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Review

Potentiality of sugarcane expansion under irrigation conditions considering natural and potential water availability

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ABSTRACT

In the face of population growth and the consequent increase in water and energy consumption, coupled with concern about climate change, society has sought renewable energy sources such as biofuels. Brazil has excelled in the production of ethanol using sugarcane as its raw material, and in recent years there has been an advance in sugarcane production towards the Brazilian Cerrado due to the existence of suitable areas and the availability of water to expand irrigated agriculture. Recognizing this, we sought to analyze the potential for expansion of the planted areas in the Paracatu River basin under full and deficit conditions of irrigation and both natural and potential water availability. Potential irrigation areas (PIAs) were estimated as a function of the average required unit flow rates for sugarcane irrigation and water availability according to the criteria for granting concessions in the State of Minas Gerais, which were compared to the areas currently planted with sugarcane and with all crops. In a macro scale analysis, considering that the water available is only for irrigation and that it is the only restrictive factor for the expansion of the agricultural areas, based on the minimum annual flow, it would be possible to irrigate in the Paracatu River basin more than 120,000 ha, indicating that the water demands could be supplied in 21% of the planted areas already existing in the basin, which could be increased by up to 19% by the use of deficit irrigation. With the availability of water potential, it would be possible to supply the water demands of the entire area planted with permanent and temporary crops, and there is also the possibility of expansion into up to 170% of these areas.

1. Introduction

The increase in the per capita consumption of essential inputs, such as water and energy, coupled with growing concern about climate change has made society increasingly seek sources of renewable energy as an alternative for reducing oil consumption (Fargione et al., 2008; Silva et al., 2011; Lourenzani et al., 2016). Renewable sources include biofuels, mainly produced by oilseeds and sugarcane, thus increasing the search for areas suitable for planting these crops.

Brazil has been considered a great power for the expansion of biofuel production without compromising food production, since there are agricultural areas suitable for the production of the raw material, with favorable edaphoclimatic conditions and relative abundance in water resources, and, in addition, the country has the technology and labor, highlighting it in the international market (Nass et al., 2007; Goldemberg et al., 2008; Lourenzani et al., 2016).

Due to these characteristics, among the raw materials for the production of biofuels, Brazil has been outstanding in the production of soybeans, corn and sugarcane. Among the three crops cited, sugarcane is the third temporary crop in terms of area occupation, but, nonetheless, the country has stood out in the production of ethanol, using it as raw material that is also used in sugar production and Animal feed, mainly due to the photosynthetic conversion of sugarcane, which allows productivity well above other crops. In 2015 Brazil produced about 30 billion liters of ethanol and it was estimated that in the 2016/17 crop the production could exceed this value (EPE, 2015; CONAB, 2016).

Sugarcane production in Brazil started in the Northeast region and today is concentrated in the Center-South region, due to the favorable climatic conditions for its production. However, in the search for new areas for cane production in recent years, there has been an advance of the agricultural frontier toward the Brazilian Cerrado owing to the greater availability of water and the existence of areas suitable for sugarcane cultivation, even if precipitation is concentrated in certain months of the year (Loarie et al., 2011).

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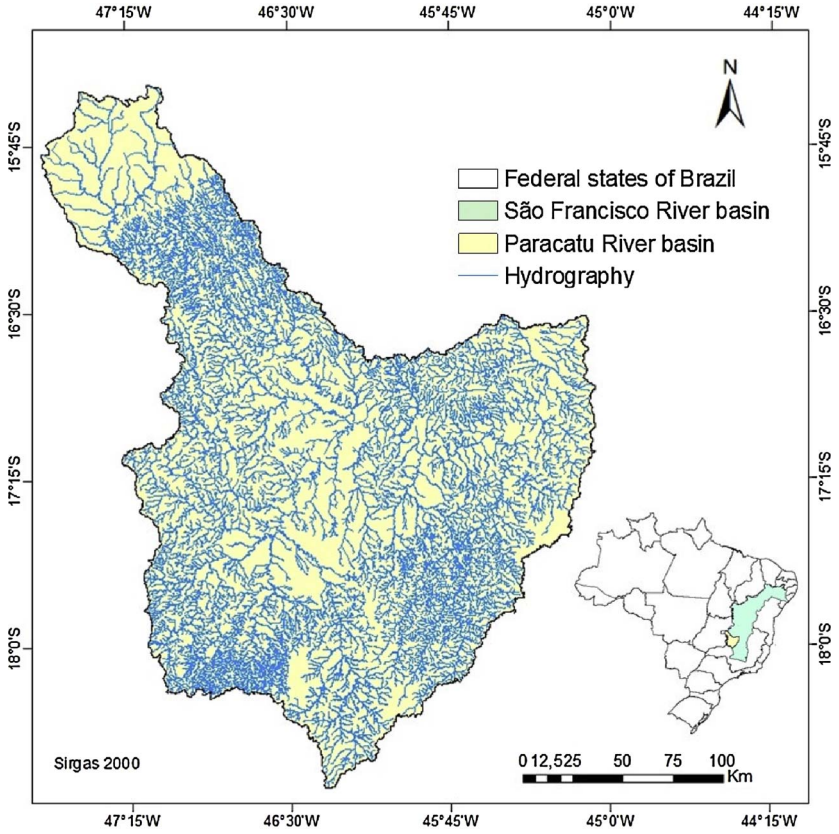

Fig. 1. Location of Paracatu River Basin and hydrography (scale 1: 50,000).

Thus, the possibility of expanding agricultural areas for the production of biofuel feedstocks in places where the rainfall regime is not favorable to the production under dry conditions is directly related to locations where water availability is not already committed, and the proper management of both water resources and irrigation is essential for achieving sustainable production.

In view of the above, this work aimed to analyze the possibility of expansion with sugarcane of potentially irrigable areas associated with the crops cultivated more in the Paracatu River basin, and in its main sub-basins, under full irrigation conditions and with deficits based on natural and potential water availability.

2. Material and methods

2.1. Characterization of the study area

The water catchment area of the Paracatu River (Fig. 1) is located in the upper middle São Francisco between the geographic coordinates of 45°10′00”/47°30′00”W and 15°30′00”/19°30′00”S and has a drainage area greater than 4,500,000 ha The Paracatu River is the tributary with the highest real contribution for the formation of the São Francisco River flow, contributing with approximately 18.20% (Pereira et al., 2007).

According to the Köppen classification, the basin presents a megathermal rainy climate of type Aw, characterized by a rainy tropical climate, in which the rains are concentrated in the period of October to April, the greater average annual precipitations occurring in the south and northwest of the basin and decreasing towards the mouth (Vasconcelos et al., 2012).

The main economic activities developed in the basin are livestock, agriculture and mineral exploration (Rezende, 2013). The main crops cultivated in the municipalities belonging to the basin are soybeans, beans, maize and sugarcane, with the municipalities of Unaí, Paracatu and Cristalina having the largest planted areas (IBGE, 2015).

2.2. Water availability

The water availability (WA) of the study area was obtained in the “Study of regionalization of flow rates for the improvement of the granting process in the State of Minas Gerais” (GPRH; IGAM, 2012). For the natural water availability, the minimum flow with seven days of duration with probability of occurrence of ten years ($Q_{7.10}$) was considered, and, for potential water availability, the mean long-duration flow (Q_{mld}). Table 1 shows the equations for the three hydrologically homogeneous regions (RHH) of the study area. Homogeneous regions allow to define areas that have similar hydrologic responses, i.e., defined as a group of stations with similar probability distribution functions of climatological and/or hydrological parameters. Thus, for a given homogeneous region, records may be extrapolated more accurately (Nathan and Mcmahon, 1990), and similar water management schemes can be developed, as well as, agricultural production planning.

The WA, natural and potential, for each river segment, was estimated by equation

$$Q_{local} = \left[Q_J - \sum_{i=1}^{n} (Q_{local\ m-c})_i / 1000 \right] \quad (1)$$

where Q_{local} is the local flow in the river segment of interest (L s^{-1}), Q_j

Table 1
Regionalization equations of the flow in the Paracatu River Basin.

RHH	$Q_{7,10}$	Q_{mld}
I	$Q_{7,10} = 0.11673\ Peq_{750}^{0.98702}$	$Q_{mld} = 0.98845\ Peq_{750}^{0.97146}$
II	$Q_{7,10} = 0.12054\ Peq_{750}^{0.90740}$	$Q_{mld} = 0.88746\ Peq_{750}^{0.93582}$
III	$Q_{7,10} = 0.13035\ Peq_{750}^{0.89122}$	$Q_{mld} = 0.77112\ Peq_{750}^{0.97078}$

where Peq_{750} is flow equivalent to the volume precipitated considering the subtraction of 750 mm rainfall abstraction factor for the formation of the flows.