ARTIGO TÉCNICO

THE EXPANSION OF CENTER-PIVOT IRRIGATION IN THE CERRADO BIOME

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ABSTRACT: In the Cerrado biome, irrigation plays a key role in food production and local socio-economic development. Among irrigation systems implemented, the center-pivot has been widely chosen for its automation and uniformity in water application. In the last two decades Cerrado has concentrated roughly 80% of all center-pivots installed across the Brazilian territory. The region alone has a potential irrigation area of 26.5 Mha, expecting to continue with large expansion of center-pivots irrigated areas, especially considering the agricultural frontiers (MATOPIBA). 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.

A EXPANSÃO DA IRRIGAÇÃO POR PIVÔS CENTRAIS NO CERRADO

RESUMO: A irrigação desempenha um papel fundamental na produção de alimento e desenvolvimento socioeconômico local no Cerrado. Dentre os diversos sistemas de irrigação, o pivô central é amplamente utilizado devido sua automação e uniformidade de aplicação de água. Nas as últimas duas décadas o Cerrado tem concentrado aproximadamente 80% de todos pivôs centrais do Brasil. Somente nessa região potencial de área irrigada chega aos 26.5 Mha, onde espera-se um grande crescimento das áreas irrigadas por pivôs centrais, especialmente considerando-se a fronteira agrícola (MATOPIBA). Mesmo considerando a projeção de crescimento médio de áreas irrigadas dos últimos anos até o ano de 2050, a área

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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 agrícola da água; demanda pela irrigação; balanço hídrico.

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 (Lima, 2011).

Among the irrigation systems implemented nationwide, the center-pivot has been widely chosen for its automation, uniformity in water application and easier operationalization. Although the first center-pivot has only been implemented in 1979, this system has been responsible for almost 40% in the annual increase in irrigation systems for the last two decades (ANA, 2019).

Often associated to the rapid expansion of center-pivots in the Cerrado is the increased water shortages and conflicts experienced in many of its watersheds (Maneta et al., 2009; Pousa et al., 2019). Unfortunately, these 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.

SUBJECT DESCRIPTION

Center-pivot expansion

In order to evaluate the development of irrigation using center-pivots in the Cerrado biome, we accessed an important database recently made available by the Brazilian National

Water Agency (ANA – Agência Nacional das Águas). 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).

For the last four decades has the Cerrado being the main region for implementation of new center-pivots (Figure 1). In 1985 the Cerrado possessed 78% (283 units) of all of these systems installed in Brazil, 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 and, although they have expanded to other regions of 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).

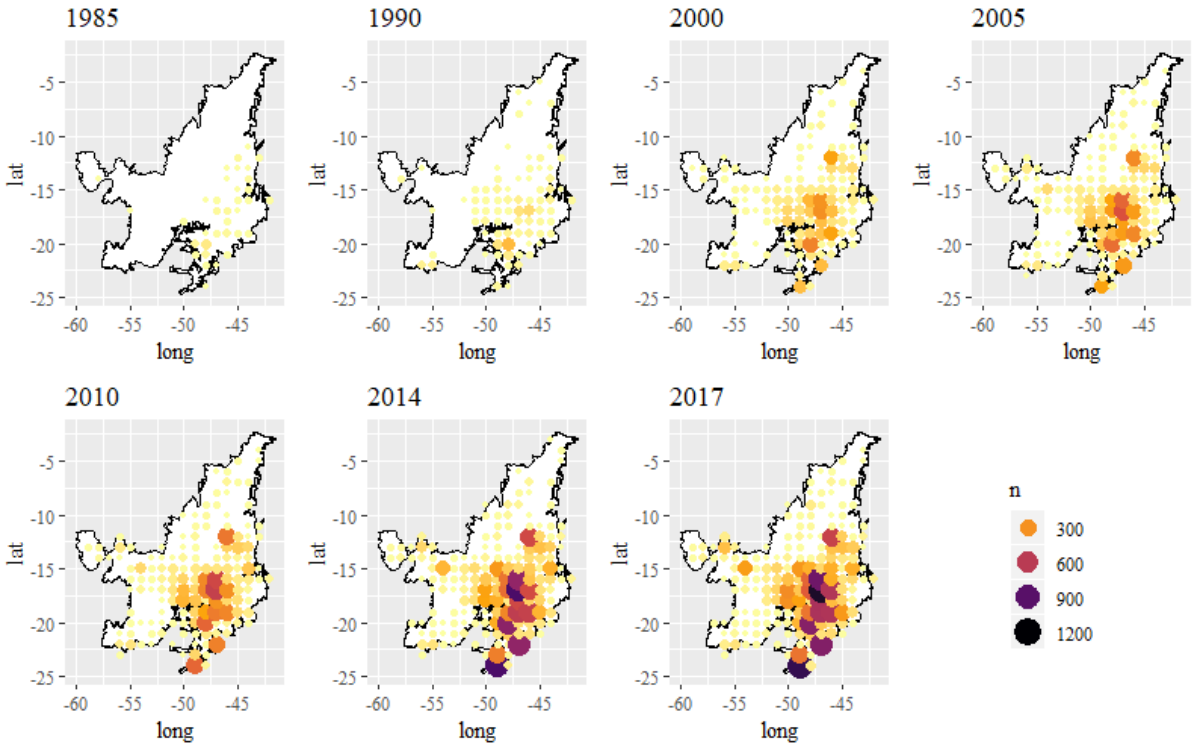

Figure 1. Location and number of center-pivots in the Cerrado biome.

The Cerrado has 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 2a). A histogram showing the number of center-pivots and their respective areas are 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 2 also shows a decrease tendency in size of center-pivots, 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.

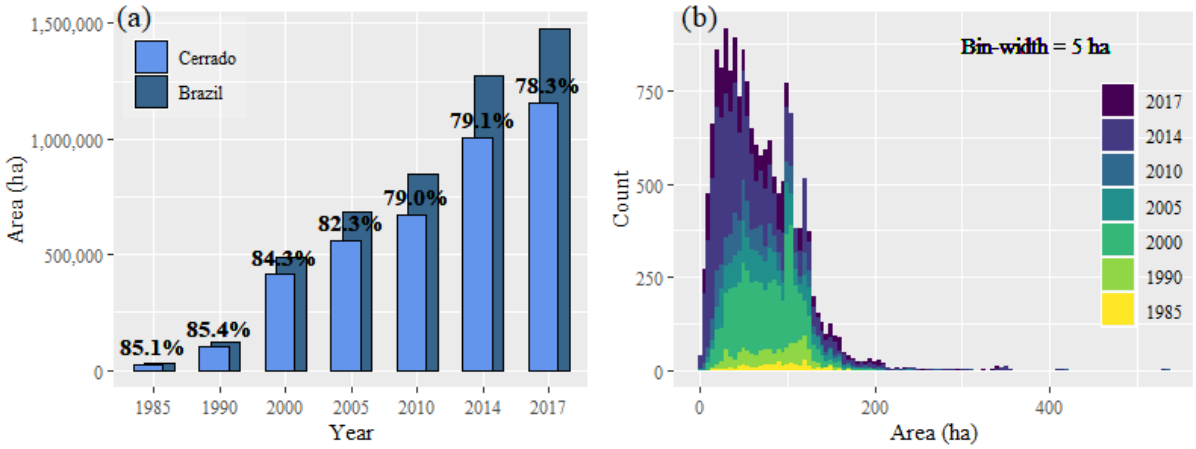

Figure 2. Proportion of center-pivots in the Cerrado biome (a) and number of pivots by size (b).

The increased number of small center-pivots could be related to producers raising consciousness of the benefits of this irrigation system, such as the higher yields, secured production and ease of operationalization.

Future

The area occupied by center-pivots has almost doubled since 2010 and 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 area for the Cerrado should be even greater . The annual increase of irrigated areas in recent years shown 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).

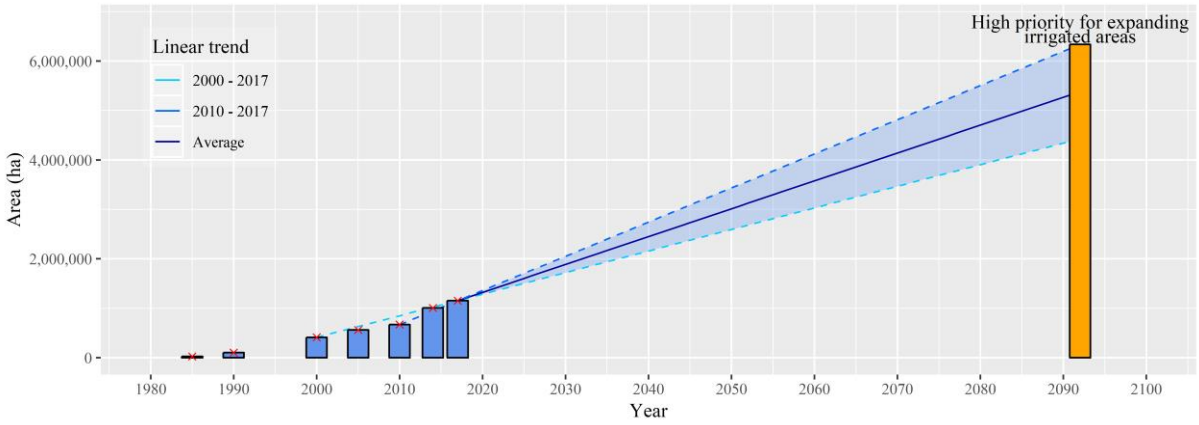

Figure 3. Linear trends for center-pivots expansion until 2050.

Although expressive, this area is still short to 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 of very high interest for public intervention in the aid for expanding irrigated areas (FEALQ, 2014) and, as the MATOPIBA is well-known for its agricultural intensification and high-end technology, irrigation expansion likely to come mainly from center-pivots.

The current disputes over water use could further increase in many regions, 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 changes have also been documented to increase evaporation rates and reduce the water availability in irrigation reservoirs, jeopardizing double cropping (Althoff et al., 2019)

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) highlight many measures to adapt to 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. However, for these measures and the expansion of center-pivots to be implemented in a sustainable way, their impacts on the hydrological cycle of hydrographic basins should be better assessed.

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, the size of center-pivots implemented in more recent years has become smaller, for farmers are now taking full advantage of this technology in areas with aptitude for it.

The Cerrado biome has been one of the main regions for expanding irrigated agriculture and will continue to be in the future, especially considering latest agricultural frontiers, such as the MATOPIBA, and areas with high interest for public intervention in the expansion. Also, by considering the increase trends from recent years, the Cerrado is still far from achieving the potential area for expansion

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