

THE EXPANSION OF CENTER-PIVOT IRRIGATION IN THE CERRADO BIOME

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1 ABSTRACT

In the Cerrado biome, irrigation plays a key role in food production and local socio-economic development. In this region, with general gentle topography and large areas planted with annual crops, center pivot, for its automation and uniformity in water application, is the preferred irrigation system. In the last two decades, the Cerrado region has concentrated roughly 80% of all center pivots installed in the Brazilian territory. The region alone has a potential irrigation area of 26.5 Mha and as so it is expected that center pivot irrigation continues increasing. By considering the average trend from recent years until 2050, irrigated area in the Cerrado will still be short from the potential area classified as high priority for irrigation expansion (6.3 Mha). However, as many of these areas are considered of maximum interest for public intervention, the increase trends could be higher than expected.

Keywords: agricultural water use, irrigation demand, water balance.

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2 RESUMO

A irrigação desempenha um papel fundamental na produção de alimento e desenvolvimento socioeconômico local no Cerrado. Nessa região, com topografia geralmente plana e grandes áreas plantadas com culturas anuais, o pivô central, por sua automação e uniformidade de aplicação, é o sistema de irrigação mais utilizado. Nas as últimas duas décadas a região do Cerrado tem concentrado aproximadamente 80% de todos pivôs centrais do Brasil. Somente nessa região potencial de área irrigada chega aos 26.5 Mha e, dessa forma, é esperado que áreas irrigadas por pivôs centrais continuem a crescer. Mesmo considerando a projeção de crescimento médio de áreas irrigadas dos últimos anos até o ano de 2050, a área total irrigada ficará distante do número classificado como alta prioridade em expansão da irrigação (6.3 Mha). Contudo, como muitas dessas áreas são consideradas de máximo interesse para intervenção pública, as tendências podem ser maiores que as esperadas.

Palavras-chave: uso da água na agricultura, demanda de irrigação, balanço hídrico.

3 INTRODUCTION

Brazil irrigated area has gone from nearly 460 thousand hectares in 1960 to more than 6.95 Mha in 2017. Most of this development has happened in the Brazilian savannah (Cerrado), which is the second largest biome in Brazil and covers 24% of its territory. The region is of great importance for agriculture in the country (KLINK, 2014; RADA, 2013; RODRIGUES; DOMINGUES, 2017) and is largely affected by rainfalls seasonality. Thus, irrigation plays a key role in increasing food production and social development in the region.

Due to its automation, water application uniformity and relatively ease operation, the center-pivot has been the preferable irrigation system to irrigate a huge variety of crop. Although the first center pivot has only been implemented in the region in 1979, this system has been responsible for almost 40% in the annual increase in irrigation systems for the last two decades (ANA, 2019).

The observed increase in water shortages and conflicts experienced in many of its watersheds is often associated to the rapid expansion of center pivots in the Cerrado (MANETA et al., 2009; POUSA et

al., 2019). Unfortunately, the water dispute may worsen due to the growth of irrigation in the region. Therefore, the expansion of irrigated areas should raise awareness for water managers.

Considering the importance of center-pivot irrigation in the socio-economic development of the region, the objective of this study was to take an in-depth look at the expansion of center-pivots irrigation in the Cerrado biome.

4 MATERIALS AND METHODS

In order to assess the development of center pivot irrigation in the Cerrado biome, the database recently made available by the Brazilian National Water Agency (ANA – Agência Nacional das Águas) was analyzed. This database is a collection of areas irrigated by center-pivots mapped in the Brazilian territory for a series of year from 1985 to 2017 (ANA, 2019). The center pivot areas were mapped using satellite images from high and moderate spatial resolution and the final product is a result of a joint effort from ANA and the Brazilian Agricultural Research Corporation (EMBRAPA – Empresa Brasileira de Pesquisa Agropecuária).

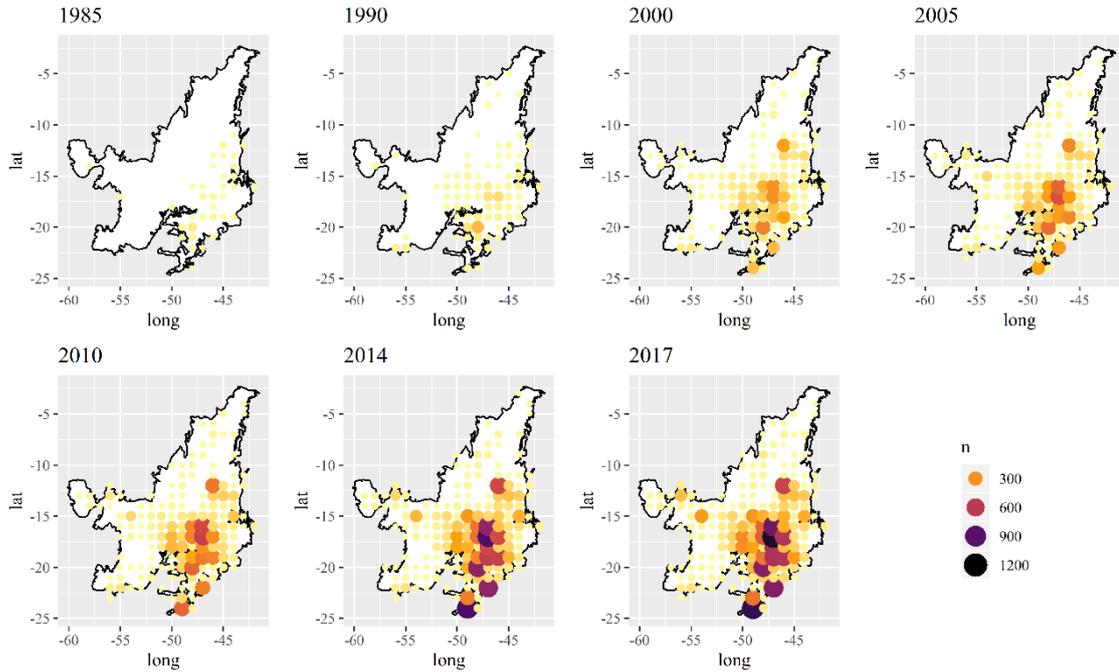
Although they have expanded to many regions within the Cerrado in the late 90's and early 2000's, the largest expansion remained in the central-southern region of the Cerrado (states of Minas Gerais, Goiás and São Paulo).

5 RESULTS AND DISCUSSION

5.1 Center-pivot expansion

The Cerrado has been the main region for installation of new center-pivots (Figure 1) for the last four decades.

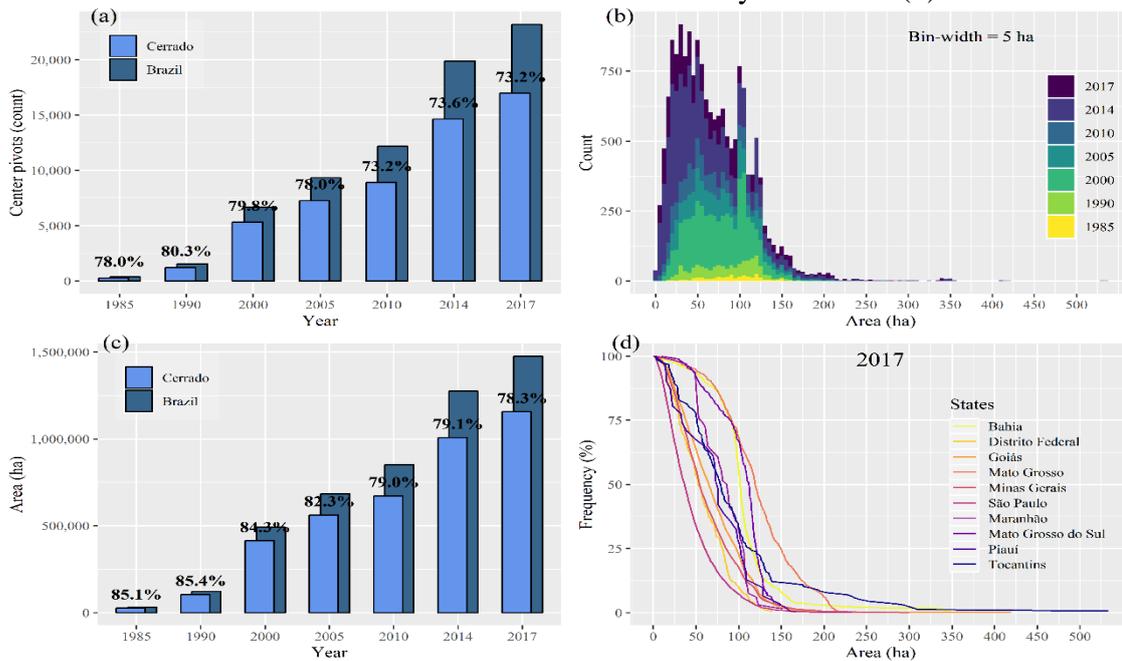
Figure 1. Location and number of center-pivots in the Cerrado biome



In 1985, the Cerrado possessed 78% (283 units) of all of these systems installed in Brazil (Figure 1 and 2a), of which most concentrated in the states of Minas Gerais and São Paulo. In 2017, the Cerrado still possess over 73% (16,964 units) of all

installed center-pivots. The Cerrado has also maintained the majority of all irrigated areas by center pivots across the Brazilian territory, from 85.2% in 1985 to 78.3% in 2017 (Figure 2c).

Figure 2. Proportion of center pivots in the Cerrado biome (a), number of center pivots by size (b), area of center pivots in the Cerrado biome (c) and frequency of center pivots by size in each state within the Cerrado biome in the year of 2017(d)



A histogram of the number of center-pivots and their respective areas is shown in Figure 2b. The peak in center-pivots with about 100 ha after 2000 relates to the implementation of center pivots in western Bahia, while the peak near 120 ha relates to the state of Mato Grosso. Figure 2b also shows a decrease tendency in the center pivot sizes, which average size was 92.8 ha in 1985 and reduced to 68.1 ha in 2017. This is mostly due to a large increase in smaller center pivots (< 50 ha) for the last decade in the states of Minas Gerais, Goiás and São Paulo, which can be assigned to both low water availability and high demands.

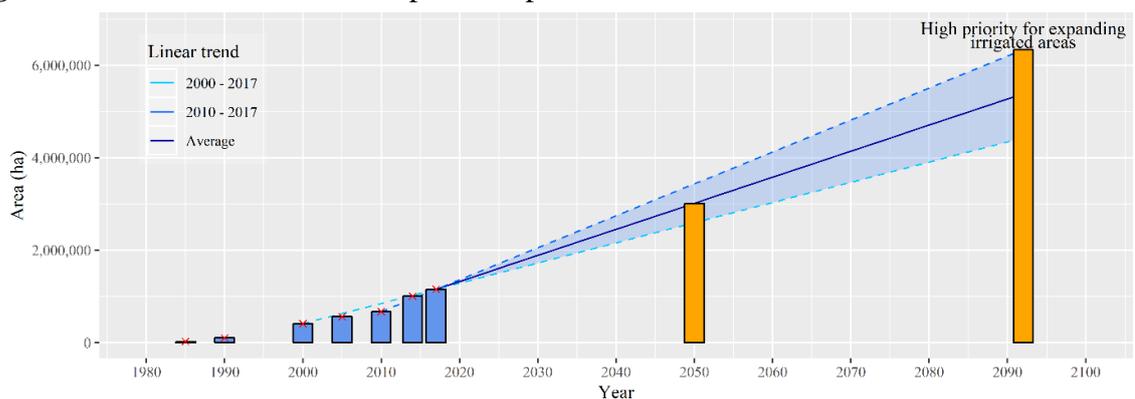
The frequency of center pivots by their given areas for each state within the Cerrado biome in 2017 is presented in Figure 2d. It may be noted that the states with higher average sizes of center pivots are Mato Grosso (120.92 ha), Bahia (105.08 ha) and Mato Grosso do Sul (101.98 ha), while the states with smallest center pivots are São Paulo (44.19 ha), Minas Gerais (62.77 ha) and the Federal District (56.32 ha). At 80% probability, the area of center pivots is smaller or equal to 156.02 ha (Mato Grosso), 126.17 ha (Tocantins),

122.69 ha (Mato Grosso do Sul), 120.29 ha (Bahia), 106.29 ha (Maranhão), 102.75 ha (Piauí), 102.63 ha (Goiás), 94.68 ha (Minas Gerais), 84.22 ha (Federal District) and 67.30 ha (São Paulo).

5.2 Future

The area occupied by center-pivots has almost doubled since 2010 and it is expected to increase even further. ANA has reported an expected increase in the country’s total irrigated area by 45% until 2030 which, if applied to the Cerrado, would represent an increase of approximately 520,000 ha (40,000 ha year⁻¹). However, irrigated areas have predominantly increased in the Southeast and Central-West regions of Brazil (ANA, 2017) and, therefore, the increase in the irrigated area for the Cerrado should be even greater. The annual irrigated areas increase in recent years shows a trend ranging from 43,000 ha year⁻¹ (2000-2017) to 69,000 ha year⁻¹ (2010-2017) and, by considering the average trend (~56,000 ha year⁻¹), irrigated area could reach up to 3 Mha by 2050 (Figure 3).

Figure 3. Linear trends for center-pivots expansion until 2050



Although expressive, this area is still short when compared to Brazil’s potential expansion for irrigated areas. Brazil’s addable area for irrigated purposes is estimated to be close to 75 Mha, of which

26.5 Mha (35%) are in the Cerrado alone (FEALQ, 2014). The projection of 3 Mha in 2050 is also far from the area classified as high priority in expansion (6.3 Mha), which are areas where irrigation may expand

without compromising public supply or raising conflicts over its use (FEALQ, 2014). Even by considering the trend observed from 2010 to 2017, of approximately 69,000 ha year⁻¹, irrigated areas are expected to only achieve the high priority areas in 2092.

It's important to highlight that high priority regions for the expansion of irrigated areas concentrate most in the MATOPIBA (an acronym formed by the states of Maranhão, Tocantins, Piauí, and Bahia), an important agricultural frontier. Many of these regions are considered areas of very high interest for public intervention (FEALQ, 2014).

An important concern for the future in the Cerrado region is about the limited supply of fresh water that are not distributed evenly. Besides of this, the region has some closed watersheds where the current disputes over water use could further increase, especially considering that climate change studies have already reported longer drought periods (PIRES et al., 2016) and raises in air temperature (CAMILO et al., 2018; DE JONG et al., 2018) for the Cerrado region. Climate change has also been documented to increase evaporation rates and reduce the water availability in irrigation reservoirs, jeopardizing double cropping (ALTHOFF; RODRIGUES; SILVA, 2019). In this context, better water resources management, along with the use of more efficient irrigation technologies will be essential in upcoming decades.

The adoption of adequate agricultural water management practices contemplating technical, infrastructure,

social and economic factors is, therefore, crucial for the proper expansion of irrigated areas (IGLESIAS; GARROTE, 2015). Iglesias & Garrote (2015) highlighted many measures that can be adopted to reduce the pressure put up by climate change and increased demand. Among these measures, the ones expected to be most efficient are the improvements in monitoring, coordination and planning, innovation in water use efficiency, increase in rainfall water interception and implementation of small-scale water reservoirs on farmland.

6 CONCLUSIONS

The expansion of center pivots occurred mostly in the core of the Cerrado, in northern São Paulo, western Minas Gerais and Goiás. In these areas, in recent years the center pivot sizes has diminished.

The Cerrado biome has been one of the main regions for expanding irrigated agriculture and will continue to be in the future, but considering the increase trends from recent years, the Cerrado is still far from achieving the potential area for expansion.

7 ACKNOWLEDGMENTS

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001 and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

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