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Short Communication

Meeting the global demand for biofuels in 2021 through sustainable land use change policy

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ABSTRACT

The 2013 renewable energy policy mandates adopted in twenty-seven countries will increase the need for liquid biofuels. To achieve this, ethanol produced from corn and sugarcane will need to increase from 80 to approximately 200 billion l in 2021. This could be achieved by increasing the productivity of raw material per hectare, expansion of land into dedicated biofuels, or a combination of both. We show here that appropriate land expansion policies focused on conservationist programs and a scientific basis, are important for sustainable biofuel expansion whilst meeting the increasing demand for food and fiber. The Brazilian approach to biofuel and food security could be followed by other nations to provide a sustainable pathway to renewable energy and food production globally.

One sentence summary: Conservationist policy programs with scientific basis are key to drive the expansion of biofuel production and use towards sustainability.

1. Introduction

Global ethanol fuel production in 2012 was 83.1 billion l (REN21, 2013), accounting for 3% of total fuel use for transportation. Of this 3%, roughly 1% was produced from sugarcane in Brazil, with small contributions from other Latin American countries. The remaining 2% were produced from corn mainly in the United States, with minor contributions from China and Europe.

In 2011, 51% of the total sugarcane harvest in Brazil was used to produce ethanol (Brazil, 2012a), totaling to a land area of 4.9 Mha. There are plans for expansion of biofuel production in many countries, because renewable fuel mandates have been adopted in 27 countries, in addition to the policies implemented by the United States and Brazil, the leading ethanol producers today (REN21, 2013).

The United States' Renewable Fuel Consumption mandate (EPA, 2010) assumes that expansion of ethanol produced from corn will not increase after 2015. After 2015 production of ~80 billion l of biofuels are expected to come from non conventional sources (EPA, 2010) using mainly 2nd generation technologies from cellulosic feedstock's. If 2nd generation technologies do not reach technical and economic viability by 2020, the most feasible alternative will be ethanol from sugarcane, classified by the EPA as an "advanced biofuel".

For the next decade, Brazil is expected to increase production from the current 21 to 61.6 billion l according to government projections (Brazil, 2012b). Even with the improvements in ethanol production by Brazil and the United States, there will be the necessity to produce an additional amount of 34.8 billion l of ethanol in 2021, which could be provided by other countries (Table 1).

Despite the relatively small areas of land used for current biofuel production, considerable attention has been given to the environmental and social impacts of biofuel related land use (LU) and land use change (LUC) (HLPE, 2013). The debates around biofuel production and LU have lead to certification standards and rules for biofuel production and trading (RES-D, 2009).

Given that the global population is growing, the demand for food will increase, in addition to the demand for energy and water. These increases will put pressure on the sustainability of this planet, requiring action for sustainable production and expansion across all sectors. From a LU perspective we will show here that regulating the land expansion dedicated to biofuel production with appropriate LUC policies, would be enough to meet ethanol

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and food demand in 2021. This is an important step for sustainable LU and expansion to meet these growing demands.

2. Material and methods

To determine the capacity for sugarcane expansion to produce ethanol and achieve global biofuel mandates, we compiled and evaluated data from several publications. The first step was to determine the amount of ethanol required by 2020/2021, primarily from corn (USA) and sugarcane (Brazil).

Biofuel policies are currently focused on a push to 2nd generation ethanol, using biomass from agricultural residues as a mechanism to meet renewable fuel and food demands from the same land area. However there are uncertainties with the economic feasibility of 2nd generation ethanol, in the US RFS2 for 2013 the number of Renewable Identification Numbers (RINS) that set renewable fuel volume targets for cellulosic ethanol, was 823,498 l whereas actual volume produced was only 548,983 l (EPA (2013)). Therefore our evaluation focused on the capacity of sugarcane expansion to achieve demand for first generation ethanol production in 2021.

2.1. Establishing ethanol requirements for 2021

Given the projected demand for ethanol in 2021 for Brazil, Brazil and the rest of the world excluding the USA, and total global; we developed three scenarios for sugarcane expansion to meet the demand in 2021: (i) 61.6 billion l (SCI), (ii) 96.4 billion l (SCII), and (iii) 176.2 billion l (SCIII).

The US RFS2 was used to determine the projected ethanol requirements in the US for 2021 (EPA, 2010), resulting in a requirement of 136 billion l by 2022. In order to produce more cellulosic biofuel with time, in 2015 there are limits on biofuel production from cornstarch under the RFS2 (57 billion l). For Brazil the biofuel requirements were based on the "Ten Year Plan for Energy Expansion" (Brazil, 2012b) for 2021, giving a total ethanol amount of 61.6 billion l for Brazil's demand.

To determine the remaining ethanol demand for countries outside the USA and Brazil we considered the most representative blending mandates (REN21, 2013), with 10% ethanol blending for global gasoline consumption in 2022 (excluding Brazil and USA). The projected gasoline consumption was estimated using data for 1990–2008 from the IEA (2012), using an exponential extrapolation out to 2022, following the same trend of growth since 1990. The total volume of ethanol required to meet the global demand outside Brazil and the USA in 2021 (138.8 billion l) is presented in Table 1.

2.2. Determining the sugarcane area and production dedicated to ethanol in Brazil

In Brazil, sugarcane is produced to obtain sugar and ethanol. Thus, to estimate the amount of land dedicated to ethanol production and the amount of ethanol produced per area or ton of sugarcane, we adjusted available data for LU and productivity using the Total Recoverable Sugar (TRS). This was performed using available data on sugarcane production in Brazil for the last five years (Tables 2 and 3).

Table 1
Ethanol requirements in 2021 (billion liters).
Source: [a]EPA, 2010, [b]Brazil, 2012b, [c]Based on REN21 (2013).

Countries	Ethanol production in 2015 (billion l)	Additional ethanol amount needed in 2021 (billion l)
United States (from corn)	57.0[a]	79.8
Brazil (from sugarcane)	37.4[b]	24.2
E10 for other countries	–	34.8[c]
Total	–	138.8

Table 2
Land dedicated to ethanol production in Brazil and sugarcane ethanol yields.
Source: Adapted from [a]Unica (2013) and [b]Brazil (2012a).

Year	Ethanol[a] (10E6 l)	Total area[a] (10E6 ha)	Ethanol[b] TRS (%)	Dedicated area (10E6 ha)	Yield (l ha^{-1})
2007/08	22,422	7.08	54	3.82	5,864
2008/09	27,513	8.14	59	4.80	5,729
2009/10	25,694	8.62	56	4.83	5,324
2010/11	27,376	9.08	54	4.90	5,585
2011/12	22,682	9.60	51	4.90	4,632
Average	25,137	8.50	55	4.65	5,427

Table 3
Total historical sugarcane production and ethanol yields for Brazil.
Source: Adapted from [a]Unica (2013) and [b]Brazil (2012a).

Year	Etanol[a] (10E6 l)	Sugarcane[a] (10E3 tons)	Ethanol[b] TRS (%)	Dedicated production (10E3 tons)	Yield (l tons^{-1})
2007/08	22,422	492,382	54	265,886	84.33
2008/09	27,513	569,063	59	335,747	81.95
2009/10	25,694	602,193	56	337,228	76.19
2010/11	27,376	620,132	54	334,871	81.75
2011/12	22,682	559,215	51	285,199	79.53
Average	25,137	568,597	55	311,786	80.75

2.3. Land required for agriculture, reforestation and sugarcane expansion in Brazil

To determine the boundaries around available land for expansion of sugarcane, we used the policy and legislation requirements from the EU. This was based on the European Directive (RES-D, 2009), where LUC for biofuel production may not include deforestation of natural vegetation or high biodiversity grasslands. In Brazil sugarcane could expand into land under other uses to accomplish global biofuel mandates in 2021.

To achieve sustainable expansion of ethanol production in Brazil there are at least two important factors to consider: (i) the existence of an agro-ecological zoning that specifies regions where sugarcane could be cropped (Manzatto et al., 2009); (ii) specific legislation (Brazil 2009, 2010) relating to the improvement of pasture by 2020, increasing productivity and freeing up current areas of pasture for other LU. The "LCAP–Low carbon agriculture plan" (Brazil, 2010) is being implemented to specifically increase the current pasture carrying capacity through the improvement of degraded pasture.

We used the projected improvement of degraded pasture through the LCAP in Brazil, to determine area of potential intensification of pasture that would meet an increasing demand for food, fiber and energy in 2021. This was performed using projections from the Brazilian government and other sources to estimate the land required for agricultural activities and reforestation. The land required for sugarcane expansion was considered in order for Brazil to meet its own ethanol demand in 2021, and also global demand (Table 1). The total land area required for each of these scenarios were used to calculate the intensification level required for pasture to facilitate and meet the required sustainable expansion of land.