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## Rapid expansion of sugarcane crop for biofuels and influence on food production in the first producing region of Brazil

Lilliane Renata Defante<sup>a</sup>, Olivier François Vilpoux<sup>b,\*</sup>, Leandro Sauer<sup>a</sup>

<sup>a</sup> Federal University of Mato Grosso do Sul – UFMS, Campo Grande, Mato Grosso do Sul, Brazil

<sup>b</sup> Catholic University of Campo Grande – UCDB, Campo Grande, Mato Grosso do Sul, Brazil

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## ABSTRACT

This paper analyzes the influence of sugarcane on soybean and livestock productions in the state of Mato Grosso do Sul, in the Midwest of Brazil, the main agricultural region of the country. We also observed indirect influence of sugarcane in non-producing regions. Two periods have been analyzed, 2006–2009, which is the beginning of the sugarcane expansion, and 2009–2013, which is the main expansion phase. In this state, sugarcane is essentially used for ethanol production, and soybean and livestock production are the main food products, together with corn. The shift-share method was used, with decomposition of the evolution in area, productivity and geographic location effects. The area effect was divided between scale and substitution effects. Data were collected from national and local databases. From 2006 to 2009, sugarcane areas replaced soybean in the best land areas. In the second period, sugarcane and soybeans occupied pasture areas. None of the activities surveyed decreased its production between 2006 and 2013. Sugarcane generated positive externalities on food production in the state, forcing the evolution of productivity, mainly in cattle raising. Positive impact of sugarcane on the productivity of livestock and soybean reduces indirect effects of the production of biofuels on land use and didn't have a negative effect on food production. The increase in food consumption had a much greater impact on the evolution of crops, with a high increase in cultivated areas of soybean and pastures in Brazil.

### 1. Introduction

In the early twenty-first century, worldwide agriculture and livestock husbandry face major challenges, such as population growth, changes in food consumption patterns, natural resource scarcity, environmental degradation and climate change. The Food and Agriculture Organization (FAO, 2015) emphasizes the necessity to increase food production due to world population growth, expected to increase from 7.2 billion people in 2015 to 9.6 billion by 2050. Parallel to that, there will be an increase in per capita food consumption in line with rising incomes in emerging populations, with a focus on China and India.

World average per capita income is expected to grow by 84% between 2010 and 2050. Consequently, the per capita consumption of meat is expected to increase by 61%. Considering the increase in world population in this period, the world demand for meat is expected to grow 120% (FAO, 2015). In addition to the expected meat consumption growth in the same period, there is a need to increase the production of soybeans by 148% and corn by 117% (FAO, 2015). These requirements anticipate increased pressure on natural resources such as land and water, which are already affected in many parts of the world.

Brazil is in a privileged situation, with agricultural production in constant growth, water abundance and new areas of available land, particularly in the savannah area (*cerrado*) located in the Western and Northeastern regions. In 2016, the country accounted approximately for 40.7% of sugarcane world production, followed by India (18.4%) (FAO, 2018). UNICA (2018) notes that for the 2016/2017 harvest, processed sugarcane amounted to 651.8 million tons in Brazil. The same year, Brazil accounted for 31.34% of soybean world production, behind the United States, with 33.84% (USDA, 2016). In 2015, the country accounted for 22.06% of cattle production, the second largest in the world, behind India, with 31.19% (USDA, 2015).

Beyond food needs, the world faces another challenge, which is growing energy needs. Faced with the lack of sustainability of fossil energy, which is non-renewable, and the impacts of this type of energy on the global climate, the need to find alternatives is becoming increasingly important. In this context, there is growing demand to use agricultural raw materials for the production of renewable energy, that is often mentioned as competing with food supply (Murphy et al., 2011; UN Water, 2014; Koizumi, 2015; Manning et al., 2015; Paschalidou et al., 2016; Rulli et al., 2016). The growing demand for renewable

\* Corresponding author.

E-mail addresses: [vilpoux@ucdb.br](mailto:vilpoux@ucdb.br) (O.F. Vilpoux), [leandrosauer@uol.com.br](mailto:leandrosauer@uol.com.br) (L. Sauer).

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energy and food, with few possibilities to increase cultivated areas globally without deforestation, raises the problem of the choice of the best alternative.

In the first decade of this century, sugarcane experienced a large increase of areas in different regions of Brazil. From 2006 to 2016, the increase was 52% in Brazil. The states that most expanded sugarcane were Mato Grosso do Sul and Goiás, with an increase of 332 and 319%, respectively (UNICA, 2018). In these states, sugarcane is essentially transformed into ethanol and food production is represented by soybean, corn and beef cattle. In the 2015/16 harvest Goiás was the third largest Brazilian producer of corn, with 6.4 million tons and Mato Grosso do Sul the fourth, with 6.3 million tons. The state of Goiás was the fourth largest producer of soybean, with 10.2 million tons and Mato Grosso do Sul the fifth, with 7.2 million tons (CONAB, 2016b). In both states pastures occupy the largest area of production.

Despite the benefits of reducing fossil energy use, this expansion has been questioned because of the possible effects on food production (Murphy et al., 2011; FAO, 2015; Koizumi, 2015; Manning et al., 2015; Paschalidou et al., 2016; Rulli et al., 2016). Consequently, it is important to determine the level of competition between the use of land for food and for energy. As Goiás and Mato Grosso do Sul have a similar agricultural profile, we choose the last one, because of the availability of data on cattle production after 2006, date of the last national census on agriculture production in Brazil.

Corn was not analyzed in the research because in the Midwest region of Brazil, almost all of this crop (96% in 2016) is produced in the winter period, after the soybean harvest (CONAB, 2016b). Thus, the evolution of corn area follows the soybean, which explains the exclusion of the corn crop in the analysis.

In this context, the objective of the research is to analyze the influence of sugarcane for ethanol production in the production of food crops in the state of Mato Grosso do Sul, Midwest of Brazil, in the 2006–2013 period, focusing on soybean and beef cattle production. This objective allows us to identify the influence of sugarcane on the other two activities. Since the expansion of an activity in one region may have an indirect effect in another one, we also observed the evolution of the three activities surveyed in non-producing regions.

Production in Mato Grosso do Sul benefited from the fact that traditional states such as São Paulo, Minas Gerais and Paraná experienced a shortage of available land for the expansion of sugarcane and high rental and purchase prices for land (Centenaro, 2012). Parallel to that, there is a concern with the movement of livestock toward the north of the country, pushed by sugarcane, which occupies large areas of degraded pasture land (Domingues and Thomaz Junior, 2012). Correa (2013) also states that in addition to degraded pastureland, sugarcane is occupying soybean and corn crop areas, causing a negative impact on food production.

First, the importance of Mato Grosso do Sul is presented. Afterward, we discuss the shift-share method used in the research. Following this presentation, we address the methodology, results and discussion and final considerations.

## 2. Importance of Mato Grosso do Sul in food and bioenergy production

Over the past decade, the sugarcane area has expanded considerably in Brazil, mainly due to the use of areas occupied with other crops. This evolution can be explained by an increased ethanol and sugar consumption (Walter et al., 2014). From 2003, the construction of new plants was driven by the growth of sugar demand in the international market and the significant increase of ethanol use in the country with the arrival of flexible-fuel cars (Gallardo and Bond, 2011).

Although sugarcane production is higher in the state of São Paulo, with 56.1% of the national production in 2016, the Midwest is the region with the greatest expansion of the crop in the last 10 years, with a production of sugarcane which went from 9.6% of national production in 2006 to 20.6% in 2016, mainly in the states of Goiás and Mato Grosso do Sul (UNICA, 2018).

In relation to agriculture, Brazil concentrates the use of its land on four products, livestock, soybean, corn and sugarcane. According to MAAF (2015), Brazil has 240 million hectares of used arable land, with 160 million hectares occupied by pastures, which are used mainly by cattle, for meat and milk production. Of the 80 million hectares remaining, in 2016 8.9 million hectares were occupied by sugarcane (CONAB, 2016a), 33.4 million hectares by soybean and 16 million hectares by corn, considering 10.5 million hectares of corn harvested as a second crop, after soybean (CONAB, 2016b). These data show the great concentration of Brazilian farming in the productions researched in this paper.

Expansion of sugarcane in the state of São Paulo does not automatically influence food production, since in addition to this crop, the state of São Paulo is only a major national producer of beef and orange juice. In parallel, the Midwest region has become, since the beginning of the century, the largest Brazilian region producing soybean, maize and beef (Table 1) and the largest export center, with an increasingly important role in the supply of food for the world. According to MAAF (2015), Brazilian exports of soy, maize and beef accounted respectively for 41, 16 and 20% of world exports of these foodstuffs in 2015, as well as 47% of world sugar exports.

Table 1 helps to select the best regions to analyze the impact of sugarcane evolution on food production. The states of Mato Grosso and Paraná are major food producers, but sugarcane production has stagnated in these states in the last ten years, with no significant impact on food production. São Paulo state is by far the largest producer of sugarcane and, despite the small variation of percentage in production between 2006 and 2016, the increase in area was 1.8 million hectares, much more than in the states of Goiás, in second place with 680 thousand hectares, Minas Gerais and Mato Grosso do Sul, in third position, both with 550 thousand hectares. However, in the state of São Paulo, the competitiveness of sugarcane with food for land use is essentially limited to cattle breeding, since the state does not have significant areas of soy and corn.

The most complete states are Goiás and Mato Grosso do Sul, with large areas of sugarcane that went through a strong expansion between

**Table 1**

Participation of the main sugarcane producing states in the soybean, corn and oxen productions, in 2016.

Source: Based on UNICA (2018) and MAPA (2018).

	Sugarcane	Evolution of sugarcane 2006–16 (%)	Soybean	Corn	Slaughtered oxen
São Paulo	56,1	38	2,8%	4,5%	9,4
Goiás	10,4	319	9,6%	10,6%	9,5
Minas Gerais	9,7	119	4,4%	8,4%	8,3
<b>Mato grosso do Sul</b>	<b>7,7</b>	<b>332</b>	<b>7,6%</b>	<b>10,0%</b>	<b>11,1</b>
Paraná	6,2	26	17,3%	19,2%	4
Mato Grosso	2,5	24	27,0%	26,9%	15,4

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