0.612) and Rio Branco do Sul (0.665) were medium-low performers, the municipalities of Bocaiúva do Sul (0.599), Doutor Ulysses (0.559), Itaperuçu (0.578) and Tunas do Paraná (0.568) were low performers. This year, only thirteen of Paraná's 399 municipalities were at the low performance level.

Spatially, based on the homogeneous groups studied, it was possible to identify four regions in the state of Paraná in the last year analyzed. The first, which stretches from the Central region to the Coast, is made up of groups five (with 53 municipalities) and eight (with 50 municipalities), in which family farming and planted forests stand out, respectively. A second region is located further to the south of the state, where group ten (with 54 municipalities) predominates, with a diverse production structure. In a strip stretching from the north to the center-west of the state is group six (with 100 municipalities), with production especially focused on temporary crops and beef and dairy cattle. On the other hand, in the north of the state, groups one (with 71 municipalities) and four (with 68 municipalities) stand out, with a greater presence of livestock and a smaller presence of family farming.

The evidence shows the persistence of the process of reducing family farming associated with the increase in land concentration, the smaller number of agricultural establishments and the reduction in the population employed in rural areas. In fact, employment in rural areas fell by 270,456 jobs, representing a 24.2% drop in employment from 2006 to 2017. In search of employment and income, in a situation of greater vulnerability, this population migrates to urban centers, particularly to the most precarious and peripheral regions, a phenomenon already described in the literature (Graziano da Silva, 1982; Abramovay, 2009; Mattei, 2015).

In this sense, as already pointed out in the literature, regional and productive heterogeneity should be given greater attention by public policies, considering, for example, increasing income and access to financing, technical assistance and environmental preservation. Thus, public policies aimed at sustainable development are needed that take into account the regional and productive differences of each location.

5 Final considerations

The aim of this study was to analyze changes in agriculture in the state of Paraná from 2006 to 2017, using information from the IBGE Agricultural Census. Using twenty indicators and factor and group analyses, it was possible to identify ten homogeneous groups in the two years of the survey.

Thus, these results show the most predominant characteristics in the productive structure of Paraná's agriculture and livestock, without, however, exhausting all the diversity present. In this sense, it is important to emphasize that, despite the heterogeneity of the agricultural structure shown in this study, there are limitations in identifying the diversity of productive activities in establishments, which merits the attention of new, more focused studies.

On the one hand, the results of the study suggest that the changes in the productive structure are following the same trend seen in previous decades, with an expansion in the use of new technologies and advances in more capitalized agriculture, characterized by more export-oriented production, temporary crops such as soybeans and corn, and livestock. More recently, forest plantations have advanced into the more central part of the state, towards the coast, since the formation of the terrain did not allow for the expansion of mechanization associated with crops; however, forest plantations have been successful in incorporating more of these locations into production chains aimed at meeting world demand.

While there is evidence of a reduction in the workforce and in family farming in the countryside, on the other hand, family farming is still the one that absorbs the largest proportion of the workforce in rural Paraná. In this sense, a public policy that is even more attentive to the specificities of these producers is essential. This will improve the well-being of this part of the population, but it can also help to reduce the flow of migrants from rural to urban areas, easing the demands for basic infrastructure in urban centers, which is often incipient.

Therefore, in general terms, it was possible to identify important transformations in the production structure of Paraná's agricultural sector that show the continuity of the process of adopting new technologies and the reduction in occupation in the countryside, while the more capitalized and technified agriculture advances beyond temporary crops and livestock, with the planted forests also standing out in the new Census. This production is mainly destined for exports, which have historically been supported by the state with attractive incentives, such as taxes. In addition, family farming still occupies the largest share of the population in rural areas, which contributes to generating income for the population that remains in the countryside and to promoting food and nutritional security in the country.

Despite the economic growth seen in the agricultural sector, in which the average value of production increased by more than 50% over the period, Paraná, like the country, continues to stand out among the links with the lowest added value in global value chains. In this sense, there is a need for greater stimulus to advance economic activities in agro-industry segments that could add more value to products and contribute even more to generating jobs and income, stimulating local economies with increased consumption and greater social welfare. In addition, family producers and those producing for domestic consumption also need greater attention from public policies.

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