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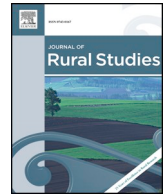
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The impact of sugarcane expansion in Brazil: Local stakeholders' perceptions

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ABSTRACT

Sugarcane expansion in Brazil during the 2000s was partly restricted by several discussions about the sustainability aspects of its cultivation. These discussions were mainly based on surveys that sometimes use highly aggregated data not including local perspectives and particularities, and sometimes used case studies with small samples which, while listening to local perspectives, cannot be considered representative of the whole sector. This work aims at filling this gap by considering both the perceptions of the local community, which add primary data on impact, and a large sample, to increase the research representativeness. To do so, we present the results of 353 interviews, covering 33 municipalities in five states of the Center-South region of Brazil (the largest cultivation area in the country). The results show that the expansion of biofuels has generated conflict mostly related to environmental and social issues, although there is good acceptance of the sugarcane mills in general. Our conclusions point to the importance of including local voices for a deeper understanding of the advantages and limitations of the expansion of biofuels.

1. Introduction

The debate about renewable fuels and its role in global warming and the environmental limits to world economic growth intensified in the early 2000s. As a possible alternative with regard to climate change and taking advantage of the great liquidity of capital available until the financial crisis of 2008 (Bunde, 2017; Marques Postal, 2014a), the emergence of large investments in the biofuels sector in Brazil and in the world took place. Palm oil in Indonesia, sugarcane ethanol in Brazil and corn ethanol in the US were soon announced as promises of renewable and sustainable energy.

However, criticism soon arose when the consequences of this unbridled race for cleaner energies began to appear. Environmental questions regarding deforestation, minority land rights, biodiversity loss, soil degradations and weak GHG savings were pointed out when palm oil cultivation in Indonesia became better known. Also, the food value chain became an issue especially when edible crops like corn, beets, wheat and sugarcane became possible energy alternatives. These issues were identified as global concerns and discussed in many academic studies, predominantly within the theme of sustainability. Even though a heated debate, regarding Brazilian sugarcane, most arguments used were basically based on two types of knowledge: (a) research, publications, and reports based on highly aggregated statistics;

and (b) case studies with small and non-representative samples. Both approaches have limitations and need complementary information.

The first approach was more frequent in the global arena and uses, besides highly aggregated data, analysis and comparisons between different crops and countries. Numerous studies indicated the negative impact of biofuel production (Actionaid, 2010; Bailey, 2007; Bernstein et al., 2007; Fulton, 2004; Giampietro et al., 1997; Harvey and Pilgrim, 2011; Ho, 2006; Hunt, 2008; Lenk et al., 2007; Mol, 2007; Vasudevan et al., 2005). The impact is mostly related to the environmental dimension, such as greenhouse emissions, soil erosion, water quality and biodiversity loss, as well as social matters in all parts of the value chain (e.g. food security, land degradation, displacement of traditional communities, health, and land conflict issues). Some studies and reports stated that the total environmental cost of biofuels is higher than that of gasoline, despite the fact that some biofuels produce smaller greenhouse gas emissions in comparison to fossil fuels (Bailey, 2008; Dahlbeck, 2004; Diaz-Chavez, 2011; Ho, 2006; Hunt, 2006; Martinelli and Filoso, 2008; Scharlemann and Laurance, 2008). Other studies indicated that there are more “problems to solve than insolvable problems” for these alternative energy sources to be more utilised in a sustainable way, such as the creation of infrastructure, new markets, new technologies and new products (Amigun et al., 2011; Escobar et al., 2009;

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Harris, 2007; Hunt, 2008, 2006; Koh and Ghazoul, 2008; Masiero and Lopes, 2008; Nassar et al., 2011; WWF Global Freshwater Programme, 2005). It is recognised that the increased production of biofuels is unavoidable and some amount of impact on land use, as well as social and environmental impact, should be expected. Because of this, international cooperation, regulation, and certification mechanisms become even more important to stimulate innovation, adequate legislation, and strategies.

On the other hand, a different approach was used in a number of studies, which emphasised local conditions in a Brazilian context and went deeper into analysing the impact of sugarcane expansion. For example, Gilio et al. (2016) focused on the state of São Paulo and concluded that the presence of an industrial plant in the region had a positive effect on socioeconomic development (average income and welfare); however, there was a negative effect on employment due to the process of crop mechanisation. Additionally, the economic activity shows a significantly greater economic dynamism when compared to the production activities in the sector of oil and by-products. The positive economic impact of sugarcane expansion can also be analysed through the studies by Bacchi and Caldarelli (2015a), Brinkman et al. (2018), Moraes et al. (2015a), and Wilkinson and Herrera (2010).

Table 1
Gaps in the debate and research aims.

	Data	Crops	Place	Shortcomings
Global concerns	Highly aggregated statistics	Corn, palm oil, sugarcane, wheat	Several countries	Does not address local impact when statistical data is not available
Local studies	Small samples used; number of interviewees limited	Sugarcane	Some (2 or 3) cities in Brazil –usually in just one state	Wider representativeness for the sector is unknown as the sample size is too small due to cost issues
This research	353 interviews	Sugarcane	Brazil, in 5 states and 33 cities	Perceptions as a proxy when local data is not yet available

The local approach was also used by Petrini et al. (2017) to shed light on the perspective of 28 local family producers of agricultural products in the city of Ipiranga, in Goiás state. The results of the study show that the farmers did not have consensus on their perceptions about the sugar and alcohol industry. They indicated the risks and threats of this activity and highlighted the need for a wider understanding of local issues for the formulation of public policies aimed at mitigating the negative aspects of the sector and, at the same time, stimulating the potential benefits to the value chain in that region. In another study, Ortolan Fernandes de Oliveira Cervone et al. (2018) interviewed 42 families to compare perceptions about the impact of sugarcane cultivation in ecosystems in two city areas: Rancharia, in a sugarcane expansion area, and Capivari, a traditional area close to Piracicaba. The study concludes emphasising the importance of including local voices to bridge the knowledge gap concerning some types of information with few or no statistics or database. Novo et al. (2012) also describe the impact of biofuel expansion on dairy farmers' activities based on 34 interviews in two regions of São Paulo state; they concluded that the lack of workforce, increasing labour costs, and the advanced age of the landowners are the main reasons for those leaving the sector and leasing their land to sugarcane companies. Coutinho et al. (2017) interviewed 32 experts from academia to test their views on the impact of sugarcane cultivation through a participatory impact assessment tool in southwestern Goiás; they concluded with the importance of including health care and quality of life as new indicators for assessing impact. Further, Duarte et al. (2013) interviewed 14 local stakeholders representing local government, mill management, and local residents and concluded that five main topics need to be taken into account regarding the sustainability of sugarcane cultivation: water availability, biodiversity, processes of mechanised harvesting, land use change and employment/income opportunities.

Several other studies concerning the Brazilian context use case study methodology (Assato et al., 2011; Egeskog et al., 2016; Galindo and Carvalho, 2016; Gomes et al., 2009; Marcatto et al., 2010; NEVES, 2019; Viana and Perez, 2013). These studies aim to develop a better

understanding about local conditions which are not taken into account in highly aggregated data statistics, or the studies put forth some aspects that have no available data. Nevertheless, it is difficult to isolate the impact of sugarcane cultivation from other aspects within its local economic or historical institutional context.

Both types of studies, however, are limited in their conclusions due to common limitations regarding their methodologies. The studies using a highly aggregated level of data have difficulties showing important social and environmental effects at the local level. Other studies, which emphasise local conditions and case studies, usually use small data samples and are not able to show a larger picture that is representative of the whole sector.

To address these gaps, in this study, a large field research and primary data gathering process was conducted. With more than 300 interviews in the five major producer states in Brazil, this field research provides a good picture of the pros and cons of the biofuel expansion in the country in the 2000s. Even though these perceptions are not accurate in terms of technical knowledge, they can serve as a proxy and provide us with a good overview of the effects of sugarcane cultivation as it pertains to the well-being of the local community. Table 1 summarises the main shortcomings of each approach, and the potential contribution of this research.

2. Methodology

Different methodologies were used in each phase of this research to analyse the stakeholders' perceptions regarding global concerns about sugarcane expansion. These methodologies are organised in three phases: setting themes, data collection and data analysis. Each phase is detailed in the following paragraphs.

2.1. Setting the themes

To define the set of concerns to be assessed, this research was based on issues expressed in the following academic articles (Borras et al., 2010; Diaz-Chavez, 2011; Eijck and Faaij, 2014; Escobar et al., 2009; Gallardo and Bond, 2011; Mol, 2007; Ribeiro, 2013; Tilman et al., 2009) and international NGO reports or statements (Actionaid, 2011, 2010; Biores, 2008; Marshall, 2009; Oxfam, 2007; Solidariedad, 2013; Valenti et al., 2012; WWF, 2011). Both groups have importance as they influence policymakers and the media. While NGOs have the ability to transform difficult matters into simple ones to reach their target audience, the academy typically looks for evidence and scientific criteria to assess the knowledge. Both groups, academics and NGOs, have both contrary and favourable positions regarding biofuels and often their views are not aligned.

The themes of national Brazilian interest that are put forth are based on the arguments of opinion makers (big Brazilian media) and local industry representatives of the São Paulo State Power Plants Association¹ (Kutas, 2010; UNICA, 2010). This mix aims at providing the respondents with a wide range of advantages and disadvantages of the expansion in their region, so that the final balance may contemplate all dimensions of the issue. On February 2016, a workshop was held to validate the language and feasibility of each statement (There were eight representatives: three from

¹ UNICA – União da Indústria de Cana-de-açúcar.

academia, two from industry, one from an NGO, and two policymakers). The initial analysis generated a list of over 30 themes, which were then filtered according to the criterion of suitability to the local perspective. The themes within the social dimension are: food insecurity, decent work, violence, health, traditional communities, and land concentration.² Themes for the environmental dimension are: air quality, soil quality, water quality and availability, biodiversity, and deforestation. Finally, the themes for the economic dimension are job creation, income generation, tax collection, the business model and increased prices. Themes such as global climate change, energy balance and reduction of greenhouse gases were left out since they demand highly complex and abstract analysis, which would not be easily understood by lay people.³

The questionnaire was built using a five-point Likert scale (1–5), with “no opinion” as an alternative answer. The main concerns identified at a global and national level were put forth affirmatively; respondents either agreed or disagreed (see Fig. 1). The answers generated quantitative (their positioning) and qualitative data based on their speech, which was recorded and transcribed when permission granted. The survey was written in Portuguese and was pre-tested, after which it was refined and the wording adjusted.

2.2. Data collection

The data collection has three orientations:

- Geographic scope;
- Definition of the representative groups;
- Identification of formal stakeholders in each municipality.

2.2.1. Geographic scope

We chose the regions to be studied based on the growth rate of sugarcane cultivation in each municipality after 2000. The idea was to focus specifically on areas of recent expansion in order to record the perceptions of residents witnessing the changes in their local environment. This task required a three-step approach: (1) identifying the states with greater sugarcane expansion in the Center-South region (Appendix B); (2) analysing the growth rates of sugarcane cultivation in the city area, in relation to the total potential area for cultivation (Appendix C); and (3) identifying new or expanded processing plants/distilleries with regional impact, and noting their opening dates (Appendix D).

As a result of these three steps, the study was defined to take place in

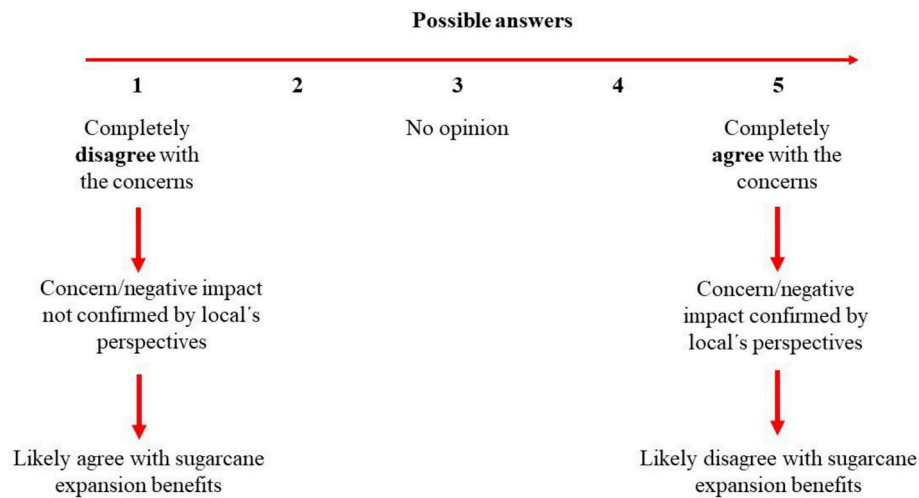


Fig. 1. Positioning interpretation.

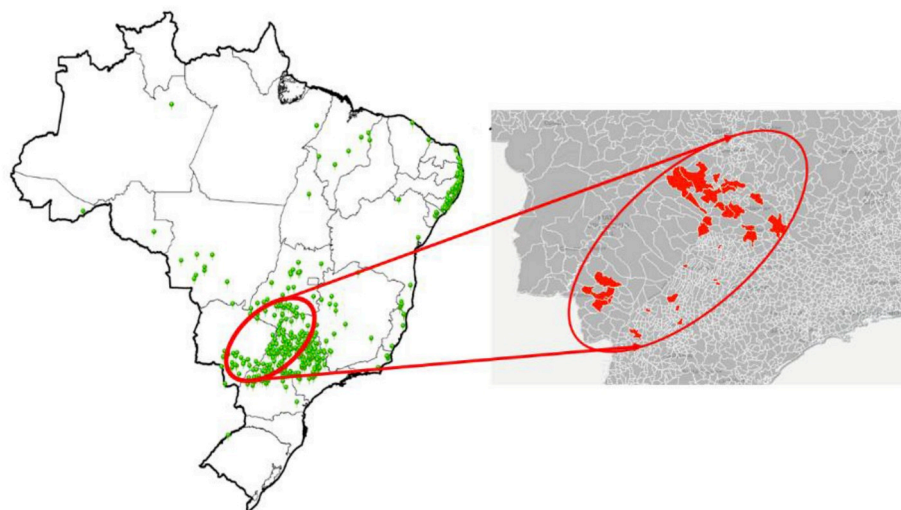


Fig. 2. Two maps showing the spatial distribution of the “active” sugar, alcohol and electric energy producing units in Brazil Sanches et al., 2017) and the researched area in detail (by the authors).

five states in the Center-South region of Brazil (Goiás, Minas Gerais, Mato Grosso do Sul, Paraná e São Paulo) and 33 cities were identified as having the best mix between being a cultivation area experiencing rapid expansion, having a “new” industrial processing site (with operations beginning after

² Land concentration – increase of land ownership for a small group of people.
³ For a complete view of the themes and statements, see Appendix A.

2000), and proximity among the cities due the logistical constraints of this study. Fig. 2 shows the area of sugarcane plantations in Brazil and the researched area.

2.2.2. Definition of the representative groups in the local community

In order to have representative results covering a wider scope of those affected by sugarcane cultivation in Brazil, we aimed at assessing a diverse range of opinions. This we did by including stakeholders from the first sector (local municipal government officials), those in the private sector (urban entrepreneurs, sugarcane producers, and other crop producers) and others in civil society (workers, researchers and community leaders). These groups were validated at the same workshop which defined the statements of field research.

2.2.3. Respondents identification and appointments

The field research was carried out from April 2016 to October 2017. In the selected cities, we arranged interviews with formal representatives of municipal government (preferably the mayor), sugarcane and other crop producers (usually represented by land owners and producers trade unions in each municipality), workers' representatives (union of rural workers of the city) and urban entrepreneurs represented by local commercial associations. The experts' group were accessed through rural agricultural department offices (Embrapa⁴) and professors and researchers from local colleges, when available. Lastly, the local communities' group were identified after initial approaches to local religious leaders, usually a catholic priest; from these interviews, new potential interviewees were generated using the snowball method (Atkinson and Flint, 2013; Biernacki and Waldorf, 1981; Browne, 2005). In order to avoid potential bias within the local sample, we sought for a balance between interest groups, looking for potential non-peers with different points of view in each town. Besides this, the large number of samples from local states, municipalities and neighbourhoods help to attenuate any influence from a major opinion maker in the region.

The interviews lasted on average 40 min, generating quantitative data (their positioning) and qualitative data based on their speech. As mentioned, the interviews were recorded and transcribed when permission granted, and using the software Fulcrum app.⁵ In the first stage of the meeting, the purpose and details of the interview were explained. The interview started with a section regarding the respondents' contact information, following some profile characteristics such as income, education level, age, how long they lived in the area, and whether they lived in a rural area or not (see appendix A). The respondents were then invited to score 17 themes - six social, six environmental and five economic topics.

2.3. Data analysis

In this paper, we use descriptive statistics to analyse the positioning of respondents recorded in our field research. For frequency analysis, we focused on the frequencies of the scores 4 and 5 (agreeing with concerns and seeing problems regarding each theme). In addition, the homogeneity of the scores for each issue was assessed using standard deviation.

The oral testimonials were then analysed using content analysis methodology (Bardin, 1977) with support of the software "MAXQDA⁶", which helps to illustrate the main reasons and arguments behind the quantitative results. Such analysis allowed us to identify the main arguments behind the prevalent score of each theme presented, and to identify which groups of respondents are better aligned or not with the expansion of the crop. These results do not represent any kind of prioritisation of the interviewees since the question was not put in this way, even though some of them expressed

⁴ Embrapa (Empresa Brasileira de Pesquisa em Agropecuária) is the Brazilian Agricultural Research Corporation, a state-owned research corporation affiliated with the Brazilian Ministry of Agriculture.

⁵ See www.fulcrumapp.com.

⁶ See www.maxqda.com.

their feelings on the theme during the open interviews.

Lastly, secondary data and a literature review were used to confirm or not some of the information recorded in the interviews.

3. Results

Each of the 353 interviewees indicated their level of agreement/disagreement to 17 statements. However, in this paper we will focus on the general results of the whole sample. In the future, we will analyse the results for each of the profile categories, such as stakeholder, state, city, level of income or education. Appendix D presents the distribution of respondents according to these profile categories.

3.1. By thematic dimension

First, we present the aggregation by thematic dimensions, which reveals that the environmental issue is more prone to controversy than the others, since it has the least agreement compared with the two other dimensions. Table 2 describes the average rates by social, environmental and economic dimensions.

Table 2
Average rates by thematic dimension.

Dimensions	Social	Environmental	Economic
Mean	2.12	2.63	1.98
Standard Deviation	1.46	1.60	1.28
Frequency of "No opinion" %	5.23	6.45	3.96
Frequency of (4&5) %	27.18	39.10	22.68

On a scale from 1 to 5, the mean of results was situated around 2.5. The results show that the economic dimension is followed by the social one (2.12 mean and 1.46 standard deviation) as the most positive dimension for the respondents.

3.2. By sub-themes

The general analysis by sub-themes helps to understand which themes present greater contrast of views between local perception and the initial concerns of world civil society and academic representatives. The general results are described in the Table 3 as follow:

Table 3
Mean, standard deviation and frequency of disagreement regarding the stated concern.

Theme	Mean	Standard deviation	Frequency of "No Opinion" (%)	Frequency of 4 & 5 (%)
Inflation	3.41	1.579	5.10	61.80
Biodiversity	3.24	1.663	3.60	58.40
Air quality	3.07	1.595	1.40	55.50
Deforestation	2.82	1.671	11.60	37.40
Land concentration	2.59	1.649	10.40	36.30
Health	2.38	1.555	3.10	35.40
Violence	2.38	1.573	3.40	35.10
Soil quality	2.35	1.566	8.50	30.60
Water quality	2.17	1.545	7.70	26.60
Water availability	2.11	1.556	5.90	26.10
Traditional communities	2.01	1.411	12.50	21.20
Food security	1.76	1.384	1.50	19.50
Decent working conditions	1.62	1.193	0.50	15.60
Tax collection	1.80	1.319	9.90	14.70
Income generation	1.65	1.259	1.40	13.90
Business model	1.59	1.152	3.10	12.50
Job creation	1.45	1.092	0.30	10.50

See Appendix E for a full list of themes and statements.

The themes with a high level of agreement with global negative concerns are the inflation of prices, biodiversity, and air quality. Those themes also present the highest rates of standard deviation, meaning larger differences of answers among the respondents with different interpretations.

The main disagreements from the initial concerns are job creation, the business model, income generation, decent working conditions, and food security. These disagreements show, additionally, the lowest levels of standard deviation, amounting to a more homogeneous set of responses. The disagreements of stated concerns mean the respondents did not validate those concerns as a real issue in their communities.

4. Discussion

The analysis of results uses the interview content to better interpret the quantitative results of the stakeholder positions. We will focus on the main reasons presented by the respondents to justify these perceptions.

4.1. Thematic dimension analysis

The highest level of disagreement regarding negative concerns on the economic and social dimensions shows that those concerns were not confirmed by the local stakeholders. Most of the time, those answers were followed by explanations and examples of opposite effects, in this case, positive impact. This is easily understood since economic and social themes are more tangible and easier to directly connect to the respondents' lives.

On the other hand, environmental issues have had a greater variability of perceptions and also received a higher frequency of “no opinion” among the respondents. Frequently those themes are not directly connected with the daily life of the respondents, especially those living in urban areas, and their opinions/perceptions are usually based on “I guess” or “I heard that” than from direct experience concerning the topic. In any event, even if those perceptions are not strong or based on the direct experience of the respondents, they represent the average opinion of the respondent's network and remains valid for the purpose of this research.

We proceeded to the analysis by sub-themes, bringing elements from descriptive statistics, and taking into account local perceptions and relevant literature to consider and examine those results.

4.2. Sub-themes analysis

Even though the results showed that themes were situated around the mean (with none extremely bad nor extremely good), we classified the results into four groups regarding the perception of impact: (a) the most negative impact; (b) the most positive impact; (c) less relevant impact, and (d) new issues put forth.

4.2.1. The most negative impact

Higher means represent the greatest agreement with global concerns, meaning those concerns were mostly confirmed by local stakeholders. Themes with the highest standard deviation show that there is less homogeneity in the perceptions of stakeholders. Themes included in this group are:

Inflation (Frequency of agreement: 61,80%) – The results show that the highest agreement was with negative impact, mainly on land and rental prices. It was mentioned that, from the beginning of sugarcane cultivation to the construction of the plant, land and rent prices in the town increased due to the high influx of people coming to work on construction projects and also with the new perspective of the local area thriving. This perception is more intense/stronger in small cities, where the impact of the new business is higher than in medium-sized cities. Some respondents considered this impact as positive since it added value to owners' properties. In fact, if we consider the states of São

Paulo and Goiás as a proxy, the value of agricultural land in expansion areas rapidly increased when the sugarcane sector arrived in the region (Marques Postal, 2014b).

Biodiversity (Frequency of agreement: 58,40%) - There were strong perceptions related to the existence of impact, but the descriptions by respondents varies from negative to positive. This variation is also shown by the high level of standard deviation of the theme. Examples of negative impact of the arrival of sugarcane cultivation on biodiversity are the decreasing number of animal species, especially many types of birds which cannot find places for their nests since the trees have been removed from the moors. In addition, “stable fly” (*Stomoxys calcitrans*) numbers have very greatly increased, which causes stress to cattle and therefore influences the milk industry, as the cattle fight the flies all day, losing weight and decreasing milk production. The appearance of this plague has been mentioned in many regions as a consequence of the arrival of sugarcane cultivation, since the irrigation of stillage in the crops would attract and foster the uncontrolled growth of this plague (Corrêa et al., 2013; EMBRAPA, 2009; Grisi et al., 2014; TV TEM, 2016).

A third aspect connected to the theme of biodiversity is related to large and medium-sized species, such as mammals and reptiles. While some respondents attribute the disappearance of some species to sugarcane plantations, others defend that after the sugarcane arrival there is a larger number of medium- and large-sized species, which benefit from the existence of sugarcane crops, with no burning process, as a hiding place favourable to these animals' migratory routes. However, the polemic remains: the most frequent “sighting” of animals is due to a positive impact – the larger presence of species – or is it a sign of negative impact since these species do not find places in the forest and therefore migrate to areas around urban centres, where they are more frequently noticed? More technical research is necessary to better understand and clarify this perception.

Air quality (Frequency of agreement: 55.50%) - The third item with the highest level of agreement regarding the concerns was initially defined as associated to CO2 pollution. However, most respondents who agreed with this concern commented on three different aspects, namely: (a) the high incidence of dust on the roads and public streets, caused by frequent truck traffic during the harvest season; (b) the bad smell released by the stillage; (c) the burning of sugarcane, which spreads soot throughout the whole area.

Regarding dust on the roads, some respondents did mention that some sugarcane companies usually water the roads to avoid dust. The bad smell due to stillage is argued to be a brief problem since plants have frequently used the product as a crop fertilizer, preventing it from accumulating and causing a bad smell for the city, which is often far from the crop areas. Also, the process of burning sugarcane, a frequent source of complaints and impact on air quality, was common at the beginning of the operations but not anymore, since the compulsory mechanisation of harvesting and the use of straw for electricity generation now prevents sugarcane from being burnt.

Deforestation (Frequency of agreement: 37.40%) - This theme needs special attention because, even though most people do agree with the occurrence of this process, their explanations about it seem different from the formal definition of deforestation (Amacher et al., 2009; Giri Tejaswi Rome, 2007; Mola-Yudego and Gritten, 2010; Moutinho and Schwartzman, 2005; Wunder, 2000). Therefore, the results should be carefully analysed. In fact, most respondents confirm that no native area, as defined by FAO (Løyche and Senior, 2010; Vermeulen and Cotula, 2010), was deforested for sugarcane expansion because their regions have been already used for other agricultural or livestock activities. Also, the native forest deforestation actually happened a long time ago, usually more than 50 years previously. What interviewees call now as “deforestation” is, in fact, the legal removal of isolated trees in pasture areas, which had to be removed to facilitate harvest mechanisation and end the sugarcane burning process. Respondents refer to the impact of this removal on landscape and biodiversity, especially on

birds, which cannot have their nests in these areas anymore.

Another fact of concern reported by several respondents, in all regions, was the illegal practice of burying cut trees in order to avoid the obligation of having to plant new trees in a new area. An explanation is necessary: even though the removal of isolated trees is allowed by law, the farmer must report it to authorities and plant new trees in a proportion which varies from 5 to 10 depend on the state or the type of removed tree. (For example, for each removed tree, 10 new or replanted trees are required in the state of Minas Gerais). The reported action was usually the same: trees are cut at night to avoid detection by local witnesses and authorities, and the trees are buried to hide the evidence.

Land concentration (Frequency of agreement: 36.30%) - This theme is naturally considered an issue in sugarcane cultivation activity since this sector has a history of vertical integration of production (when all feed-stock is provided by the own mill owner), which usually puts the land in the mill owners' hands. However, during the 2000s expansion phase, the predominant business model to access sugarcane production was horizontal arrangements (with the raw sugarcane belonging to other land owners and producers, then bought by sugarcane companies through contractual arrangements), which avoids the land concentration effect (Marques Postal, 2014b).⁷ Nevertheless, some concentration of activities may have occurred as 36.3% of the respondents agree with this concern. The explanation is that even though mill owners prefer leasing the land, several land owners in traditional areas saw a new opportunity to increase their activities in a new frontier with cheaper land prices, while leasing their land to reputable, established companies and with that assurance. This is referred to by some stakeholders that mention “the size of properties does not change in the city [area] but several new owners from other cities or states have bought some medium/large farms and rented them to sugar mills.” From a local viewpoint, there was no land concentration; but from a national point of view this concentration is clear, as owners from other states bought the land. More studies should be done to further explore and examine this topic.

4.2.2. Positive impact

The lowest frequency of agreement and, consequently, of means, indicates the lowest agreement with global concerns, being also a proxy to assess perceived better benefits of the arrival of sugarcane cultivation. Actually, the content analysis of these responses indicates there are several arguments and justifications for those with the lowest frequency of agreements. Additionally, these themes present a lower standard deviation value, showing a greater consensus among the respondents. Themes perceived as with positive impacts are:

Job creation (Frequency of agreement: 10.50%) - It is largely agreed among the respondents that the creation of jobs is seen as the greatest benefit of the sector's arrival in the region. This was one of the themes which generated the highest number of positive perceptions in the interviews, with various reports mentioning the increase of formalised contracts, higher salaries, more medical assistance, improved transportation, increase in security equipment, etc. In fact, according to Moraes et al. (2015a), during the period of 2000–12 the net increase of jobs in the sector was 69.8% (with a decrease of 7.4% in sugarcane plantation employees due to harvest mechanisation, an increase of 153.9% in sugar industry employment, and an increase of 205.2% in the ethanol industry). This effect exceeded the sphere of the mill employees, bringing indirect jobs to other sectors in the region enhancing the whole value chain. This conclusion is aligned with different studies by Bacchi and Caldarelli (2015a), Brinkman et al. (2018), Caldarelli et al. (2017), Caldarelli and Perdigão (2018), IRENA (2013), and Mann et al. (2014).

Business model (Frequency of agreement: 12.50%) - Disagreement

on the prevalence of vertical integration (via land acquisition) as the most common way of cultivating and processing sugarcane shows that horizontal arrangements as the new business model prevalent in the sector. These horizontal arrangements are based on different types of contracts and relationships between companies and farmers (leasing land, sharecropping, or spot buying from independent farmers) and usually means a more inclusive business model. When compared with vertical integration, this is a way for local farmers to participate in the sugarcane value chain (Marques Postal, 2014a,b) and for including them in a share of those profits. Further, the farmers can continue working in the region where they live and invest their extra income from sugarcane activities into other local business activity.

Income generation (Frequency of agreement: 13.9%) - The growth of income in the region is a consistent perception among the respondents and aligned with academic literature (Bacchi and Caldarelli, 2015a; Brinkman et al., 2018; Caldarelli et al., 2017; Caldarelli and Perdigão, 2018; Satolo and Bacchi, 2009). These studies describe the relationship between the arrival of sugarcane cultivation and the growth of GDP per capita especially where the industrial mill is located. The respondents' comments that agree with this focused mentioning the growth of local commerce and the arrival of new business to the city, such as machinery maintenance, hotels, restaurants and other suppliers of the sugarcane company. This economic dynamism goes beyond the sector and people directly linked to the mill. Most respondents that agreed with the concern that the sector would not make a relevant difference on community income come from the largest cities in the sample, such as Rio Verde - GO, Umuarama - PR, or Dourados - MS, where economic dynamism was already in place.

Tax collection (Frequency of agreement: 14.70%) - Just 14.7% of the respondents agree that the increase of tax collection is not relevant to compensate for the negative impact of sugarcane arrival. Most of these respondents, 14.7%, live in cities where there is no mill and, consequently, the tax revenue remains low due to the absence of an industrial plant in the city, which would pay a kind of sales tax or VAT, the ICMS.⁸ This claim is a constant demand of small municipalities on the surroundings of mills. Since the ICMS tax goes just for the city where the industrial facility is situated, the small municipalities on the surroundings of mills often have to support the increased social costs of a larger number of inhabitants relocating to the region, without receiving enough taxes to pay those additional costs. However, the situation is better now with the current, predominant, horizontal business model, than in the previous expansion cycle. On leased land and sharecropping plantations, taxes are collected based on the services performed on the plantation. Therefore, at least the tributes over those services (ISS)⁹ should be distributed to cities with sugarcane plantation area. The impact of sugarcane expansion on the municipalities' budgets was the object of studies of Chagas et al. (2011), which concludes that there is positive direct and indirect impact related to sugarcane expansion.

Decent working conditions (Frequency of agreement: 15.6%) - One of the main concerns of Brazilian academics and humanitarian organisations has been the quality of work conditions due to the historically degrading conditions for workers in this sector, especially because of the traditional manual process of cutting sugarcane. The hard task and the absence of minimal labour rights, such as having a formal contract or minimum wage, were common until several protests and the emergence of new legislation and monitoring of the sector (Laat, 2010; Ministério do Trabalho e Emprego Secretaria de Inspeção do Trabalho Para, 2010; Moraes et al., 2015a).

This theme was one of the top concerns in the social dimension, but surprisingly the results in our field research show a different scenario.

⁸ ICMS – “Imposto sobre circulação de mercadorias e serviços”, a type of sales tax or VAT or tax over sales activities.

⁹ ISS – “Impostos sobre serviços”, a tax over services provided.

⁷ See also the explanation of business models further in this paper.

In fact, just 15.6% of all respondents agreed partially or completely with the statement that sugarcane expansion impacts negatively on working conditions. For the majority, 84.4%, the perception is a positive impact and exceeding the sphere of the direct mill employees, pointing out benefits also to workers in other sectors in the region due to the increase in demand for labour.

The most reliable explanation for the positive result regarding this theme is a combination of three factors: (a) the evolution of harvesting mechanisation (Bordonal et al., 2018), making the process much easier for workers and requiring more skilled employees (Carvalho, 2013; Novacana, 2015; Walter et al., 2014); (b) the scarcity of labour in regions of sugarcane expansion (with low-density populations), while at the same time huge dam projects were being carried out in the north of the country (Cavalcante et al., 2008). This created increased demand for labour, while the construction sector in Brazil was substantially absorbing people available for the mechanisation of harvest processing. These factors caused a competition for available workers, contributing to wage increases and better working conditions not only for the employees in the sugarcane sector, but also for workers as a whole; and (c) the increased scrutiny of importers from the EU and US, the main destination of Brazilian ethanol exports, that increased pressure to meet sustainability standards (Diaz-Chavez et al., 2015; Moraes et al., 2015b). As a result, most cities reported better working conditions and higher wages for all sectors due to the competition for employees (Bacchi and Caldarelli, 2015b).

4.2.3. Less relevant impact

In the middle of the two extremes are those themes that have a frequency of agreement with global concerns scored between 19.5% and 36%. Although these numbers are still below the majority of respondents, meaning they see more benefits than problems on that set of themes, those themes were less “emphatically defended” by the respondents as a positive or negative aspect. Most arguments used to defend their points of view were linked to specific characteristics of their city or community.

Food security (Frequency of agreement: 19.5%) - This theme was considered to be worrisome by international organisations, and one of the main arguments against biofuel expansion (Bailey, 2008; Gomes et al., 2011; Marcatto et al., 2010; Schlesinger, 2014; Searchinger and Heimlich, 2015). The concern was distributed across many fronts, highlighting the decreasing land for planting food crops that, in their vision, would lead to a local lack of supplies and increased prices for the items, which would constrain access to food. From the literature review on this topic, a broad spectrum of aspects is included in this issue and their importance can vary depending on the specific geography that is being studied. For this project we refer to the food security concept defined by Brazilian law (Brazil, 2006), which focuses on regular access to quality food without compromising access to other essential needs (Frate and Brannstrom, 2015).

The results of the interviews were analysed through descriptive statistics and MAXQDA qualitative analyses and showed that 80.5% of the local respondents don't agree that sugarcane cultivation impacts upon food quality or food access. Most respondents' arguments point out that the new areas of sugarcane cultivation substituted predominantly soybean monoculture cultivation and extensive cattle farming, bringing no impact in terms of quality or diversification of food at their tables. Since long time ago, items such as rice, beans and vegetables have come from different areas of Brazil supplementing local production. Testimonials in different regions indicated that certain edible crops had been banned from the areas studied more than 30 years ago due to climate and market factors. Examples include rice in Minas Gerais, coffee in São Paulo state, and beans in Mato Grosso do Sul.

Another aspect mentioned indicates improvement in the access to food in some cities as a result of increased income and wealth enabling the increased presence of such food items in the local markets. These

perceptions appear confirmed with studies by Escobar et al. (2009), Frate and Brannstrom (2015), Kline et al. (2017) and Rosillo-Calle (2019, 2012).

With a different view, 19.5% respondents agree with some impact on food production and the more frequent argument is the change in fruit and dairy production areas. Second, in their testimonials, the land use change of medium-sized properties to sugarcane cultivation occurs because the farm owner prefers to lease the land to a sugar mill since using their own family as workers is not so much an option anymore. Family members have increased their educational skills and have gained employment in other urban sectors and activities. There also is no longer an inexpensive workforce available for crop production as sugarcane mills have caused an increase in wages as well as better working conditions in the areas. These observations are in accordance with the findings of Novo et al. (2012) that also pointed out that Brazil's aging population is the main reason for small and medium-sized farm owners to lease their land to sugarcane producers.

Traditional communities (Frequency of agreement: 21.2%) - Communities of “quilombolas” (descendants of slaves) are not common in the researched area (three municipalities), and indigenous communities are present only in Mato Grosso do Sul state, in the cities of Caarapó and Dourados. From the interviews, the comments were of two kinds. First, those that disagreed with the negative impact (88.8%) said that there was no presence of traditional communities in their area, and in the case of Mato Grosso do Sul state, indigenous communities were included in the local society with several members working for a mill company. In addition, there is no land conflict with sugar plantations. Second, there were those that agreed with the negative impact of sugarcane cultivation, this in Mato Grosso do Sul, where only a few indigenous persons still worked for the company but they cannot meet productivity standards, and the land use change to sugarcane diminishes the opportunity for them to work on other crops, of which they were more suited (Rafael Cruz and Marques Casara, 2013).

In the other four states, negative perceptions of impact include mention involving the “colono”. This is how people who work and live on the farms are called. When the land owner leases the land to a company, the “colono” lose their work and have to move to the cities. But instead nowadays most of them opt to work for the company – with better wages and working conditions than before and, since they begin to live in urban areas, they have better access to public education and other public services. Sometimes this change is positive, sometimes negative. In any event, the facts are that sugarcane cultivation in this context has significantly improved the lives of these workers.

Water quality (Frequency of agreement: 26.6%) - For most respondents (74.4%), there was no impact of sugarcane cultivation on water quality. Some of them claim that the better management of land by the companies helped to increase the quality of water, due to better contour lines and terraces, which avoid the silting and contamination of rivers and lakes. However, 26.6% of the respondents agree with some amount of impact; the most common explanation is the flow of chemicals through badly implemented soil preparation, as well as aerial pulverisation and some leaks or over application of vinasse on the fields.

Water availability (Frequency of agreement: 26.1%) - The availability of water is a critical issue to biofuel cultivation in many areas of the world. However, in the researched area this does not seem to be an issue for almost ¾ of the respondents. They usually justify their position using three main arguments. First, companies have been managing the water sources better than traditional farmers, taking care of land preparation in a way that conserves water. This includes avoiding planting close to rivers and lake springs, and protecting the spring areas from cattle. Second, the current water crisis in Goiás and Minas Gerais states is due to climate change and not only linked to sugarcane cultivation. This perception seems consistent with the findings of Diaz-Chavez and Vuohelainen (2014). Lastly, regarding Mato Grosso do Sul and Paraná states, these areas have a large amount of water and scarcity is not a

problem at all.

For those who see some direct impact from sugarcane cultivation on water availability (26.1%), the most frequent arguments are that (a) sugarcane plantations use a lot of ground water, (b) the burning process reduces water springs, and (c) some producers are cutting trees affecting watershed areas.

Soil quality (Frequency of agreement: 30.6%) - Most respondents (69.4%) do not see negative impact from sugarcane cultivation on soil quality. Some of them argue the opposite, that the sugar mill improves the soil conditions with the adubation process (calcarium, vinasse, phosphorus and others) in a frequent and controlled way. In addition, the construction of contour lines and terraces to avoid erosion and the “direct planting” process (putting some straw on the soil to keep the humidity and to diminish the release of CO₂) are procedures cited as examples of good practices conducted by mills. Those practices usually were not performed by the land owners before, as they are expensive tasks. In areas where the previous dominant activity was cattle raising, this argument is more frequent than areas where soybean cultivation was the prevalent activity.

However, analysis using MAXQDA shows groups that agree with some amount of negative impact. These respondents are concentrated in Paraná state, and they refer to higher ground declivity. It is because, due to the obligations of mechanised harvesting, companies had to enlarge the terraces and contour lines to enable the usage of harvesting equipment. This enlargement of terraces increases the risk of leaks in contour lines when heavy rains occur causing deep erosion. This impact is more frequent now with the mechanised harvesting than before, when manual harvesting was the standard. The consequences of harvest mechanisation on soil compaction seems to be a challenge and an important trade-off for the sector. This theme is the focus of some studies by Bordonal et al. (2018), Cortez et al. (2014), Jesus and Torquato (2014).

Violence (Frequency of agreement: 35.1%) - Respondents that agreed with the impact of sugarcane cultivation on increased rates of violence in the region used to justify their positioning by mentioning the increase of migrant workers for constructing mills and manual labour at the beginning of the mills' operation. The most common violence cited were petty theft, drug-related violence, fights, and arguments. In any event, 64.9% of respondents do not believe in any relationship between the expansion of sugarcane and violence rates since, in their viewpoint, mechanised harvesting ended the burning sugarcane process resulting in a smaller number of migrants, and those with higher skills. This analysis is aligned to the scores by state. For example, in Paraná state, the frequency of agreement with this concern is the lowest. This is perhaps due to the state's population density and available workforce, resulting in a lower number of migrants.

Health (Frequency of agreement: 35.4%) - 35.4% of respondents agree that the sugarcane arrival has brought some problems to the health system in their cities. The most common argument was the increased demand on the public health system, mostly in the beginning of the process or during mill construction, due to the sudden rise of temporary inhabitants in the city. Even though the practice of burning sugarcane is no more in most places studied, as pointed out by respondents, a common complaint was respiratory illnesses when this process was in place. Few respondents mentioned traffic accidents caused by dust on rural roads that were used to transport sugarcane to the mills.

The 64.6% of those that did not agree with the negative impact of sugarcane arrival on the health system mentioned that some problems had occurred in the beginning of the operations but now the whole situation has improved. The main reasons for improvement that were mentioned include: the end of the sugarcane burning process, which reduced respiratory problems; health campaigns; the provision of private health insurance to employees, alleviating the demand on the public system; and, lastly, the increased number of doctors working in the city.

4.2.4. New issues raised by respondents

From the qualitative analysis with MAXQDA software, we can see that a new topic has emerged regarding the impact of sugarcane cultivation. During the interviews, farmers (sugarcane producers and other crop-producing types of stakeholders) mentioned concern about “bad” contract terms regarding the lease of land. Respondents mentioned concern about soil quality conditions, profit sharing, biodiversity loss, and other factors.

Since horizontal agreements seem to be the prevalent way for companies to access their main raw material, sugarcane, these agreements or contracts have a critical role in the governance and management of impact on environmental, social, and economic aspects of the business. Unfortunately, due to the lack of previous knowledge on sugarcane cultivation negotiation aspects, some contract topics were not very well clarified and defined. Land owners, however, received clarity experiencing the process. Some of the recommendations from land owners to improve contracts are: taking into account the costs associated with ceasing contracts for previous activity (cattle raising, soybean cultivation, etc.); the company's obligation to give back the land in a similar condition (fertility), payments for compulsory set aside land and legal reserves, etc. These issues require a deep and broad analysis in future research.

4.3. Main differences from the initial debate

By analysing the differences between concerns extracted from reports and the literature review of the 2000's, used to set the themes of field research, and the current perceptions of local stakeholders, we could identify three main types of results:

4.3.1. Themes with comparatively different impact assessments

Regarding social concerns, important themes indicated by the international debate, such as worsening work conditions and food insecurity, were not confirmed. In fact, in the case of work conditions, the expansion of sugarcane cultivation is locally considered to have had among the most positive impact generated, with salary increases, formalised contracts, and access to benefits such as medical assistance and basic food provision. This positive effect has expanded beyond the sugarcane sector and spread throughout the labour market in the areas.

4.3.2. Themes with different meanings for local stakeholders

Some themes such as biodiversity, deforestation, and air quality were confirmed as the most common concerns of respondents. However, when examined more deeply, one can see that the understanding of the population on what each theme actually represents is different from the vision established in the international debate. Thus, for example, the matter of deforestation, identified as having major impact, is reported not as deforestation of untouched/native forests, but as the extraction of isolated trees in areas of pasture, which is the predominant type of terrain.

Also, the theme of biodiversity was prioritised by the respondents especially due to the appearance of a “stable fly” plague, which affects cattle, reducing milk production. Besides this, the impact on fauna, although undoubtedly existing, is at times expressed as a positive impact due to the larger perception of large animal species in the area, and at times is mentioned as a negative impact because of the lower frequency of certain bird species.

4.3.3. Themes with lower levels of expected negative impact

Most of the themes have low or almost no relevance from the point of view of local respondents. The reasons behind such analysis are: no occurrence of the specific problems in most of the researched area, such as displacement of traditional communities; and some themes had negative impact in the past but, due to changes in technology and/or process, the negative impact has ceased partially or completely, e.g., health-related concerns, levels of violence, reduced soil or water

quality. From the analysis of the interviews, two main points can be extracted:

- a) Most of the themes included in this research were not confirmed as having high negative impact by the stakeholders directly in touch with the effects of sugarcane cultivation expansion. In addition, even though some themes were confirmed as having potential negative impact, their intensity is lower than initially thought.
- b) From the results presented, one can say that a public policy was essential for a general positive result in the sector: the obligatory ending of the sugarcane burning process in harvesting. In fact, all of the companies had to be mobilised to adapt to the new reality, and in 2011 about 80% of all sugarcane harvested in the Center-South region of the country was already harvested in a mechanised way, according to data in the last Varietal and Productivity Census available.¹⁰

In fact, according to the respondents' perceptions, the measure of ending sugarcane burning had positive impact concerning several topics considered relevant to international organisations and local stakeholders. In the environmental field, several interviewees link the end of the sugarcane burning process with the end of nutrient loss in the soil, the greater preservation of the local fauna (biodiversity) and the improvement of air quality (less smoke and soot). In the social field, several responses indicated that the end of sugarcane burning accelerated the process of harvest mechanisation, improving the working conditions of rural workers, improving health in surrounding communities by reducing respiratory problems related to fires, and also reduced the migratory influx for manual harvesting processes, which positively impacted the respondents' security perceptions. In the economic field, it has been said many times that although the mechanisation had reduced the numbers of jobs, the quality of jobs has increased. Moreover, new business sectors linked with the mechanised harvesting process brought more attractive jobs to the region.

5. Limitation

To our knowledge, the current study is the most extensive research on the local stakeholders' viewpoints regarding the social, environmental, and economic issues involving the sugarcane ethanol sector in Brazil. Due to the broad geographical area covered by the field research, and the number and diversity of types of stakeholders, the patterns identified in the field research present a meaningful overview of local communities' perception and awareness in the Center-South region of Brazil. Even so, due to the chosen criterium to define the geographical area for interviews (regions with high rates of sugarcane plantation growth), some issues maybe have been unintentionally underappreciated.

The perceptions of local stakeholders can serve as a proxy of reality and a good tool for exploring topics of impact assessments. However, real impact should be assessed utilising complementary methodologies specific to each one of the studied issues, which were out of the scope of this research. Moreover, for other regions (e.g. Northeast of Brazil or other countries), the relevance of issues may differ due to different

socioeconomic contexts. Therefore, repeating the survey shall be valuable for other regions. Additionally, due to the objective of this study of listening to local people, the expert stakeholders' survey was out of scope since they live in big centres far from producing areas. Conducting another survey of expert stakeholders would complement the different perspectives and could considerably enhance and add value to the research results.

6. Conclusion

The objective of this study was to improve understanding about the potential impact of biofuel expansion in Brazil using the viewpoint of local stakeholders directly exposed to those impacts. To improve the robustness of this knowledge, we designed a field research that includes, at the same time, local stakeholders' perceptions and a broader geographical area (different regions and cities in five Brazilian states). This study aims to show a more representative view of different experiences and avoid the pitfalls of small samples, which may not necessarily represent the overall experience of expanded sugarcane cultivation in Brazil. To do so, the main themes and alerts/concerns put forth during initial debates and in the literature were identified, and questionnaires were formulated which served as a basis for the field research in the sugarcane expansion area.

Quantitative and qualitative analyses led to determining that the population has a generally positive view of the effects of sugarcane expansion in their region, although there is room for improvement. Some of the analysed themes have different meanings and results locally than previously put forth in academia and general civil society. There are new issues to be tackled— better and clearer contracts involving the lease of land, and the phenomenon resulting in the burying of isolated trees to avoid the cost of legally having to plant new trees, which is an unwanted and negative consequence, but not the same thing as deforestation.

Including local viewpoints in a representative manner enabled us to better identify impact which was not foreseen. Furthermore, it contributes to our understanding about the advantages and limitations of biofuel expansion from local and global viewpoints. Future studies, however, can analyse if the different types of impact were equally distributed among regions and types of stakeholders. This research helps policymakers to develop new policies, or enhance existing ones, regarding first-generation biofuels by taking into account local stakeholders' perceptions.

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Declaration of competing interest

None.

¹⁰ Centro de Tecnologia Canavieira (2011).

Appendices

Appendix A. Field Research Questionnaire

Section A: Contact data

Last name:
 First name:
 Organization.....
 Email:.....
 Phone:.....
 City:.....
 State:

Section B: Respondent Profile

What type of stakeholder:
 Govern Representative Expert/Academics Urban Entrepreneur
 Sugarcane Producer
 Other Crops Producers Workers Community Leader

Age of the respondent
 20 - 30 y/old 31 - 60 y/old above 60 y/old

Level of Income
 < 2 mw 2 - 5 mw 6 - 10 mw 10 > mw

Level of Education
 Elementary School High school Higher Education/above

Length of dwelling
 Less than 5 years From 6 to 10 years From 11 to 20 years More than 20 years

Local of Residence
 Urban Area Rural Area

Section C: Thematic Questionnaire

Express your level of agreement for each one of the following statements. Please score each phrase from 1 to 5 (i.e., 1, 2, 3, 4, 5), being (1: completely disagree and 5: completely agree).

Completely Disagree - Disagrees with the phrase and gives elements to justify their position;
 Partially Disagree - Disagrees with parts of the phrase or minimizes the importance of the evidences;
 No opinion about - Does not have information about the topic;
 Partially Agree - Agrees with some parts of the phrase but points this is not always or everywhere;
 Completely Agree - Agrees with the phrase and gives elements to justify their position.

Social Themes	Completely Disagree -1	Partially Disagree- 2	No opinion about - 3	Partially Agree - 4	Completely Agree 5
Food Security The arrival of sugarcane in the region has diminished the availability of food and/or increased a lot the price of food, impacting the food security.					
Working conditions The arrival of sugarcane in the region brought/increased the frequency of workers in degrading conditions.					
Violence The arrival of sugarcane brought violence and disturbances to the region.					
Health The planting of sugar cane brought diseases, work accidents, overloading health posts, affecting the health of the entire community.					
Traditional Communities The planting of sugar cane forces traditional communities to abandon their areas of origin.					
Land Concentration There was concentration of lands in the hands of few people / companies with the arrival of sugarcane in the region.					

Environmental Themes	Completely Disagree -1	Partially Disagree - 2	No opinion about - 3	Partially Agree - 4	Completely Agree 5
Water Quality Water quality in rivers and lakes in the region worsened due to sugarcane.					
Water Availability The cultivation of sugar cane demands an excessive amount of water, impacting the availability for other uses.					
Air Quality The arrival of sugarcane worsened the air quality in the region.					
Soil Quality The arrival of sugarcane in the region had a negative impact on the soil quality.					
Deforestation The expansion of sugarcane in this region caused deforestation of native forest.					
Biodiversity There was loss of biodiversity caused by sugarcane expansion (less plant variety and/or animal species).					

Economic Themes	Completely Disagree -1	Partially Disagree- 2	No opinion about - 3	Partially Agree - 4	Completely Agree 5
Jobs creation The quantity and quality of jobs created in the sugar value chain WERE NOT relevant to the region.					
Income Generation The arrival of the sugar-energy sector in the region HAS NOT ALTERED THE INCOME LEVEL of the community.					
Tax collection The collection of municipal taxes did not increase due to sugarcane-related activities					
Increase of Prices The arrival of sugarcane brought significantly increased prices of goods and services (except food)					
Land Business Model The mills access sugarcane through planting their own lands (land acquisition/vertical integration). Leases, partnerships and supply contracts to access sugarcane are a minority.					

Appendix B. Sugarcane Planted Area (hectares)

Source: Elaborated by UNICA with information from IBGE (Instituto Brasileiro de Geografia e Estatística).

States/year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2016/2006
Espírito Santo	64.042	68.816	78.249	80.162	81.393	76.488	73.459	75.821	77.937	76.683	71.733	12%
Goiás	237.547	278.000	416.137	524.194	578.666	697.541	732.870	860.482	1.018.281	930.052	931.342	292%
Mato Grosso	202.182	219.217	218.873	241.668	212.498	226.993	246.298	282.741	289.673	291.100	280.191	39%
Mato Grosso do Sul	152.747	191.577	252.544	285.993	399.408	495.821	558.664	642.686	639.899	546.099	658.282	331%
Minas Gerais	431.338	496.933	610.456	715.628	746.527	831.329	882.624	896.582	1.090.977	917.878	911.614	111%
Paraná	432.815	538.931	594.585	595.371	625.885	641.765	655.509	645.280	667.297	626.375	656.429	52%
Rio de Janeiro	164.290	132.504	137.407	135.130	133.286	105.091	117.892	108.144	95.393	79.388	56.770	-65%
Rio Grande do Sul	33.277	35.767	36.779	36.688	35.970	32.694	30.760	27.670	24.606	19.508	17.828	-46%

São Paulo	3.498.265	3.890.414	4.541.509	4.977.077	5.071.205	5.216.491	5.172.611	5.415.013	5.417.391	5.576.838	5.590.586	60%
Santa Catarina	17.154	17.740	18.084	17.646	9.528	11.129	10.845	10.581	–	8.030	7.628	–56%
South-central region	5.234.211	5.870.467	6.905.380	7.610.340	7.895.289	8.336.225	8.482.249	8.965.450	9.321.454	9.072.407	9.182.699	75%
North-Northeast region	1.158.635	1.216.384	1.305.497	1.235.493	1.269.467	1.280.390	1.270.079	1.257.593	1.324.204	1.107.420	1.062.403	–8%
Brazil	6.392.846	7.086.851	8.210.877	8.845.833	9.164.756	9.616.615	9.752.328	10.223.043	10.645.658	10.179.827	10.245.102	60%

Appendix C. Proportion of Sugarcane Planted Area related to the total agricultural area of the cities visited

Source: Prepared by the author based on IBGE data

State	Municipality	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
GO	Bom Jesus de Goiás	7,51	9,2	15,06	25,48	24,67	29,45	27,17	28,59	30,64	28,59	27,25	23,38
GO	Cachoeira Alta			51,72	65,96	64,1	83,61	84,88	92,86	91,65	97,61	99,56	99,49
GO	Caçu		12,7	74,43	78,03	83,11	82,19	83,63	92,73	93,68	91,46	91,4	89,99
GO	Goiatuba	14,3	15,07	22,08	23,82	21,54	21,71	29,14	29,17	31,57	35,04	31,55	31,42
GO	Jataí	0,03	0,03	0,28	1,94	4,86	3,98	2,16	6,85	4,72	3,45	4,3	4,29
GO	Porteirão	39,37	51,68	58,38	58,36	60,98	66,51	59,6	64,36	54,61	56,25	48,16	51,12
GO	Quirinópolis	11,9	31,85	46,53	57,19	63,25	65,22	64,1	68,85	68,47	68,73	66,93	65,91
GO	Rio Verde	0,84	0,95	1,81	2,25	2,49	3,24	4,26	5,37	5,81	5,3	5,76	3,71
GO	São Simão		0	77,67	83,51	85,43	89,39	94,7	95,16	95,26	94,96	95,55	95,55
GO	Turvelândia	36,27	41,57	32,72	39,38	36,42	32,08	32,23	27,12	31,54	35,19	37,79	44,11
MG	Carneirinho	12,55	88,07	85,9	91,15	91,15	91,15	92,29	92,29	96,18	95,98	95,98	94,49
MG	Comendador Gomes	15,73	12,51	13,99	30,43	29,71	24,99	57,71	60,61	61,84	71,6	62,9	60,59
MG	Frutal	20,78	20,8	63,87	66,47	67,54	67,76	71,95	70,19	73,03	76,39	76,44	65,07
MG	Gurinhata	0,8	1,67	1,66	55,06	57,8	58,36	62,07	62,06	91,02	93,39	94,56	94,88
MG	Itapagipe	9,66	8,87	8,55	65,6	64,19	86,42	86,42	84,75	88,13	85,94	87,69	88,79
MG	Ituiutaba	30,87	34,18	56,54	64,5	62,71	65,05	58,39	49,86	53,96	49,59	46,77	43,64
MG	Limeira do Oeste	86,28	92,47	95,69	97,03	97,03	97,03	95,47	95,51	96,76	96,43	93,93	97,85
MG	Santa Vitória	0,14	37,45	86,04	94,98	98,04	96,59	93,48	91,17	90,95	91,17	94,9	94,42
MG	Tupaciguara	8,59	9,85	9,08	11,71	10,12	18,97	24,32	18,74	30,63	20,96	19,7	93,94
MG	Uberaba	18,27	19,78	27,36	22,96	25,36	25,65	29,29	29,01	34,55	33,33	26,07	29,76
MS	Caarapó				0,61	6,05	12,16	13	13,86	13,85	9,2	10,94	8,99
MS	Dourados		2,99	1,36	4,36	6,95	11,26	13,29	14,87	14,31	8,79	10,11	8,23
MS	Fátima do Sul		0,33		2,03	2,51	4,83	4,98	5,97	9,08	7,06	7,03	7,62
MS	Rio Brillhante	8,93	13,43	24,97	28,09	29,75	30,42	29,76	29,63	29,01	26,32	31,3	30,38
MS	Vicentina		8,13	10,89	18,74	22,54	25,77	29,75	35,08	34,74	38,27	38,6	29,93
PR	Astorga	10,62	9,05	8,59	8,73	10,71	9,7	11,39	9,74	6,48	5,24	4,49	6,16
PR	Nova Londrina	66,43	85,06	79,7	78,09	80,25	77,9	77,81	80,23	77,03	76,47	74,5	74,78
PR	Santo Inácio	40,51	67,96	81,66	88,65	89,76	86,57	83,18	75,51	70,93	68,76	68,52	65,08
PR	Umuarama	11,66	39,58	65,99	69,42	71,4	81,98	82,24	82,09	83,81	85,11	82,82	76,41
SP	Castilho	58,67	83,5	89,69	95,59	97,2	96,56	97,19	87,38	86,63	88,23	90,97	91,23
SP	Gastão Vidigal	27,47	78,75	68,12	81,05	93,07	88,51	96,07	95,49	94,35	95,1	92,08	93,41
SP	Luizânia	55,73	80,71	72,03	98,81	94,96	95,29	91,57	92,98	87,12	86,81	88,64	88,31
SP	Meridiano	35,46	89,61	90,25	99,34	99,15	94,52	92,15	93,96	95,85	100	93,17	90,41
SP	Mirante do Paranapanema	29,69	31,16	43,46	84,74	79,39	86,57	88,12	90,76	91,25	89,39	93,34	89,47
SP	Monções	86,9	92,19	94,4	98,5	99,3	97,44	97,05	78,16	89,9	99,49	97,53	81,29
SP	Nova Independência	42,24	49,14	48,57	93,39	93,39	98,78	98,87	98,58	99,53	99,69	100	99,69
SP	Queiroz	53,21	42,62	86,97	82,96	92,71	92,73	91,61	91,62	93,56	92,91	91,5	98,2
SP	Sebastianópolis do Sul	75,44	85,07	86,96	98,36	98,36	98,46	95,8	93,53	92,26	94,04	94,87	93,51
SP	Votuporanga	61,82	84,34	62,27	90,21	85,13	16,21	86,11	83,72	89,16	91,64	92,26	88,2

Appendix D. Visited cities and reference plants in the region

Source – Prepared by the author based on field research and website information.

State	City	Company Name	Opening
GO	Bom Jesus de Goiás	None	
GO	Caçu	Usina Rio Claro (Oderbrecht)	2009
GO	Goiatuba	None	
GO	Jataí	Raízen	2009
GO	Porteirão	None	
GO	Quirinópolis	1) Usina Boa Vista (Grupo São Martinho) 2) Usina São Francisco (USJ)	2006 2007
GO	Rio Verde	Rio Verde Decal	2004
GO	Turvelândia	Vale do Verdão	2006
MG	Carneirinho	Usina Coruripe - Grupo Tercio Wanderley	2008
MG	Comendador Gomes	None	
MG	Frutal	None	

MG	Gurinhata	CNAA/BP	2008
MG	Itapagipe	Bunge	2006
MG	Ituiutaba	CNAA/BP	2008
MG	Limeira do Oeste	Cabrera Energética	2009
MG	Santa Vitória	1)Mitsui/DOW; 2)Vale do São Simão (Grupo Andrade)	2014 2010
MG	Tupaciguara	None	
MG	Uberaba	None	
MS	Caarapó	Raízen Energia	2010
MS	Dourados	São Fernando Açúcar e Álcool Ltda	2009
MS	Fátima do Sul	Fátima do Sul Agroenergética S.A.	2010
MS	Rio Brilhante	1)Biosev 2)Biosev 3)Odebrecht Industrial	2008 2013 2008
MS	Vicentina	None	
PR	Astorga	Nova Produtiva	1999
PR	Nova Londrina	Grupo Melhoramentos (Copersucar)	2012
PR	Santo Inácio	Grupo Alto Alegre	2007
PR	Umuarama	Santa Terezinha	2008
SP	Luiziânia	None	
SP	Meridiano	Noble Group	2010
SP	Mirante do Paranapanema	Odebrecht Agroindustrial	2009
SP	Monções	Grupo Virgolino De Oliveira	2008
SP	Nova Independência	Grupo Pedra Agroindustrial (Copersucar)	2005
SP	Queiroz	Grupo Clealco	2006

Blanked cells – There is no mill in the specific city but there are farms that supply the mill in the surrounding areas.

Appendix E. Respondents' Profile

Stakeholders per State

Stakeholder/State (a)	GO	MG	PR	MS	SP	Total	Sector of Society	
Visited Municipalities (a)	8	10	5	4	6	33		
Govern	18	20	5	10	9	62	62	1st Sector Govern (1)
Experts	15	15	6	6	5	47	129	2nd Private Sector (2)
Urban Entrepreneurs	13	8	6	10	4	41		
Sugarcane Producers	9	13	5	7	9	43		
Other Crops Producers	9	12	3	8	13	45	162	3rd Civil Society (3)
Workers	19	16	13	12	12	72		
Community Leaders	13	9	4	6	11	43		
Total	96	93	42	59	63	353		

(a) States and municipalities defined by rate of growth of sugarcane area from 2006 to 2016

(1) Includes Govern

(2) Includes Urban Entrepreneurs, Sugarcane Producers and Other Crop Producers

(3) Includes Workers, Community leaders and experts (academia)

Respondent's income per State

Income Level/State	GO	MG	PR	MS	SP	Total
< 2 mw	15	7	8	13	10	53
2 - 5 mw	35	39	11	19	30	134
5 - 10 mw	20	31	8	13	8	80
10 > mw	26	16	15	14	15	86
Total	96	93	42	59	63	353

mw = minimum wage in Brazil.

Age of the respondents per State

Age/State	GO	MG	PR	MS	SP	Total
20 - 30 y old	20	11	5	4	11	51
31 - 60 y old	70	69	29	38	42	248
above 60 y old	6	13	8	17	10	54
Total	96	93	42	59	63	353

Education Level of the Respondents

Age/State	GO	MG	PR	MS	SP	Total
Until fundamental School (1)	10	22	7	13	15	67
Secondary school (2)	26	26	11	19	18	100
Graduated school/above (3)	60	45	24	27	30	186
Total	96	93	42	59	63	353

(1) – includes illiterate, incomplete, and complete elementary school education.

(2) – includes incomplete and complete high school education.

(3) – includes incomplete and complete undergraduate and graduate education.

Length of dwelling per State

Length of dwelling/State	GO	MG	PR	MS	SP	Total
Less than 5 years	10	6	2	2	3	23
5–10 years	9	7	6	5	3	30
11–20 years	14	14	1	6	5	40
More than 20 years	63	66	33	46	52	260
Total	96	93	42	59	63	353

Place of Residence per State

Place of residence/State	GO	MG	PR	MS	SP	Total
Urban Area	81	77	37	45	40	280
Rural Area	15	16	5	14	23	73
Total	96	93	42	59	63	353

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