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PANORAMA DA EVOLUÇÃO DA AGRICULTURA IRRIGADA NO SUDESTE DO BRASIL ENTRE 2006 E 2017

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1 RESUMO

O presente estudo buscou contribuir no debate sobre a situação da irrigação no Brasil, dando ênfase na região Sudeste. Buscou-se entender, a partir dos dados dos Censos Agropecuários do IBGE de 2006 e 2017, quais direções a agricultura irrigada tomou no Sudeste do Brasil durante esse período. Houve aumento na área irrigada no Brasil em todas as regiões geográficas, atingindo 6,9 milhões de hectares (Mha) em 2017. No período 2006-17 a expansão da área irrigada no estado de Minas Gerais foi de 616 mil hectares, em São Paulo foi de 321 mil hectares e de 155 mil hectares no Espírito Santo. Na região Sudeste a irrigação por gotejamento é majoritária em área, com 25% da área irrigada, seguida de forma acirrada pela irrigação por aspersão (24%) e por pivô central (23%). A área irrigada na região Sudeste, segundo o Censo 2017, é destinada majoritariamente para cultivo de lavouras temporárias (48%), lavouras permanentes (29%), horticultura e floricultura (14%) e pecuária (10%). Essas informações são importantes para o planejamento do crescimento sustentável da agricultura irrigada e o uso eficiente dos recursos hídricos.

Palavras-chave: área irrigada, Censo Agropecuário; métodos de irrigação.

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2 ABSTRACT

This research aimed to contribute to the debate about the current situation of irrigation in Brazil, with emphasis on the Southeast region. Based on data from the IBGE Agricultural Censuses of 2006 and 2017, we aimed to understand which directions irrigated agriculture has taken in Southeastern Brazil during this period. There was an increase in the irrigated area in Brazil in all geographical regions, reaching 6.9 million hectares (Mha) in 2017. In the period 2006-17, the expansion of the irrigated area in the state of Minas Gerais was 616,000 hectares, in São

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Paulo it was 321,000 hectares and 155,000 hectares in Espírito Santo. In the Southeast region, drip irrigation is the majority in the area, with 25% of the area irrigated, followed by sprinkler irrigation (24%) and central pivot (23%). The irrigated area in the Southeast region, according to the 2017 Census, is mostly for temporary crops (48%), permanent crops (29%), horticulture and floriculture (14%), and livestock (10%). These information are important for planning the sustainable expansion of irrigated agriculture and efficient water use.

Keywords: irrigated area, census of agriculture, irrigation methods.

3 INTRODUCTION

Currently, irrigated agriculture around the globe covers 275 million hectares (Mha), approximately 20% of cultivated land, and accounts for 40% of global food production. With rapid population growth, water withdrawals have tripled in the last 50 years (FOOD AND AGRICULTURE ORGANIZATION, 2017). Irrigated agriculture occupies an estimated area of 310 Mha, 75% of which is located in Asia, where India (66 Mha) and China (62 Mha) are the countries with the largest areas equipped for irrigation (FOOD AND AGRICULTURE ORGANIZATION, 2017). Between 1960 and 2015, the irrigated area in Brazil increased significantly, from 0.462 to 6.95 Mha, and may expand another 45% by 2030, reaching 10 Mha. (NATIONAL WATER AGENCY, 2019).

According to Mukherji *et al.* (2009), 80% of the products needed to meet the needs of the world's population over the next 25 years will be provided by irrigated crops. To meet the current challenge of agriculture in terms of food production, even with simultaneous growth in biofuel production, increasing crop productivity, especially that of grains, which can be achieved in the short term with the expansion of irrigated agriculture and other research advances in production chains, is necessary (NATIONAL WATER AGENCY, 2019).

The maximum crop yield depends on several factors, such as climate conditions, fertilization, and phytosanitary treatments. Among these factors, climate conditions are among the greatest risk factors, with the added problem of not being controllable at the rural property level (PEREIRA; ANGELOCCI; SENTELHAS, 2002; ASCOLI *et al.*, 2017; BISPO; HERNANDEZ; TEIXEIRA, 2017; AVILEZ *et al.*, 2018; SILVA JUNIOR *et al.*, 2018). Thus, to reduce the effects of unevenly distributed rainfall, dry spells, and other potential adverse conditions, many producers have adopted irrigation techniques to address water deficits and achieve maximum crop yield (BERNARDO *et al.*, 2019). Furthermore, proper management promotes increased productivity and helps producers achieve and maintain the economic viability of their crops. Importantly, irrigation also promotes the stabilization of food production and prices (RODRIGUES, 2001; WORLD BANK, 2006).

The National Irrigation Policy (Law No. 12,787, of January 11, 2013) has the principles of sustainable use and management of soil and water resources for irrigation; integration with sectoral policies on water resources, environment, energy, and environmental sanitation; coordination between different instances and spheres of government and the private sector; and democratic and participatory management of public irrigation projects with common-use irrigation infrastructure and prevention of waterborne rural endemic diseases (BRASIL, 2013).

This legal framework uses various instruments, such as irrigation plans and projects; the National Irrigation Information

System; tax incentives; credit and rural insurance; human resource training; scientific and technological research; technical assistance and rural extension; special electricity tariffs for irrigation; the certification of irrigation projects; the Infrastructure Participation Investment Fund (FIP-IE); and the National Irrigation Council (BRASIL, 2013).

For the National Irrigation Policy to be effective, it must be reviewed periodically, its goals and achievements must be assessed, certain objectives must be rethoughtorated, and potential inconsistencies must be addressed. In this context, monitoring the sector's progress is essential to reduce social and economic disparities between Brazilian regions and promote development within diverse contexts throughout the country.

This study aimed to contribute to the debate on the irrigation situation in Brazil, with an emphasis on the Southeast Region. An overview of the evolution of irrigated agriculture was outlined by comparing the 2006 and 2017 Agricultural Censuses to determine developments in irrigation systems and the allocation of irrigated land, with an emphasis on data from the Southeast Region.

4 MATERIALS AND METHODS

The research was based on a survey of data from 2017 (BRAZILIAN INSTITUTE OF GEOGRAPHY AND STATISTICS, 2017) and 2006 (BRAZILIAN INSTITUTE OF GEOGRAPHY AND STATISTICS, 2006) Agricultural Censuses and compared with the results of previous census surveys.

Data from the 2017 Agricultural Census were acquired through the IBGE Automatic Recovery System (SIDRA). The 2017 census tables analyzed were 6857 (IBGE AUTOMATIC RECOVERY SYSTEM, 2020a) and 6868 (IBGE AUTOMATIC RECOVERY SYSTEM, 2020b), and the 2006 census table was 855 (IBGE AUTOMATIC RECOVERY SYSTEM, 2020c). These tables are multidimensional matrices ($4 \times 7 \times 7 \times 5 \times 4 \times 12 \times 1 \times N$), where N is the number of territorial units to be analyzed; when the search is performed by municipalities, N is equivalent to 6039; when it is performed by states, N is equivalent to 27 (including DF); and so on.

It is worth highlighting the premises of the two census surveys to make comparisons more appropriate for the data. According to the census taker's manual (BRAZILIAN INSTITUTE OF GEOGRAPHY AND STATISTICS, 2017), the definition of irrigation for the 2017 Agricultural Census (the same as that of 2006) was as follows:

> Irrigation is the practice of applying water, other than rainwater, directly to the surface of soil cultivated with pastures or crops in specific quantities and at specific intervals to provide water to plants under conditions appropriate for their growth and production. This includes manual watering via buckets, hoses, or cans.

Several types of irrigation methods were surveyed in the 2017 Census, namely, 1) surface irrigation systems (Flood, Furrow, Corrugation and Strip); 2) sprinkler irrigation systems (detailing self-propelled/winding reel, central pivot, conventional portable, semiportable, fixed, semifixed sprinkler, hydraulic cannon and mesh); 3) localized irrigation systems (Drip, microsprinkler, Xique-Xique, Potejamento, etc.); and 4) other systems (subsurface and wetting). The census taker's manual contains a definition of each of these methods. In the 2006 census, the survey was more generic, surveying 1) flood, 2) furrow, 3) central pivot, 4) sprinkler, 5) localized and 6) other irrigation and/or wetting methods.

This irrigated area also had its destination raised in the 2017 Census (in

2006, this detail was not made), considering 1) the production of temporary crops and 2) horticulture and floriculture. 3) Production of permanent crops; 4) seed production; 5) livestock; 6) planted and native forests; and 7) aquaculture.

5 RESULTS AND DISCUSSION

5.1 Irrigated areas in Brazil

The Southeast China region is the main irrigation region of the country, followed by the South China, Northeast China, Central-West China, and North China regions. The largest irrigated area is in the states of Rio Grande do Sul, Minas Gerais, and São Paulo, representing 20.4%, 16.6%, and 16.0%, respectively, of the total irrigated area. Figure 1 shows the evolution of the irrigated area occupied by each irrigation method in Brazil according to the 2006 and 2017 Agricultural Censuses. In Brazil, there was an increase of approximately 32% in the total irrigated area between the 2006 and 2017 censuses.

This demonstrates that technology and information are increasingly reaching the field. Furthermore, the survey reveals a concern with water use, as one of the techniques that uses the most water is furrow irrigation (efficiency of approximately 50%), the only one that is reduced (52%). There was also a 376% increase in the use of the localized system (95% efficiency), which is a highly efficient technique. The central pivot irrigation method resulted in a 60% increase, as, according to Albuquerque *et al.* (2020), this increase is associated with agricultural expansion in the Cerrado and the reduced cost of pivot installation, resulting in a lower *payback period* and higher financial returns.

The census also identified several other methods with lower usage rates that are considered artisanal, all of which are included under "other methods." These methods are used regionally to meet specific needs and are mostly low cost and inefficient. Therefore, their use has remained virtually unchanged.

Figure 1. Evolution of the irrigated area occupied by each irrigation method in Brazil according to the 2006 and 2017 Agricultural Censuses.

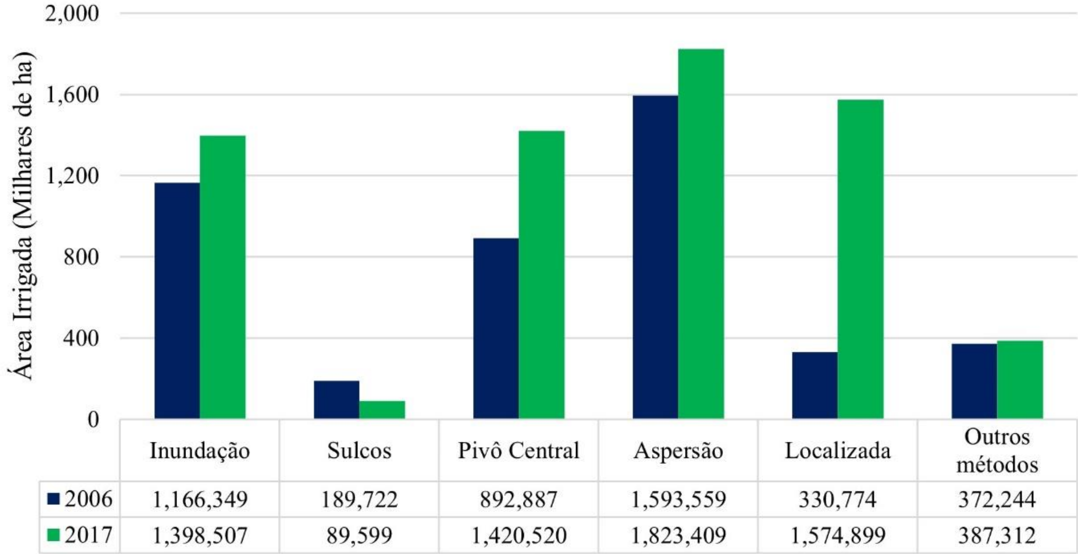
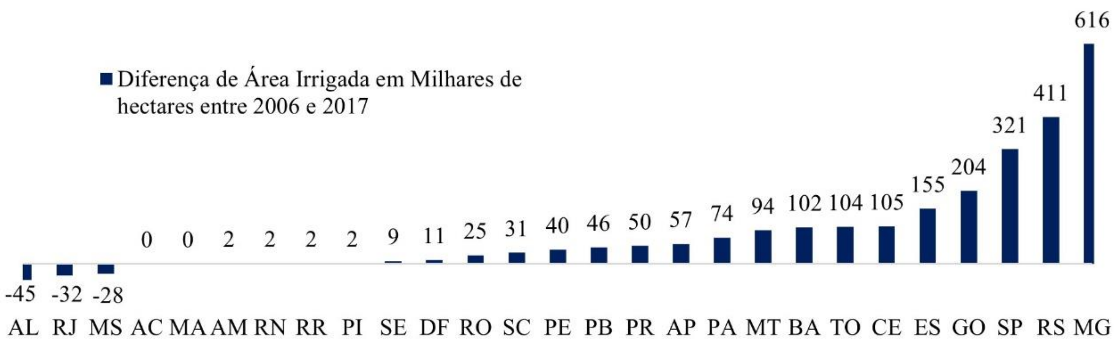


Figure 2 shows the difference in total irrigated area by state between the 2006 and 2017 Agricultural Census surveys. Notably, during this period, the state of Minas Gerais experienced the largest expansion in the country, with 616,000 hectares more irrigated from 2006--2017. In São Paulo, there was an expansion of 321,000 hectares, and in Espírito Santo, there were 155,000 hectares. Rio de Janeiro, on the other hand, had 32,000 hectares contracted. Paulino *et al.* (2011) highlighted that from 1995–2006, the state of São Paulo experienced the largest expansion (330,000 ha), followed by Minas Gerais (202,000 ha) and Espírito Santo (117,000 ha).

In general, the absolute areas of the states of Goiás, São Paulo, Rio Grande do Sul, and Minas Gerais expanded the most. The states of São Paulo and Minas Gerais stand out for this increase because of their proximity to the largest consumer centers, which focus primarily on vegetable cultivation (SCHERER *et al.*, 2016). Notably, the state of São Paulo has experienced an expansion of citrus orchards due to the advance of *greening. Proper irrigation and* fertigation management reduce its impact, and this, combined with increased demand, leads to an intensified use of irrigation (ERPEN *et al.*, 2018).

Figure 2. Differences in irrigated area by state according to the 2006 and 2017 Agricultural Censuses.



The state of Minas Gerais is associated with its consolidation as a coffee producer and gaining prominence in the production of specialty coffees, in which irrigation becomes essential to reduce the impacts of water deficit and increase productivity (GUIMARÃES; CASTRO JÚNIOR; ANDRADE, 2016). The state of Goiás is consolidating itself as a grain-producing hub; thus, investment in central pivot irrigation systems has gained prominence since its relief allows for larger areas and thus optimizes production and reduces water deficit problems (PEREIRA JÚNIOR; FERREIRA; MIZIARA, 2017). In the State of Minas Gerais, the advancement of the installation of central pivot irrigation systems for rice cultivation has also increased substantially in recent years, thus causing an increase in the absolute irrigated area (MANKE *et al.*, 2017).

Figure 3 shows the percentage of irrigated area in Brazil by each irrigation method, according to the 2017 Agricultural Census. Among all the irrigated areas in Brazil surveyed by the 2017 census, an asymmetrical distribution of irrigation methods is observed, with central pivot and flood systems (21%) being the most technologically advanced methods. Moreover, less technologically advanced methods, such as wetting, furrow irrigation, and other (artisanal) methods, are the least widely used. Notably, subsurface irrigation is a recent technique and is still rarely used due to its cost. Additionally, issues related to clogging raise doubts and the cost of resolving the problem (BERNARDO *et al.*, 2019). An interesting cross-section is the Cerrado biome, which, according to Althoff and Rodrigues (2019), has concentrated approximately 80% of all central pivots in Brazil. In this region alone, the potential irrigated area reaches 26.5 Mha.

The 2017 survey revealed the trend identified by Paulino *et al.* (2011) of a predominance of pressurized irrigation in Brazil, in contrast to the predominance of surface (or flood) irrigation in the rest of the world, which continues to be observed, placing Brazil in a prominent position within global irrigated agriculture. The fact that pressurized irrigation is more efficient than surface irrigation (BERNARDO *et al.*, 2019) is also relevant in explaining the significant productivity of agriculture in Brazil, which, combined with better financing conditions, can make agribusiness more competitive in Brazil than in other countries.

Figure 4 shows the percentage of destination/type of use of the irrigated area in Brazil by each irrigation method according to the 2017 Agricultural Census.

Throughout Brazil, 40% of irrigated land is used for livestock farming, making it predominant. In addition, 22% of these crops are used for temporary crop production, 17% for horticulture and floriculture, and 16% for permanent crop production. Minor uses include irrigation for planted and native forests and seed production, each accounting for 2% of Brazil's irrigated land.

Figure 3. Percentage of area irrigated in Brazil by each irrigation method according to the 2017 Agricultural Census.

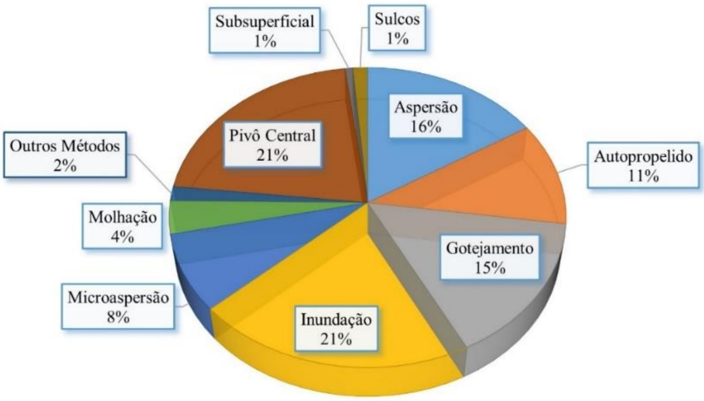
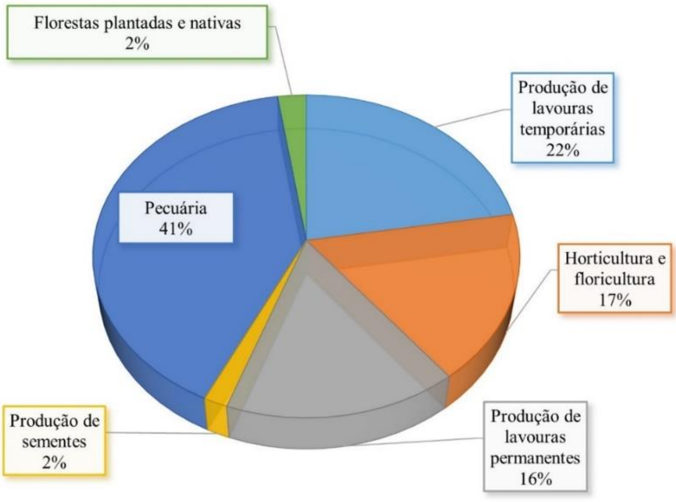


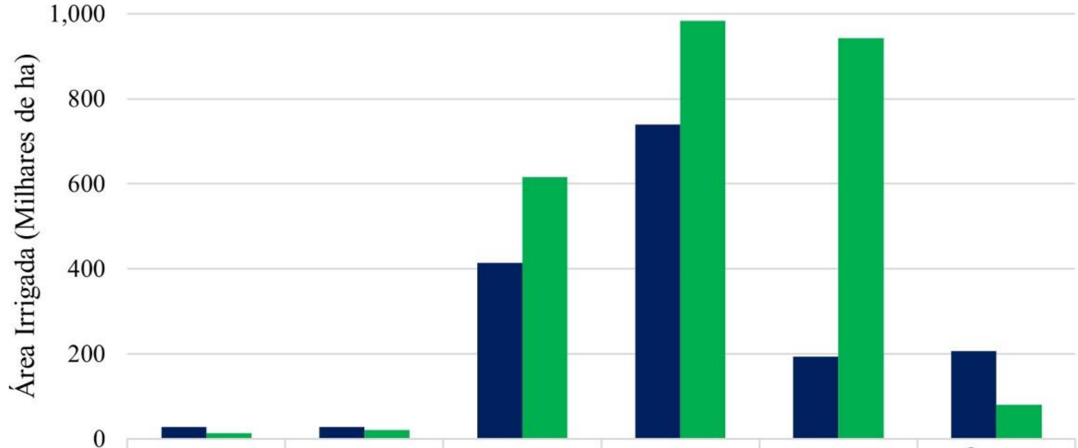
Figure 4. Percentage of destination/type of use of irrigated area in Brazil by each irrigation method according to the 2017 Agricultural Census.



5.2 Irrigated area in the Southeast Region

The Southeast Region, with 92.7 Mha (10.9% of the national territory), is home to 80.35 million inhabitants according to the 2010 Census (BRAZILIAN INSTITUTE OF GEOGRAPHY AND STATISTICS, 2010), which corresponds to 44% of the population and is responsible for 55.2% of the Brazilian GDP (BRAZILIAN INSTITUTE OF GEOGRAPHY AND STATISTICS, 2010). The Southeast Region, according to Christofidis (1999), has 4.3 Mha suitable for irrigation (without floodplains), and its total irrigated area in 2017 was 2.65 Mha.

Figure 5. Evolution of the irrigated area occupied by each irrigation method in the Southeast Region according to the 2006 and 2017 Agricultural Censuses.



	Inundação	Sulcos	Pivô Central	Aspersão	Localizada	Outros métodos
2006	27,815	28,417	413,562	738,557	193,217	206,114
2017	13,789	20,194	616,386	983,383	941,812	79,762

In the Southeast Region, drip irrigation accounts for the majority of the area, accounting for 25% of the irrigated area, followed closely by sprinkler irrigation (24%) and central pivot irrigation (23%) (Figure 6).

According to the 2017 census, the irrigated area in the Southeast Region is used mainly for temporary crop production (48%), permanent crops (29%), horticulture and floriculture (14%), and livestock (10%) (Figure 7). Unlike the national scenario, where livestock is the largest destination for irrigated land (Figure 4), in the Southeast Region, temporary crops predominate, with the State of São Paulo standing out for the rapid and strong expansion of sugarcane.

According to Rudorff *and Paulino et al.* (2010), almost all of the land-use change for sugarcane expansion in the 2008/09 agricultural year occurred in pastures and annual croplands, which were equally distributed within each year. It was also observed that during the 2008 harvest, the burned sugarcane area was reduced to 50% of the total harvested area in response to new protocols aimed at eliminating the practice of burning sugarcane straw by 2014 for mechanized areas. We also highlight that between 1995/06 and 2006, the expansion of irrigation in the Southeast Region was significantly impacted by the increase in vinasse application, which was associated mainly with the use of self-propelled systems in sugarcane areas for biofuel production.

Figure 6. Percentages of irrigated area in the southeastern region for each irrigation method according to the 2017 Agricultural Census.

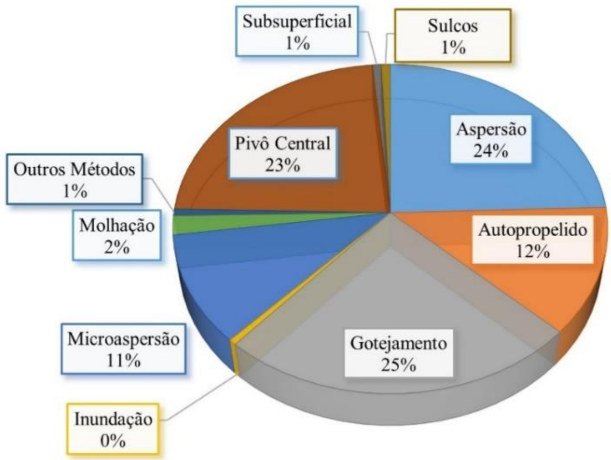
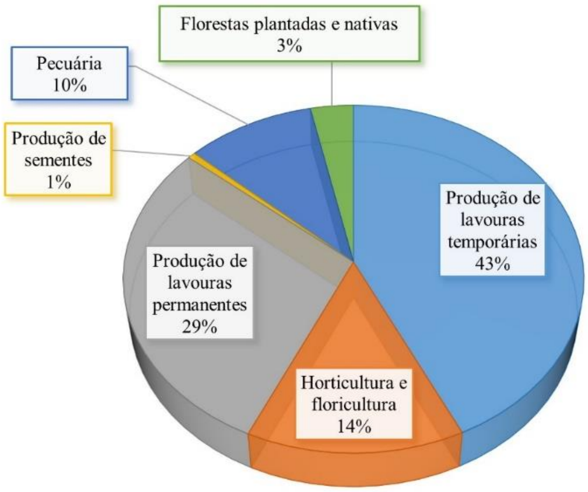


Figure 7. Percentage of destination/type of use of the irrigated area in the Southeast Region by each irrigation method according to the 2017 Agricultural Census.



6 CONCLUSION

The 2006 and 2017 Agricultural Censuses revealed that the Southeast Region is the country's main irrigation region. The states of Minas Gerais and São Paulo represent 16.6% and 16.0%, respectively, of the country's total irrigated area.

The 2006 and 2017 Agricultural Censuses revealed the predominance of pressurized irrigation in Brazil, especially in the Southeast Region, where drip irrigation accounts for the majority of the area, with 25% of the irrigated area, closely followed by sprinkler irrigation (24%) and central pivot irrigation (23%).

The irrigated area in the Southeast Region, according to the 2017 Census, is used mainly for temporary crops (48%), permanent crops (29%), horticulture and floriculture (14%) and livestock (10%).

In the Southeast Region, flood irrigation accounts for less than 1% of the total area. This situation sets us apart globally, as flood irrigation is predominant worldwide and less efficient. This important factor in explaining agricultural productivity in Brazil should be taken into account to encourage the development of better financing conditions that could make our agribusiness more competitive than that of other countries.

7 ACKNOWLEDGMENTS

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