Seminario “**Innovación y Valor Agregado en el Sector Azucarero del MERCOSUR”**

Sesión 1: **Innovaciones en la producción e industrialización de caña de azúcar**

Manejo y control ambiental, balance de carbono, índices, etc.

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27 Mayo 2021

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PSE

Una contribución al debate sobre la producción sostenible de biocombustibles

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Summary

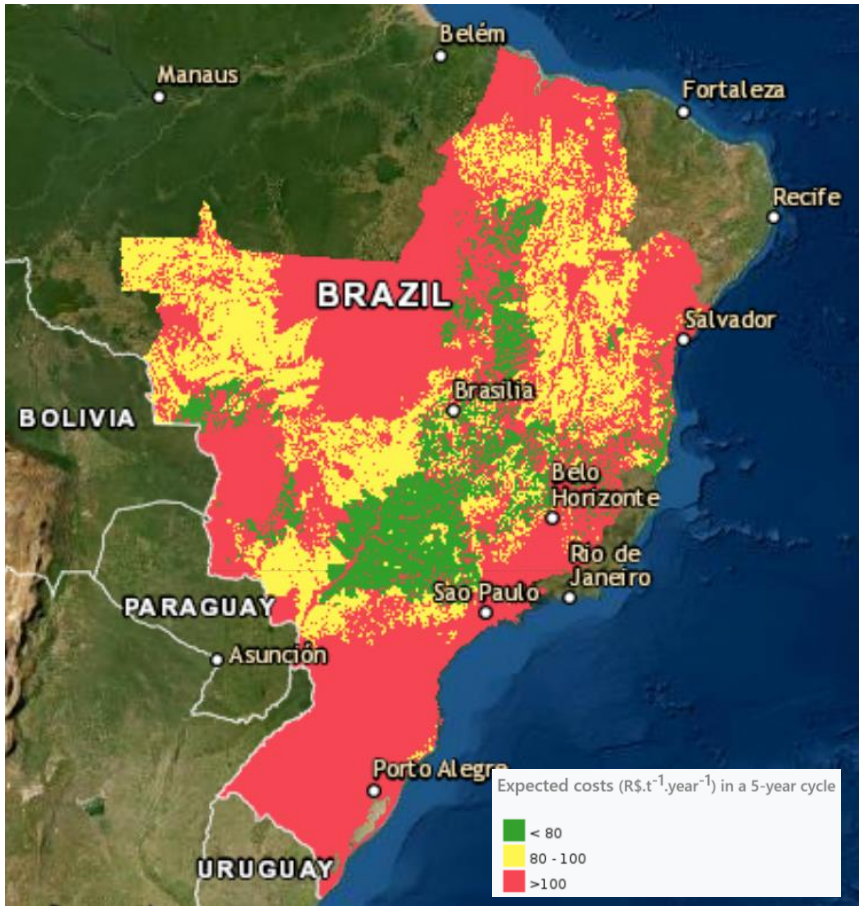
- The sugarcane industry in Brazil;
- The demands regarding sustainability and the context worldwide and in Brazil;
- RenovaBio;
- ISO 13065;
- My personal research experience in this topic;
- Final comments and conclusions.

Sugarcane industry in Brazil (1)

- The sugarcane industry in Brazil is a good example of a modern biomass industry (e.g. the biorefinery concept): diversified production (sugar, ethanol and surplus electricity), in some cases with diversified feedstocks (e.g. using corn), efficient (in some cases), in many cases with integrated use of residues.
- However, in more than a decade the industry has faced problems: lower number of industrial units, lower investments (e.g. in the agricultural phase, reducing yields), ethanol production is not growing significantly, and ethanol production has lost competitiveness.
- Nevertheless, Brazil is still the largest sugarcane producer, the largest producer of ethanol from sugarcane, and the carbon footprint of ethanol production is still the lowest among existing commercial biofuels.

Sugarcane industry in Brazil (2)

- Information available at www.safmaps.com and at http://dx.doi.org/10.17632/dp4y36fjw5



Sustainability of biofuels (1)

- For about 15 years sustainability has been a crucial aspect of biofuels production, and its consumption.
- For exporting biofuels to Europe and US, for instance, it is necessary to observe some conditions. And it is necessary to have certified production. In case of sugar, the largest consumers also demand certified production.
- In the case of biofuels, it is necessary to certify a minimum contribution to the reduction of GHG emissions (compared to the fossil alternative). Impacts due to land use change must be taken into account.
- Mainly in Europe, there are concerns regarding impacts on food supply.
- Negative impacts on water resources, on biodiversity, working conditions, etc. are also issues of concern.

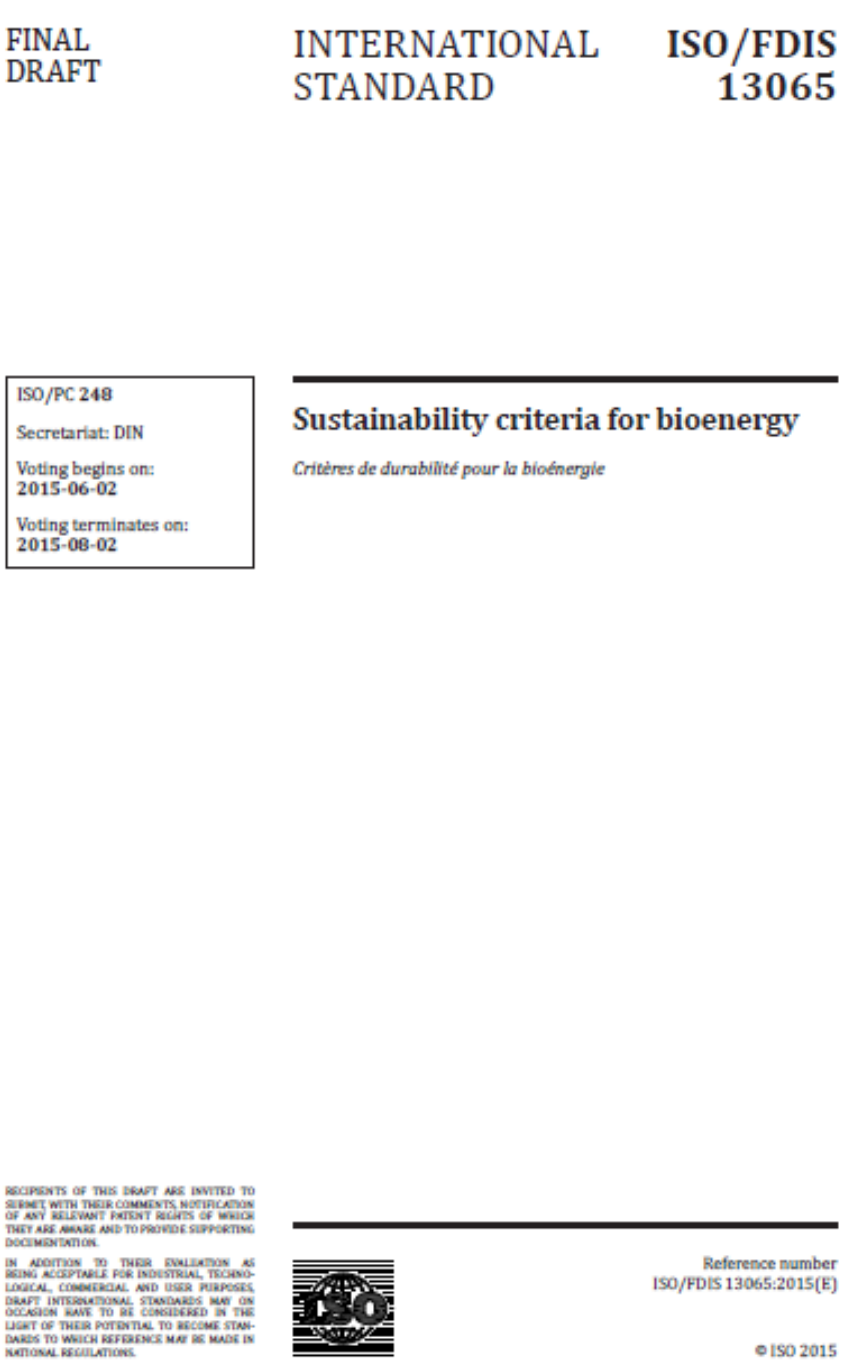
Sustainability of biofuels (2)

- In Brazil, so far, the bulk of biofuel consumers is not concerned about sustainability. However, for exporting ethanol, certification is necessary.
- The most important sugar and ethanol producers have certified production. In general, BONSUCRO is the certification scheme mostly used. Also in general, the largest producers choose the units that are certified.
- An new issue in Brazil is RenovaBio (the so-called Brazilian bioenergy policy). The aim is to reduce GHG emissions in the transport sector. There are targets to be observed. In order to attest actions in this direction, fuel suppliers need to present CBios. A CBio (1 t of CO_2e) can be bought in an open market. The producers of the “most efficient” biofuel production would have more CBIOs to sold.

RenovaBio

- Annual targets are released by the regulatory agency ANP. In 2021, the target is about 25.2 million CBios (that is, 25.2 MtCO2e). The targets are allocated to all fuel distributors and dealers. The target for 2020 was 14.5 million CBios.
- The commercialization of CBios started in June 2020. So far, the price has fluctuated between 15 and 72 R$/CBio (~3-13 US$/tCO_2).
- A CBio means 1 tCOe avoided with sustainable biofuel. The carbon footprint (based on the life cycle) is estimated according to defined procedures.
- In addition to assessing the carbon footprint, other conditions include: production of feedstock in non-deforested areas (after 2018), regularization of producing area according to the Forest Code and production in areas identified as suitable by the ZAE-sugarcane.

ISO 13065 (1)



FINAL DRAFT

INTERNATIONAL STANDARD

ISO/FDIS 13065

ISO/PC 248

Secretariat: DIN

Voting begins on: 2015-06-02

Voting terminates on: 2015-08-02

Sustainability criteria for bioenergy

Critères de durabilité pour la bioénergie

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Reference number
ISO/FDIS 13065:2015(E)

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- ISO 13065 (Sustainability Criteria for Bioenergy) was approved in September 2015. After five years, currently there is a reassessment procedure.
- The whole process took 5.5 years. The are four stages in an ISO standard (WD, CD, DIS e FDIS). There are specific rules for moving from stage to other.
- The final approval depends on the votes of ISO members (not just the so-called P-Members).

ISO 13065 (2)

- ISO 13065 is organized in chapters (Environmental, Social and Economic), and also has annexes (“Guidance related to indicators”).
- As all ISO standard, it was not create to be the basis of a certification standard.
- In practice, it will be very difficult to create a standard based on ISO 13065.

Chapter	Principles	Criteria	Indicators
Environmental	**7**	**8**	**33**
GHG	1	1	2
Water	1	1	5
Soil	1	1	6
Air	1	1	4
Biodiversity	1	2	8
Energy efficiency	1	1	2
Waste	1	1	6
Social	**4**	**7**	**23**
Human rights	1	1	2
Labour rights	1	4*	13
Land use rights	1	1	3
Water use rights	1	1	5
Economic	**2**	**2**	**6**
Economic feasibility	1	1	3
Financial risk manage/	1	1	3

In total, 13 Principles, 17 Criteria, and 62 Indicators.

* Forced or compulsory labour; Child labour; Collective bargaining rights; Working conditions.

ISO 13065 (3)

ISO 13065 (3)

- "The purpose of this International Standard is **to provide a framework for considering environmental, social and economic aspects that can be used to facilitate the evaluation and comparability of bioenergy production and products**, supply chains and applications."
- "This International Standard aims to facilitate the sustainable production, use and trade of bioenergy and will enable users to identify areas for continual improvement in the sustainability of bioenergy. **It can be used in several ways** …. **business-to-business communications** …., …. **to compare sustainability information from suppliers** …., **to help identify bioenergy processes and products that meet their requirements**. **Other standards**, certification initiatives and government agencies **can use** this International Standard **as a reference** for how to provide information regarding sustainability."

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Viewpoint

Sustainability assessment of bio-ethanol production in Brazil considering land use change, GHG emissions and socio-economic aspects

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ABSTRACT

Three sustainability aspects of bioethanol production in Brazil were considered in this paper. Results show that the recent expansion of sugarcane has mostly occurred at the expense of pasturelands and other temporary crops, and that the hypothesis of induced deforestation is not confirmed. Avoided greenhouse gas emissions due to the use of anhydrous ethanol blended with gasoline in Brazil (E25) were estimated as 78%, while this figure would be 70% in case of its use in Europe (E10). Conversely, considering the direct impacts of land use change, the avoided emissions (e.g., ethanol consumed in Europe) would vary from −2.2% (i.e., emissions slightly higher than gasoline) to 164.8% (a remarkable carbon capture effect) depending on the management practices employed previous to land use change and also along sugarcane cropping. In addition, it was shown that where the bulk of sugarcane production takes place, in state of São Paulo, positive socio-economic aspects are observed. The general conclusion is that a significant share of ethanol production in Brazil can be considered sustainable, in particular regarding the three aspects assessed. However, as production conditions are extremely heterogeneous, a generalization of results is not possible.

1. Introduction

Global interest in the production and consumption of biofuels (mainly ethanol and biodiesel) has been growing since the turn of the century. In part, this interest has been caused by environmental concerns and mainly due to the need to mitigate greenhouse gas emissions (GHG).

Recently, doubts have been raised about the actual benefits of biofuels regarding the mitigation of GHG emissions. Questions have also been raised about potential environmental, social and economic impacts, such as disruption of food supply, risks of losing biodiversity, impacts on water quality and water availability, and lack of benefits to those directly affected by biofuels production.

Due to social sector pressure, mainly in Europe, sustainability criteria have been proposed in order to promote the effective sustainable production of biofuels. Theoretically, such criteria could allow differentiation between products with similar fuel properties, but with important differences in their supply chain. The adoption of sustainability criteria could result in certification of biofuels production (i.e., mandatory or voluntary schemes to verify that sustainability criteria are met), and some producer countries have concerns that a certification process could impose new barriers for the international trade in biofuels.

Brazil is worldwide the second largest producer of fuel ethanol, as US surpassed Brazil in 2006. In 2008 its production reached 27.6 billion l, while the domestic consumption as fuel was close to 20 billion l; in the period 2000–2008, ethanol production in Brazil raised at annual average rates of 12.8% (MAPA, 2009). Internal consumption has grown continuously since the launch of flex-fuel vehicles (FFVs) in 2003 and their high domestic take-up. Unlike neat ethanol cars, FFVs can be fuelled with a mixture of gasoline and ethanol allowing a higher flexibility to respond to price changes. In recent years, almost 90% of the new cars sold in Brazil are FFVs, while no neat-ethanol vehicles have been produced. It is estimated that by mid-2009 FFVs represented 32% of the fleet of light vehicles (MME, 2009) and this share will possibly reach 65% by 2015 (Jank, 2008); as consequence, the domestic consumption of ethanol could reach 35 billion l in 2015 and 50 billion l in 2020 (EPE, 2008). Brazil is also the main exporter of fuel ethanol, with 5.1 billion l exported in 2008 (MAPA, 2009). Future exports depend on how open the main consumer markets will become, but it is estimated that about 13 billion l could be exported by 2016 (UNICA, 2008).

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Energy Policy 2011

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- Avoided GHG emissions were estimated as 70-78% (E10 or E25, respectively).
- Conversely, depending on management practices, carbon capture is possible.
- In some production places (e.g. in São Paulo), remarkable positive macro socio-economic impacts were identified.
- **A large share of ethanol production in Brazil could be considered sustainable (according to sustainability schemes).**
- **However, as production conditions are heterogeneous, a generalization of results is not possible.**

Advanced Review

Brazilian sugarcane ethanol: developments so far and challenges for the future

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Sugarcane ethanol has been produced in Brazil since the early 20th century, but production increased in the mid-1970s aiming at substituting 20% of the gasoline. Despite an increase in the 2000s production has been stable since 2008. This paper presents a review of the main developments achieved and future challenges. The sector has had positive economic and environmental results through technological development, as a result of research and development by private companies and strong public support. Sugarcane yield has steadily increased and positively impacted production costs, primarily due to better agronomic practices and breeding programs. Owing to environmental and economic reasons, there are on-going programs to phase out burning, with the gradual replacement of manual harvest with burning by unburnt mechanised harvest. Important agronomic impacts are expected, caused by the large amount of straw left on the soil surface, which also represents a significant bioenergy potential. The sugarcane industry in Brazil has taken advantage of the combined production of sugar and ethanol, and, recently, many mills have enlarged their revenues with surplus electricity. The current efforts for diversification aim at ethanol production through hydrolysis of sugarcane residues and the development of chemical routes. From an environmental point of view, impacts related to land use change are expected on greenhouse emissions, water resources, and biodiversity. Ethanol production is likely to expand in Brazil due to the potential size of the domestic market and to the opportunities for exporting, but this will occur in a context of different and new challenges.

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INTRODUCTION

The production of liquid biofuels is rapidly increasing, as governments are setting targets to enlarge the share of biofuels in the energy matrix for the purposes of climate change mitigation, improving energy security, and fostering rural development. It was estimated that the production of fuel ethanol was nearly 86 billion liters (BL) in 2011 (it was 39.2 BL in 2006 and 17 BL in 2000), whereas in the same year the production of biodiesel was estimated at 21.4 BL (6.5 BL in 2006 and only 0.8 BL in 2000).[1] The use of fuel bioethanol in 2011 was estimated to be the equivalent of 3% (energy basis) of the gasoline consumption, considering the consumption of light distillates to be approximately 1640 BL in the same year (mainly motor gasoline).[2] World production and consumption of fuel ethanol is dominated by the United States and Brazil, with more than 75 BL of 86 BL

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WIRES 2014

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- Sugarcane yield has steadily increased and positively impacted production costs, primarily due to better agronomic practices and breeding programs.
- … **on-going programs to phase out burning, with the gradual replacement of manual harvest by unburnt mechanized harvest**.
- …. **impacts are expected, caused by straw left on the soil** … **and a significant bioenergy potential**.
- … impacts related to land use change are expected on greenhouse emissions, on water resources, and biodiversity.

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The use of socioeconomic indicators to assess the impacts of sugarcane production in Brazil

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ABSTRACT

Global biofuel consumption increased in 2013, following a slight decline in 2012. The bulk of ethanol comes from two countries: United States (based on corn), and Brazil (sugarcane). The International Energy Agency predicted a world market of approximately 200 BL of fuel ethanol in 2020, and both US and Brazil might keep their importance. It is still a matter of discussion the impacts of such economic activity at the level it takes place. In this sense, a research activity has been conducted aiming at evaluating the socioeconomic impacts of sugarcane activities at a municipal level. Three important states in Brazil for sugarcane production were chosen, São Paulo, Alagoas and Goiás. Eight indicators were used to assess quality of life: Illiteracy Rate, Human Development Index, Theil Index, Percentage of Poor People, Connection to the Grid, Connection to the Sewer System, Child Mortality and Life Expectancy. The analysis of the socio-economic indicators of the municipalities showed with statistical rigor, that in all three states studied the municipalities in which sugarcane activity is relevant with sugarcane presented, over all, better socio-economic conditions represented by the indicators selected. However, the state of São Paulo was the only to present advantage for the municipalities with sugarcane, for all indicators selected. On the other hand, the differences between municipalities are not so strong in Goiás state, but it is important to highlight that sugarcane production started more recently than other states. The analysis related to the evolution of the selected socioeconomic indicators of both groups did not allow the acceptance of the hypothesis that the indicators evolved differently when comparing the groups with sugarcane and without. When statistically significant, municipalities without sugarcane show better evolution. Nevertheless, considering the indicators used, the advantages of the municipalities with sugarcane are reduced in the course of time.

Contents

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- Research activity aimed at evaluating the **socioeconomic impacts of sugarcane activities at a municipal level** (in São Paulo, Alagoas and Goiás).
- Eight indicators: Illiteracy Rate, Human Development Index, Theil Index, Percentage of Poor People, Connection to the Grid, Connection to the Sewer System, Child Mortality and Life Expectancy.
- Statistically, it is shown that **the eight indicators are not worse in municipalities where the production of sugarcane is relevant, in comparison with similar municipalities**. **In São Paulo, the indicators are better where sugarcane production is relevant**.

Biofpr
Biofuels Bioproducts & Biorefining

Assessing potential impacts of sugarcane production on water resources: A case study in Brazil

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Abstract: Sustainability has been considered essential for the future consumption of biofuels in large scale and, thus, assessing the impacts on water resources is one of the priorities. The aim of this study is to assess the potential impacts of sugarcane expansion both on the quality and on the quantity of water resources, but using a publicly available database and well-established statistic procedures. The case studies were defined in São Paulo state, where the bulk of sugarcane production in Brazil is, and more specifically three regions where significant expansion recently occurred: Palmares Paulista, Pontal, and Ribeirão Preto. Time series of streamflows and precipitations (1974–2011) and water quality parameters (1989–2011) were evaluated using non-parametric tests for detecting trends and abrupt changes. Quality parameters analyzed were concentrations of potassium, total phosphorus, nitrite, nitrate, ammoniacal nitrogen, total solids, dissolved oxygen, and biochemical oxygen demand. Sugarcane cropping data were correlated with streamflows and water quality parameters. Water quality parameters were analyzed vis-à-vis sugarcane production and population growth. Significant impacts due to sugarcane cropping were detected only in the case of the smallest basin. In the three studied regions a significant increasing trend of nitrogen and biochemical oxygen demand was observed, but these results can be explained either by sugarcane–ethanol production or by the discharge of sewage and industrial effluents without appropriate treatment. Based on data availability it was not possible to rigorously determine the contribution of large-scale production of sugarcane cropping to both the quantity and the quality of water resources.

Keywords: ethanol; sustainability; water quantity; water quality; land use; time-series analysis

Introduction

In Brazil, in 2014, ethanol consumption in the road transport sector was almost 25 billion liters (BL), while the consumption of biodiesel reached 2.7 BL.[1] The consumption of liquid biofuels in Brazil has been stimulated by the interest in alternative sources which contribute to the diversification of the national energy matrix and also for reducing greenhouse gas (GHG) emissions.[2] Bioenergy production in large scale has been a matter of concern and, among the environmental issues involving biofuels, the potential impact on water resources is one of the main topics.[3–5]

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Biofpr 2016

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- The aim was to assess the potential impacts of sugarcane expansion both on the quality and on the quantity of water resources.
- Case studies in São Paulo. Data used: stream flows and precipitations (1974–2011) and water quality parameters (1989–2011).
- Water quality parameters analysed. **Significant impacts due to sugarcane cropping were detected only in the case of the smallest basin**.
- Significant increasing trend of nitrogen and biochemical oxygen demand was observed.
- **It was not possible to rigorously determine the contribution of large-scale production of sugarcane cropping to both the quantity and the quality of water resources.**

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Research paper

Resident perceptions of the impacts of large-scale sugarcane production on ecosystem services in two regions of Brazil

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ABSTRACT

Sugarcane ethanol is an alternative to fossil fuels that can mitigate greenhouse gas emissions and offer socioeconomic benefits, but at the same time have a series of negative impacts. Brazil is the second largest producer of fuel ethanol globally, with this production predicted to almost double over the next 15 years. However sugarcane ethanol production in the country has been shown to interact with a range of ecosystem services. It is only when such interactions are understood that we can fully determine the potential trade-offs, synergies and sustainability outcomes of biofuel production in the country. This paper explores the local perceptions about the impacts of sugarcane production on ecosystem services in two municipalities in the state of Sao Paulo with significant sugarcane production: Capivari and Rancharia. Impact perceptions have been elicited through interviews with local residents, with the results showing that perceptions vary between the two study sites and are affected considerably by the different local experiences with sugarcane production. For example, although sugarcane farming has been traditionally performed in Capivari, it has been Rancharia that has experienced more recently a rapid sugarcane expansion that has caused considerable changes in land use and farming patterns. Interview results also suggest that the negative effects of sugarcane farming can be reduced through the adoption of good agricultural practices and the enforcement of existing laws, as many respondents cited considerable improvements in ecosystem health from such actions. Assessing the perception of local communities such as the one reported in this paper can be crucial in designing policies and planning land uses that enhance the sustainability of biofuel production.

1. Introduction

Anthropogenic activities have contributed to the destabilization of ecosystems [1]. Agricultural systems constitute part of this problem. The increasing pressure to boost productivity and produce bioenergy at large scales pose a great threat to the environment because of land use change, potential biodiversity loss, and excessive fertilizer use [2,3]. For example, agriculture is expected to cause approximately 70% of the projected loss in terrestrial biodiversity [2]. Nevertheless, when managed well, agricultural systems can also contribute positively to the environment [4,5].

However, land management practices that primarily focus on maximizing one service from agricultural systems (e.g. biomass production for food, energy and other industrial uses) are likely to cause the degradation or loss of other services such as aesthetic and historical values [6]. Conversely, focusing on the optimizing the delivery of multiple benefits from agricultural systems can lead to the provision of multiple ecosystem services [7]. An ecosystem services perspective to agricultural systems can help understand their negative impacts in a systematic manner, and contribute to the development of management practices that can increase their capacity to provide multiple benefits [5]. Here, ecosystem services (ES) are understood as the benefits people obtain from ecosystems directly and indirectly, such as provisioning (e.g., food, fuel), regulating (e.g., water flow regulation, water purification), supporting (e.g., nutrient cycling) and cultural services (e.g., recreation, cultural heritage) [8].

In Brazil, sugarcane cultivation is a major agricultural activity for the production of sugar, ethanol and other industrial products. Currently the area designated for farming sugarcane is estimated at 87,000 km^2. All fuel ethanol production in Brazil is based on sugarcane, with approximately 50% of the sugarcane being used to produce ethanol. The large-scale production of fuel ethanol started

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0961-9534/

Biomass & Bioenergy 2018

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- The paper explores the local perceptions about the impacts of sugarcane production on ecosystem services.
- Impact perceptions have been elicited through interviews with local residents. **Perceptions vary between the two study sites and are affected considerably by the different local experiences with sugarcane production**.
- **Results also suggest that the negative effects of sugarcane farming can be reduced through the adoption of good agricultural practices and the enforcement of existing laws**.

energies

MDPI

Article

Techno-Economic Assessment of Bio-Energy with Carbon Capture and Storage Systems in a Typical Sugarcane Mill in Brazil †

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check for updates

Abstract: For significantly reducing greenhouse gas emissions, those from electricity generation should be negative by the end of the century. In this sense, bio-energy with carbon capture and storage (BECCS) technology in sugarcane mills could be crucial. This paper presents a technical and economic assessment of BECCS systems in a typical Brazilian sugarcane mill, considering the adoption of advanced—although commercial—steam cogeneration systems. The technical results are based on computational simulations, considering CO_2 capture both from fermentation (released during ethanol production) and due to biomass combustion. The post combustion capture technology based on amine was considered integrated to the mill and to the cogeneration system. A range of energy requirements and costs were taken from the literature, and different milling capacities and capturing rates were considered. Results show that CO_2 capture from both flows is technically feasible. Capturing CO_2 from fermentation is the alternative that should be prioritized as energy requirements for capturing from combustion are meaningful, with high impacts on surplus electricity. In the reference case, the cost of avoided CO_2 emissions was estimated at 62 €/t CO_2, and this can be reduced to 59 €/t CO_2 in case of more efficient technologies, or even to 48 €/t CO_2 in case of larger plants.

Keywords: bioelectricity; carbon capture; negative emissions; sugarcane; biomass; climate change

1. Introduction

In order to maintain 2 °C as the maximum increase in the global average temperature, the levels of atmospheric concentrations must be kept below 450 ppm of CO_{2eq} during the 21st century [1]. Therefore, worldwide emissions of CO_2 have to be drastically reduced in the coming decades, inducing deep changes in the energy systems [2]. This scenario requires that emissions from electricity generation should be negative by the end of the century, with fast progress in energy efficiency and promotion of low-carbon technologies. In this context, carbon capture and storage (CCS) is crucial because it represents a process by which large amounts of carbon dioxide can be captured and stored for the long term [1].

The CCS technology involves four main steps: conditioning processes to separate CO_2 into a pure stream, carbon capture itself, its compression and, finally, storage for long term periods [1]. In the case of CCS applied to power units, significant losses in efficiency are expected; for instance, the Intergovernmental Panel on Climate Change (IPCC) indicates a 9% net reduction in efficiency for coal-fired power plants (pulverized) and 7% for combined cycle gas-fired power plants [1].

Energies 2019

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- Bio-energy with carbon capture and storage (BECCS) technology in sugarcane mills could be crucial for reducing GHG emissions.
- A technical and economic assessment of BECCS systems in a typical Brazilian sugarcane mill: **CO_2 capture both from fermentation and due to biomass combustion**.
- Technology considered: post combustion capture based on amine.
- Results show that **CO_2 capture from both flows is technically feasible but with high impacts on surplus electricity**.
- The **cost of avoided CO_2 emissions** was estimated at **62 €/tCO_2**, and this can be reduced to 59 €/tCO_2 in case of more efficient technologies, **or even to 48 €/tCO_2 in case of larger plants**.

Final comments/conclusions

- General sense, it can be said that the sugarcane sector in Brazil is sustainable (on average, at least). There are some benchmark cases, but there are also bad examples.
- Avoided GHG emissions in relation to fossil fuels are significant, as long as LUC does not occur. Results can be improved with adoption of best agricultural practices and CCS.
- The impacts on biodiversity must be minimized, with the adoption of best conservation practices: respecting the Forest Code, maintaining existing native vegetation and creating biological corridors.
- General sense, the impacts on water resources are reduced, mainly in the case of production without irrigation. However, the impacts on water quality can be significant in small basins, depending on the amount of chemicals applied.
- Local populations are awareness of the importance of ecosystem services and can contribute on enhancing sustainability.

- Muchas gracias por la invitación y por la oportunidad!
- Estoy a la disposición!

- Visite SAFmaps
- www.safmaps.com