Sugarcane crop for biofuel production, demand on soil resource and food security in Brazil

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Abstract
The expansion of agriculture is responsible for major changes of land use in Brazil. There is a great potential for growth of the ethanol production in Brazil, due to growing demands from both domestic and international markets. Sugarcane is the raw material for sugar and ethanol production. We present a sugarcane land expansion scenario for the next 10 years (2008-2017); it takes into account the market forces (supply and demand). The total land required for the sugarcane cropping will be around 17 million hectares in 2017. This sugarcane expansion is planned to occur in substitution of pasture and degraded lands. There are approximately 37 million ha of pasture area located in suitable zones for sugarcane cropping in Brazil. The concentration and extension of sugarcane cropped areas in the center-south regions of Brazil is associated with potential impacts to the environment, society, and economy. Thus, considering the dynamic interactions between the global effects of land use environmental impacts, and demands of agroenergy production and food security, it is important to implement sustainable effective regulating policies targeting sugarcane crop expansion and to carry out ex ante evaluations of the impacts derived from the expansion of sugarcane crops in different regional scenarios.

Key Words
Ethanol, soil resource, sustainability impacts, policy intervention.

Introduction

The expansion of agriculture is responsible for major changes of land use in Brazil. As a response mainly to market demands, new agricultural frontiers have been gaining ground in the country. Over the past 15 years, the growth of Brazilian agricultural exports increased by 6% per year and there are opportunities for this growth to continue at rates equal or greater than this (CONAB 2007). Brazilian livestock and agricultural production are large and diverse. The total land area of the country is 845 million hectares (Mha), of which approximately 260 Mha are under agriculture and pastoral use (FAO 2004). The area of Brazilian land occupied by agriculture was approximately 60 Mha, of which about 22 Mha with soybeans, 12 Mha by corn, and nearly 7 Mha by sugarcane, while the area under pasture was about 200 Mha in the 2007/08 season (IBGE 2008). The country has the second largest bovine herd in the world, after India, but the standard beef cattle production systems are based on animals feeding on open air pasture conditions, only a small amount of animals, around 2.7 million, that corresponded to 6.7% of the slaughtered animals, were fed in feedlots in 2008 (Ferraz and de Felicio 2009).

Projections made by the Brazilian Ministry of Agriculture, Livestock, and Food Supply (MAPA) state that Brazil would soon become the world leader in the production of biofuels (MAPA 2008). According to MAPA (2007) the amount of agroenergy crops cultivated in the country can still expand, since 91 million hectares of land are available for agricultural expansion, provided the legal and normative requirements related to land use and occupation are complied with. Sugarcane is the raw material for both sugar and ethanol production. Among all raw materials used to produce ethanol, sugarcane presents the highest yield and the lowest cost, resulting in lower production costs to the country (MAPA 2007). Sugarcane cropping is concentrated in the Center-South regions of the country and the state of São Paulo contains around 60% of the Brazilian sugarcane crops, occupying about 3.8 Mha (CONAB 2008).

The expansion of sugarcane cropped areas will occur mainly as a result of the implementation of new sugar and ethanol industrial plants and the growth of existing industrial plants (Macedo 2002). Sugarcane has a very high impact in the changes of soil use; therefore the formulation of public policies regarding agroecological zoning should be the base in each State in order to expand sugarcane crops in a sustainable way in the country.

This paper presents a sugarcane land expansion scenario for ethanol production for the 2008-2017 period, based on available data regarding ethanol demand and supply in Brazil, formulated by the Brazilian Energy Research Corporation (EPE 2008). Based on the sugarcane land expansion scenario for ethanol produce, we compared the land demand for sugarcane production until 2017 and the currently available land for food production in Brazil, and present an initial discussion about the impacts of land use to energy production and the food security in the country. Even if there is, in Brazil, availability of land for both energy production and to meet the demands of future food production, it is necessary to safeguard the natural resources, and in some cases even increase the environmental quality of agricultural development, in order to contribute to global sustainability.

Methods

The land demand scenario for sugarcane crop aiming at ethanol production was developed considering the bioethanol supply and demand scenarios for Brazil. These were obtained from the document National Supply and Demand Projections for 2008-2017, published by the Energy Research Company, as part of the Decadal Energy Plan of the Brazilian Government (EPE 2008).

For the elaboration of the scenarios the premises adopted were: a tonelade (ton) of sugarcane produces in average 81.6 liters of ethanol; the average physical yield of sugarcane varied linearly from 81.4 tons/ha in 2008 to 86.2 tons/ha in 2017. The productivity value assumed in 2008 corresponds to the average Brazilian productivity in the 2007/08 seasons and the 2017 value assumes that average Brazilian productivity in 2017 will be equal to the average productivity of sugarcane in the state of São Paulo in the 2007/08 seasons, the state with the highest physical productivity in the country (Table 1). In order to develop the sugarcane expansion scenario for ethanol production in Brazil, we first estimated the amount of sugarcane, in tons, needed to produce additional ethanol to attend the ethanol supply predict by demand andsupply scenarios (EPE 2008). We considered a linear increase in the liters of ethanol produced by ton of sugarcane and in the physical productivity of cane in the period 2008/2017. Then we calculated the area needed to produce the sugarcane in this period. To calculate the amount of sugarcane by liter of ethanol produced we considered the industrial returns that are measured by the amount of TRS (Total Recoverable Sugar) obtained per ton of sugarcane. This index is directly related to climate behavior, which interferes in the level of sucrose concentration achieved by the plant and offers an indication of which regions have the best environmental and climatic conditions for growing this type of crop.

Table 1 shows the profile of sugarcane and ethanol production in the 2007/2008 seasons, including the average TRS, the amount of ethanol produced per ton of sugarcane and the average productivity for the Brazilian Center/South. (It is composed of following states: São Paulo, Minas Gerais, Rio de Janeiro, Espírito Santo in the southeast region and Paraná in the south region and Mato Grosso, Mato Grosso do Sul, Goiás in the central-west region) and for the North/Northeast (Acre, Amapá, Amazonas, Pará, Rondônia, Roraima and Tocantins - North region and Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia-Northeast region).

Table 1. Area sugarcane (thousand hectare), Production (thousand tonelade), Total Recoverable Sugar –TRS (Kg TRS/ tonelade sugarcane), quantity of ethanol produced per ton of sugarcane (liter ethanol/ tonelade sugarcane) and average physical productivity (tonelade sugarcane/ hectare) for the Center/South and North/Northeast regions and the Brazilian average in 2007/2008 seasons.

Region	Area sugarcane 2007/08 season (000s ha)	Production of Sugarcane (000s ton)	TRS (kg/ton)	Ethanol production (liter/ton)	Average Productivity (ton/ha)
Center /South	5,996	505,925	141.7	82.2	84.3
North /Northeast	1,075	65,885	133.8	77.6	65.8
São Paulo State	3,851	342,911	142.3	82.5	86.2
Brazil	7,071	571,810	140.7	81.6	81.4

Source: CONAB (2008).

The Center/South regions, in comparison with the North/Northeast regions, present a higher edaphoclimatic for sugarcane cropping, concentrated in the State of São Paulo (Table 1).

Results

The expansion scenario of sugarcane crops in Brazil, based on the EPE demand and supply scenarios, is shown in Table 2.

Table 2. Projections of ethanol supply, sugarcane production associated land requirement for cultivation, in Brazil, 2008 – 2017

Year	Ethanol Supply (Billion liter)	Sugarcane demand (000s ton)	Potential yield (ton/ha)	Total land required for ethanol production (000s ha)	Additional land required for ethanol production (000s ha)
2008	25.1	307.598	81.9	3,779	-
2009	29.5	361.121	82.4	4,409	630
2010	32.8	401.076	82.8	4,867	458
2011	36.9	450.715	83.3	5,443	576
2012	41.6	507.565	83.8	6,093	650
2013	46.5	566.728	84.3	6,763	670
2014	50.8	618.456	84.8	7,336	574
2015	55.0	668.856	85.2	7,887	551
2016	59.1	717.930	85.7	8,426	539
2017	63.9	775.391	86.2	9,048	621

The expansion scenario of sugarcane cultivation for ethanol production in Brazil starts from approximately 3.8 million ha (about half of total sugarcane cropping area, including crops directed towards sugar production), in 2008 (CONAB 2008). In 2017, about 9 million ha will be needed in order to attend to the ethanol supply forecasted by EPE (Table 2). If we consider crops to produce sugar, this figure rises to approximately 17 millions hectares. This scenario produced a projection of the area demanded for bioethanol sugarcane crop production in Brazil, not considering any political intervention, taking into account solely market forces (supply and demand).

Due to the favorable environmental and climatic conditions and the greater variety and quality of genetic material for sugarcane crop, around 90% of the new areas of production and most of the new production units will be built in the Center-south regions of the country. This region, which the states have wet summers and dry winters, are the most productive regions for the production of ethanol, presenting a high level of sucrose concentration as measured by TRS. The Northeast region, with warmer temperatures and a low thermal amplitude over the year, and the North (including the Amazon), which is a very warm and wet region, have much lower sugar and ethanol returns than the other states mentioned.

Conclusion

As mentioned, in Brazil, the amount of land available to the expansion of agricultural crops, including sugarcane, with no need for any deforestation, is significantly high, considering there are 91 million ha of suitable land, including degraded pastures and abandoned land. Based on EPE data, we estimate that 17 million hectares of land will be needed to attend the demand for ethanol production in 2017. This expansion could occur under current pasture areas. This would require the adoption of more sustainable and intensive systems of livestock production (more units per hectare), higher investments in technological development aiming at enhancing yields, and genetic improvement and recovery of pastures.

The Sugarcane Agroecologic Zoning – ZAECANA (Manzatto et al 2009) is an environmental policy instrument, developed within national development plans and programs that regulate agricultural growth in Brazil. It guides sugarcane crop expansion in the Brazilian territory, defining the spatial distribution of areas suitable and unsuitable for sugarcane crop establishment. The national sugarcane zoning determines the areas and locations of regions allowed receiving governmental incentives for sugarcane cultivation and ethanol plants establishments. According to the ZAE CANA, there are approximately 64 million ha under pasture and agriculture that area suitable for sugarcane cropping in Brazil, most of them under pasture (37 million ha). Currently, research efforts are being dedicated to map the degraded lands in Brazil, so that the future demand for sugarcane cultivation is directed to these areas, guaranteeing that the new plantations will not compete with the soil or water resources needed for food production, considering the growing needs of the growing world population.

A great deal of the impacts derived from sugarcane crops in Brazil is due to the concentration and extension of sugarcane monoculture crops in the Center-South regions of Brazil can result in significant negative environmental impacts of an increase in the extension land occupied by monocultural plantations of sugarcane . The main concerns are the loss of habitat and biodiversity, the offset or worsening of, such as: enhanced erosive processes, with consequent soil and water losses from the system due to bad management, greater water and soil nutrients demands,; imbalanced hydrological cycles; changes in fauna dynamics, pesticide contamination of soil and water, and biodiversity and habitat loss (De Maria 1999). Therefore, in addition to territorial ordinance policy instruments, such as agroecologic zoning and preferential funding schemes, governmental regulations aiming at sustainable soil, water and crop management are necessary to prevent the offset of land degradation processes associated with sugarcane plantations expansion in Brazil.

Thus, from the perspective of assembling the land use, agroenergy production and food security issues, resolving the problem of the added demand for planted area is not enough, Federal and State governmental regulations and policy instruments are necessary to regulate sugarcane crop expansion in a sustainable way and more research is needed to develop tools for land use change sustainability impact evaluations under different regional scenarios.

Acknowledgements
This work was funded by an extension of the Project SENSOR ("Sustainability Impact Assessment: Tools for Environmental Social and Economic Effects of Multifunctional Land Use in European Regions"), EU-FP06/003874-2.

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