Global Assessment of Biomass and Bioproduct Impacts
on Socio-economics and Sustainability

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Global-Bio-Pact Case Study

Socio-Economic Impacts of the Sugarcane chain in Brazil

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Abbreviations

ANA – National Water Agency

ANP – Oil, Natural Gas and Biofuels National Agency

BEN – National Energy Balance

CETRUP – Pindorama's Rural Training Centre

CONAB – National Supply Company

EPE – Energy research Company

FAO – Food and Agriculture Organization

FFV – Flex Fuel Vehicles

GDP – Gross Domestic Product

IBGE – Brazilian geography and Statistics Institute

MAPA – Livestock, Agriculture and Supply Ministry

MMA – Environment Ministry

MME – Mines and Energy Ministry

PNAD – National Household Sample Research

UNICA – Sugarcane Industry Union

WRI – World Resources Institute

Preface

This report was elaborated in the framework of the Global-Bio-Pact project (Global Assessment of Biomass and Bioproduct Impacts on Socio-economics and Sustainability) which is supported by the European Commission in the Seventh Framework Programme for Research (FP7). Global-Bio-Pact is coordinated by WIP Renewable Energies and runs from February 2010 to January 2013.

The main aim of Global-Bio-Pact is the improvement and harmonisation of global sustainability certification systems for biomass production, conversion systems and trade in order to prevent negative socio-economic impacts. Thereby, emphasis is placed on a detailed assessment of the socio-economic impacts of raw material production and a variety of biomass conversion chains. The impact of biomass production on global and local food security and the links between environmental and socio-economic impacts are analysed. Furthermore, the Global-Bio-Pact project investigates the impact of biomass production on food security and the interrelationship of global sustainability certification systems with international trade of biomass and bioproducts as well as with public perception of biomass production for industrial uses. Finally, Global-Bio-Pact focuses on socio-economic sustainability criteria and indicators for inclusion into certification schemes, and the project elaborates recommendations on how to best integrate socio-economic sustainability criteria in European legislation and policies on biomass and bioproducts.

A core activity of Global-Bio-Pact is the description of socio-economic impacts in different countries and continents in order to collect practical experience about socio-economic impacts of bioproducts and biofuels under different environmental, legal, social, and economical framework conditions. The results of these surveys are described in different case studies.

The present report presents the Global-Bio-Pact Case Study for sugarcane value chain in Brazil. This Case Study was elaborated by a research group based at UNICAMP – University of Campinas.

1 Introduction

A strong public debate on sustainability aspects for biomass use for energy and products emerged in the last few years. This debate focused mainly on negative social and environmental impacts. In consequence, several initiatives were set-up, which are engaged in developing tools to ensure sustainability of biofuels. One option to ensure the sustainability of biofuels is the application of certification systems.

The main aim of the Global-Bio-Pact project is the improvement of global sustainability certification systems for biomass production, conversion systems and trade in order to prevent negative and to promote positive socio-economic impacts. Thereby, emphasis is placed on a detailed assessment of the socio-economic impacts of feedstock production and a variety of biomass conversion chains.

In order to generate data on the ground, five in-depth case studies for socio-economic impacts were investigated in the framework of Global-Bio-Pact:

- Biodiesel from soy in Argentina
- Palm oil and biodiesel in Indonesia
- Bioethanol from sugarcane in Brazil
- Bioethanol from sugarcane in Costa Rica
- Jatropha oil and biodiesel in Tanzania
- Jatropha oil and biodiesel in Mali
- 2nd generation biofuels and products from lignocellulosic material in Europe and North- America

The present report presents the Global-Bio-Pact Case Study for sugarcane value chain in Brazil. This Case Study was elaborated by a research group based at UNICAMP – University of Campinas.

For the regional case study, the Northeast region was selected for being a traditional production area, and because of its socioeconomics differences from the largest production region (Centre South). The local case studies are in these two main producer areas: Pindorama Mill is situated in the Northeast region, and São Francisco Mill in the Centre South, more specifically in São Paulo State.

2 Case Study selection

Since the impacts of the production of biofuels and bioproducts depends on the scale, different levels were investigated in all Global-Bio-Pact Case Studies, including the national, regional, and local/company/project level (Figure 1). In each Case Study (country) of the Global-Bio-Pact project the following assessments were made:

- One study at national level
- One study at regional level
- Two studies at local, company or project level

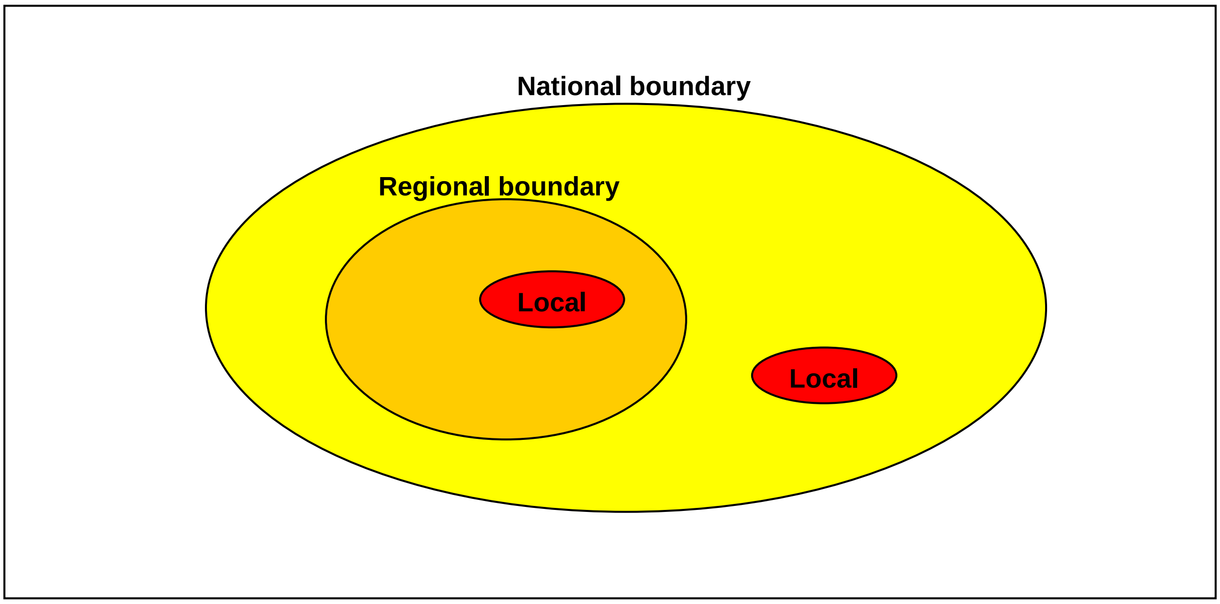


Figure 1: System boundaries of the Global-Bio-Pact

2.1 Case Studies at national level

The Case Studies at the national level were selected in order to balance the geographical distribution (Africa, Latin America, Asia, Europe, North America), feedstock sources (soy, palm oil, jatropha, sugarcane, lignocellulosic feedstock), conversion technologies (e.g. fermentation, pressing, transesterification, hydrolysis, gasification) and products (biodiesel, pure plant oil, ethanol, bioproducts, 2nd generation technologies). Thereby, the assessment focuses on existing conversion technologies since these are the current hotspots of socio-economic concern, but also include impacts of future technologies which are not yet commercially available.

The present report presents the Global-Bio-Pact Case Study for sugarcane value chain in Brazil.

2.2 Case Studies at regional level

In this project, the regional level was defined as a homogenous region in climate, soil, and socio-economic parameters. The size of the region depends on the country and can be a province or district.

In the present report, the Northeast region was selected as Case Study region since it is a traditional sugarcane area, with an important participation on the national ethanol and sugar production, with different characteristics and aspects than other areas, like São Paulo state or the expansion areas (Centre of Brazil).

2.3 Case Studies at local level

At the local level the system boundary is a local area from an e.g. farmer, company, association or project level. The local area refers to the area where the biomass feedstock (including by-products) is produced and converted into the final or intermediate product. In each Global-Bio-Pact Case Study country two different local Case Studies (projects, companies) were selected and investigated. Thereby, these two local Case Studies can be within or outside the regional boundary. In the present report, the São Francisco Mill and the Pindorama Mill were selected as case studies.

São Francisco Mill was selected since it is a different model of production. It is located north of São Paulo state and is the largest organic sugarcane producer in the world. The hypothesis is that the difference between regular and organic sugarcane production should show also different socioeconomic and environmental impacts.

On the other hand, Pindorama Mill was selected since it is a cooperative. This system is not very common in Brazil, and Pindorama is the only cooperative in the sugarcane business in the Northeast region. Pindorama is situated in Alagoas state, that is one of the poorest in Brazil.

3 General description of the Case Study

3.1 Case Study at the national level: Brazil

Brazil is worldwide the fifth largest country by geographical area, and the fifth most populous country; is the largest country where Portuguese is spoken. Is located in South America and occupies almost 50% of that region; Brazil has borders with all South American countries, except Chile and Ecuador. The country has a total area of 851.5 Mha, and in 2010, according to the Brazilian Institute of Geography and Statistics (IBGE), the total land area used for agricultural purposes was of 61.4 Mha, and around 196 million hectares were occupied by pastures. The legal reserves and preserved areas, as well as natural woods and/or forests covered were of 520 million ha (FAO, 2011). Figure 2 presents its position in South America and details of the country's topography.

Figure 2: Map of Brazil

3.1.1 Economy

Characterized by large and well-developed agricultural, mining, manufacturing, and service sectors, Brazil's economy outweighs that of all other South American countries and Brazil is expanding its presence in world markets.

The Gross Domestic Product (GDP) in Brazil expanded at an annual rate of 2.74 percent in the first quarter of 2010. Brazil GDP worths 1210 billion Euros or 2.54% of the world economy, according to the World Bank (2010).

Although Brazil is the 9th largest economy in the world, according to Economy Watch website (2010), it still has a large percentage of people living under the poverty line. As presented in the CIA's Factbook, in 2008 26% of Brazilian population was living under that condition. Furthermore, the country has a GINI Index of 0.538, representing one of the worst levels of inequality in the world, according to 2009 data from IPEA (Institute of Applied Economic Research).

The main industrial branches in Brazil are: automobile, petrochemicals, machinery, electronics, cement, textiles, food and beverages, mining, aircraft, etc. The main products of Brazil's agriculture are soybeans, coffee, beef, citrus, sugarcane, rice, corn, cocoa, etc.

3.1.2 Population

According to the last official demographic survey, in 2007 the Brazilian population was almost 190.7 million inhabitants (IBGE, 2010). The average population growth between 2000 and 2010 was 1.17% per year. Brazil is divided in five geographic regions, and the population in each one is presented in Table 1, while the Demographic density is presented in Figure 3.

Table 1 - Demographic information – Brazil, 2010

Region	Population (1,000)	Area (100,000 ha)	Density (hab/ha)
North	15, 865.6	3,851.6	0,041
Northeast	53,078.1	1,556.0	0,341
Southeast	80,353.7	927.3	0,867
South	27,384.8	575.3	0,476
Centre-West	14,050.3	1,604.9	0,088
Total	190,732.6	**8,514.9**	0,224

Source:IBGE (2010)

According to IBGE, in 2010 51% of Brazilian society was female. In the matter of race, 48.4% were white, 6.8% black, 43.8% were considered brown and 0.9% indigenous people, being 6.2% of the white population is illiterate, versus 13.3% of black and 13.7% of the brown inhabitants (data for 2009). The urban population has reached 84.4% (IBGE, 2010).

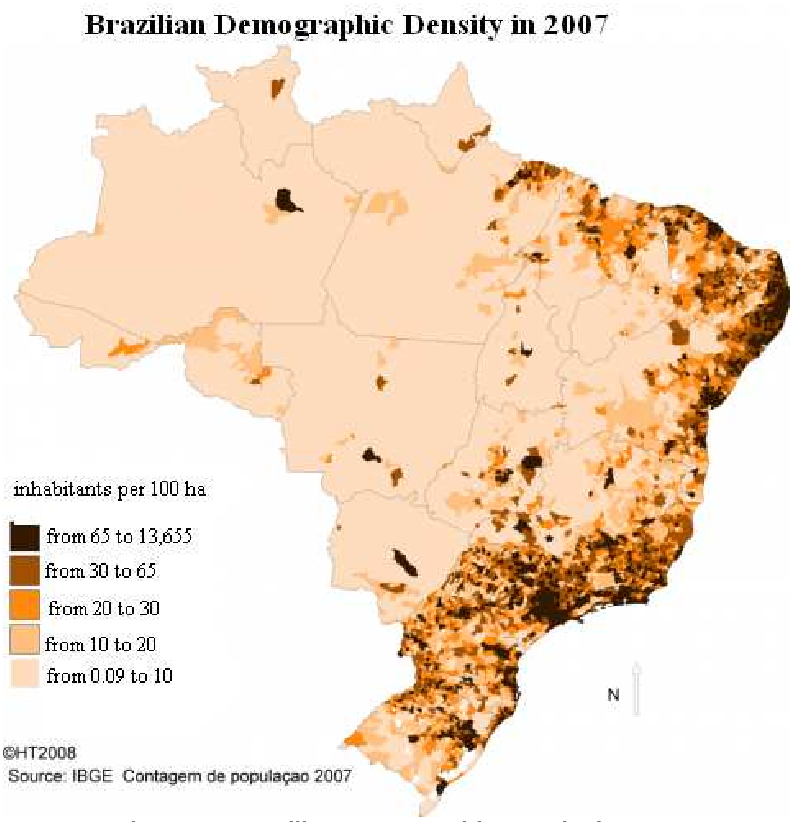


Figure 3 – Brazilian Demographic Density in 2007
Source: : IBGE: Contagem de população 2007.
(Available at ibge.gov.br - 2010)

3.1.3 Agricultural sector

Agriculture is, historically, one of the country's major economic bases, evolving from extensive monocultures to the production's diversification. Initially a sugarcane producer (during the colony period), and then moving onto coffee plantations, Brazilian agriculture is one of the largest exporters of different types of species, including cereals, fruits, grains and others.

In 2008, Brazil main crops were soybeans, with a total area of 23.3 Mha and total weight of 68.5 Mt (IBGE, 2010). The production of soybeans in Brazil has been blamed for deforestation, due to the fact that the recent expansion of this crop has been in the Cerrado region, in the central part of Brazil. It is believed that soybeans expansion has caused deforestation in that area (i.e., directly causing land use change) and has indirectly contributed to the deforestation in the south of Amazon region (Walter, 2009).

In second place came Maize, totalizing 12.9 Mha, resulting in 56.1 Mt. Sugarcane in third place, being planted in 9.2 Mha, with a total production of 730 Mt (IBGE, 2010).

The top products Brazil imports are wheat and maize, followed by malt. Brazil is the top importer of wheat in the world. As an exporter, soybeans and sugar are the top products (FAO, 2007).

3.1.4 Forestry sector

Brazil's forests are among the richest in the world, yielding timber, oil-bearing fruits, gums, resins, waxes, essential oils, cellulose, fibres, nuts, mate, and other products. In the rainforest, as many as 3,000 different species per sq miles may coexist. However, only a limited percentage of forestland is being exploited, in part because of a lack of adequate transportation, as described in the Encyclopedia of Nations (2010).

Brazilian round wood production in 2008 was 101.3 Mt, of which 58.2 Mt were used for paper and pulp making.

Brazil is still a large importer of natural rubber, with 221 thousand tonnes in 2008 (FAO, 2010). Some of the Brazilian exports are: wood pulp, sawn wood, plywood, fibreboard and veneer.

Particularly in case of dedicated forests of eucalyptus, it is believed that Brazil has worldwide the best technology for implementing them. Eucalyptus plantations have been condemned for years, but some of the constraints of the past are no longer a matter of concern (e.g., soil drainage, soil degradation, nutrient leaching and reduction of water storage capacity can be almost completely avoided if adequate techniques are applied). Regarding biodiversity preservation, the usual solution is both to form and maintain wildlife corridors connecting areas under conservation (native vegetation) (Couto et al., 2002).

3.1.5 Land ownership concentration

As of the mid 1990s, after the restructuring and modernization of the agricultural production, economic issues impacting on land conflicts have won greater degree of intensity. This has occurred due to significant institutional changes and uncertainties surrounding property rights associated with increasing disputes among land owners, squatters, social movements organizations, Indians, Afro-Brazilians (quilombolas), environmentalists and government bodies (Nascimento, 2007).

In the sugarcane scenario, Table 2 and Table 3 show a profile of sugarcane production, indicating how sugarcane production is divided in Brazil, and the capacity of producers and their land size in the state of São Paulo, Brazil's largest sugarcane producing region.

Table 2 - Profile of Sugarcane production in Brazil from 1960 to 2009

Season	Sugarcane crushed (thousands of tonnes)			From suppliers (%)
	Own production	From suppliers	total	
1960-1961	18,562	17,985	36,547	49.2
1970-1971	31,125	29,409	60,534	48.6
1980-1981	65,295	58,385	123,680	47.2
1990-1991	133,457	88,971	222,428	40.0
2000-2001	173,559	81,361	254,920	31.9
2004-2005	230,724	150,722	381,446	39.5
2005-2006	232,462	150,019	382,481	39.2
2008-2009	357,764	214,374	572,136	37.5

Source: MAPA (2007), Conab (2010).

Table 3 - Profile of sugarcane suppliers in the state of São Paulo – 2009-2010

Range of production (t)	% of producers	Average area (ha)	Production (1000 t)	% of production	Average yield (kgTRS/ha)
1,000	40	7	4,556.5	3.3	132.68
1,000-6,000	41.5	42	27,282.9	19.6	132.76
6,000-12,000	8.9	134	18,912.3	13.6	132.49
12,000-25,000	5.8	271	24,780.4	17.8	132.10
25,000-50,000	2.4	552	20,578.2	14.8	131.72
50,000-100,000	1.0	1091	17,001.6	12.2	131.11
>100,000	0.5	3503	26,096.4	18.7	132.07
Total	**100.0**	**58**	**68,649.0**	**100.0**	**132.16**

Source: Orplana (2011).

3.1.6 Food security

A recent study from the FAO Special Programme for Food Security has revealed that about 90% of Brazil's total food production is concentrated in the south, south-east and the southern part of the central western region. However, 60% of food insecure populations are located in the north and north-eastern regions. In Brazil, local food production is inadequate to satisfy the population's nutritional requirements (FAO, 2010).

To fight this local problem, the government increased subsidies to agricultural credit and guaranteed minimum prices for rice, beans, corn, wheat, and cassava. The government temporarily stopped transportation taxes. A special National Wheat Plan has been introduced, which aims to increase wheat production by 25 percent. In order to achieve this target, a separate credit line for wheat production has been introduced with relatively low interest rates and has allocated BRL 1.2 billion in agricultural credit to wheat producers (FAO/GIEWS 2008).

Although 44 million Brazilians live in extreme poverty on a daily income which is less than US$ 1.06 a day the country still has an energy supply of 3,145 kcal/capita, with undernourished people of 6%. If only the children are counted, it drops to 5%, as reported by the Food Security Portal (2010).

3.1.7 Energy sector

Few countries with reasonable to good level of industrialization, like Brazil, have an energy matrix with such an important share of renewable energy sources. In 2009, 47.3% of its primary energy supply was covered by renewables. The share of hydraulic energy that year was 15.3% of the total supply. In the same year, the set of biomass sources covered 31% of the domestic energy supply, with a share of 18.1% of sugarcane products (ethanol and bagasse) (BEN, 2010).

Along the last three decades or so, Brazil has remarkably reduced its dependency on oil supply and is currently (on average) self-sufficient. But in contrast, Brazil is highly dependent on high-quality coal (and coal coke), used in iron and steel production; this dependency was reduced in the early 1980s, when Brazilian government implemented policies aiming at substituting coal coke for charcoal, but imports raised again when coal's (coke's) prices declined. The dependency on natural gas is a new event, and started with the imports from Bolivia; Brazilian government (and Petrobras, the stated-controlled oil company) has worked on enlarging domestic production and diversifying suppliers. Finally, the dependency on electricity is mostly due to the imports from Paraguay, as this country is owner of 50% of Itaipu's capacity (the largest hydro power plant, with almost 14 GW installed) (Walter, 2009).

3.1.8 Policy framework (concerning ethanol and sugarcane production)

During the first 15 years of the Brazilian ethanol program, supply and demand were both stimulated and adjusted through central coordination. Producers accepted the Program since the very beginning as it was also created in order to minimize the difficulties frequently faced by sugarcane sector due to the excess of sugar production and fluctuations of its international prices. In addition, the required investment was assured by credits given at low interest rates and risks were extremely reduced as sales were guaranteed and prices were controlled – both to sugarcane and to ethanol. In fact, fixed prices for producers and consumers played an essential role in the general trust of the program (van den Wall Bake et al., 2008). Also aiming at assuring the supply, the government has obliged the state-controlled oil company (PETROBRAS) to provide and operate the required infrastructure of transport, storage, blending and distribution. Eventual losses during ethanol commercialization were also assumed by PETROBRAS. In parallel, in order to induce the consumption, the government negotiated with the automobile industry to introduce the required modifications in engines and parts. More modifications are required as the share of ethanol in the fuel blend is large (Coelho et al., 2006). In early 1980s, the automobile industry has accepted to give full warranties to the consumers. The R&D efforts regarding engines able to run with blends and straight ethanol started at a federal research centre (Aeronautics Research Centre) where the development of engines and tests were performed. The first neat ethanol engine was commercially available in 1979 and technology was quickly transferred to the automobile industry. On the other hand, the ethanol market was induced by mandates. In 1975, a mandate for 20% anhydrous ethanol (E20 – volume basis) on fuel blend was established. However, just by early 1980s the share of ethanol into all gasoline commercialized reached 20%. Through the years, the share of ethanol in fuel blend has changed: the ethanol share was reduced to 13% between 1989 and 1993, during a (domestic) supply ethanol crisis, while in 1993 it was defined by law that the share of ethanol in fuel blend should be in the 15–25% range, depending on the conditions of ethanol market. Since then the lowest level reached was 20%. In practice, this relative wide range allows the shift of production to more sugar (when it is convenient), allowing the producer to maximize its earnings. Recently, the share of anhydrous ethanol in the fuel blend was reduced to 20%, due to constraints on ethanol production (mainly due to the difficulties on enlarging sugarcane production).

In Brazil, taxes have a strong impact over the consumer's fuel price. Currently, six different taxes and contributions have been applied over automotive fuels, being just one equivalent to the value added tax (VAT). For instance, in 2005, the average taxation over gasoline C (gasoline blended with ethanol) in Brazil was estimated as 47%, while the average taxation over hydrated ethanol was evaluated as 34%. In addition, in state of São Paulo (the largest producer and consumer of ethanol in Brazil), the taxation over hydrated ethanol was close to 20% in the same year (Cavalcanti, 2006). In the state of São Paulo an additional advantage for ethanol consumers is the lower value of the annual license paid by owners of neat-ethanol vehicles (including FFVs).

Direct subsidies were completely eliminated with the deregulation process that finished in early 2000s. However, a tax exemption policy is in place and part of the benefits received by ethanol consumers is due to lower taxes applied to ethanol regarding those paid by gasoline consumers.

Anyhow, it should be noticed that in Brazil the taxation applied to diesel oil is even lower than the correspondent applied to ethanol (about 27% in 2005, on average) (Cavalcanti, 2006).

When it comes to agricultural and forestry policies, the Brazilian government has created the Agro Ecological Zoning of sugarcane for ethanol and sugar in Brazil. The overall objective of Agro Ecological Zoning of sugarcane is to provide technical support to formulate of public policies aimed at the expansion and sustainable production of sugar cane in Brazil. Through digital processing techniques a valuation of the potential land for crop production of cane sugar in rainfed conditions (without full irrigation) was carried out based on the physical, chemical and mineralogical soils characteristics expressed spatially in soil surveys and studies on climate risk related to the requirements of the crop (rainfall, temperature, drought and frost occurrence). Figure 4 shows the areas that are apt to receive sugarcane. The colours represent the level of aptitude of the land.

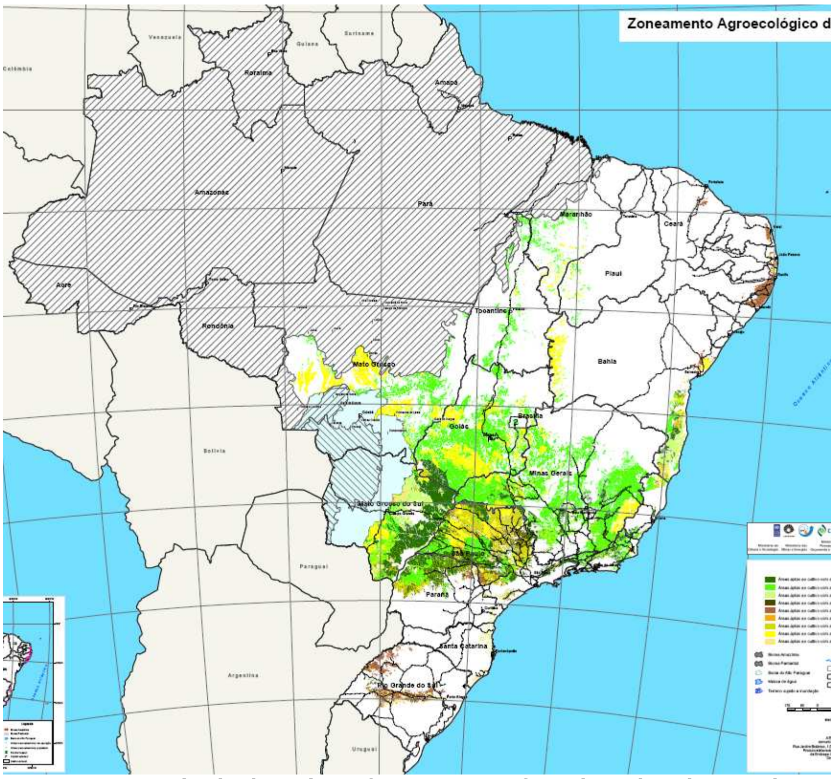


Figure 4 - Agro ecological Zoning of Sugar Cane for ethanol and sugar in Brazil. Source: Mazatto et. al. (2009).

3.1.9 The Sugarcane supply chain in Brazil

Figure 5 shows a simplified scheme of the sugarcane supply chain in Brazil. As previously mentioned, about 60% of the sugarcane is produced by the own mills, and the complement by suppliers. Most of the mills produce both sugar and ethanol, some produce just ethanol and few produce just sugar. All sugarcane mills in Brazil are self-sufficient regarding electricity supply, and about 20-25% have installed for surplus electricity generation.

In 2009, 178,618 10^3 tonnes of sugarcane juice and 16,226 10^3 tonnes of molasses were produced (BEN, 2010), using 6.75 Mha to cultivate sugarcane (UNICA, 2010). On the main products, production of ethanol reached 19,089 10^3 m^3 of hydrated ethanol and 7,014 10^3 m^3 of anhydrous ethanol, with a 26.8% reduction comparing with 2008 (BEN, 2010).The transport sector was the main consumer of both types of ethanol, with 16,471 10^3 m^3 of hydrated and 6,352 10^3 $m^3$of anhydrous, and export accounted for 3,292 10^3 m^3, decreasing 35.7% from 2008 to 2009. The national consumption in 2009 was 11,792 10^3 tep of ethanol, increasing 7.1% in comparison with 2008 (BEN, 2010). Figure 6 shows the evolution of national production from 1970 to 2010.

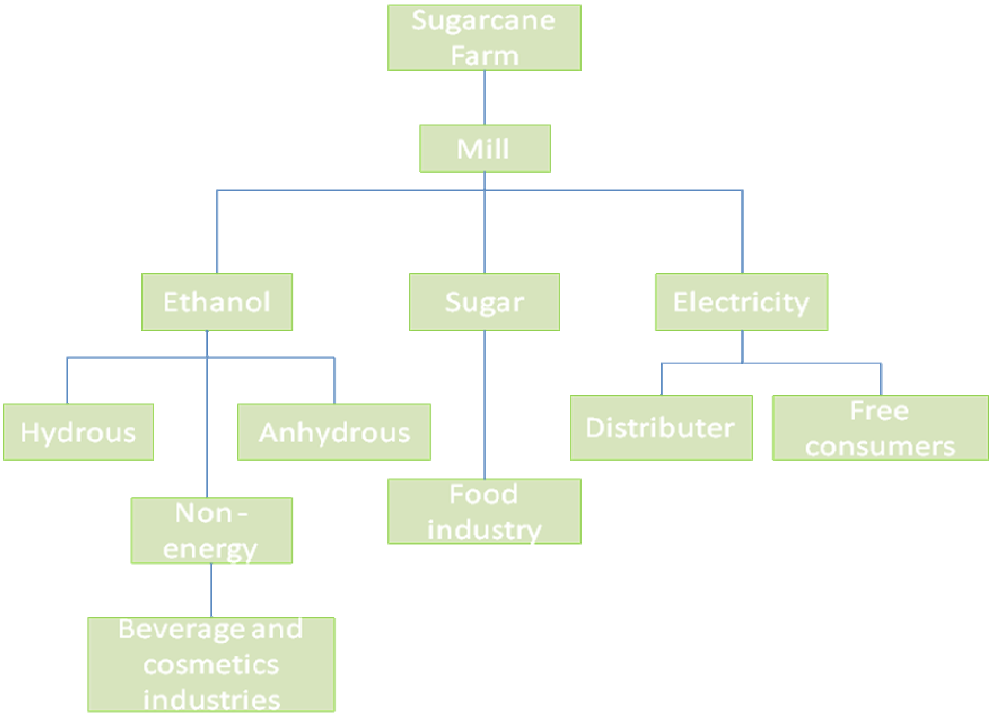


Figure 5: Flowchart of the supply chain of sugarcane in Brazil
Source: Neves et al. (2011)

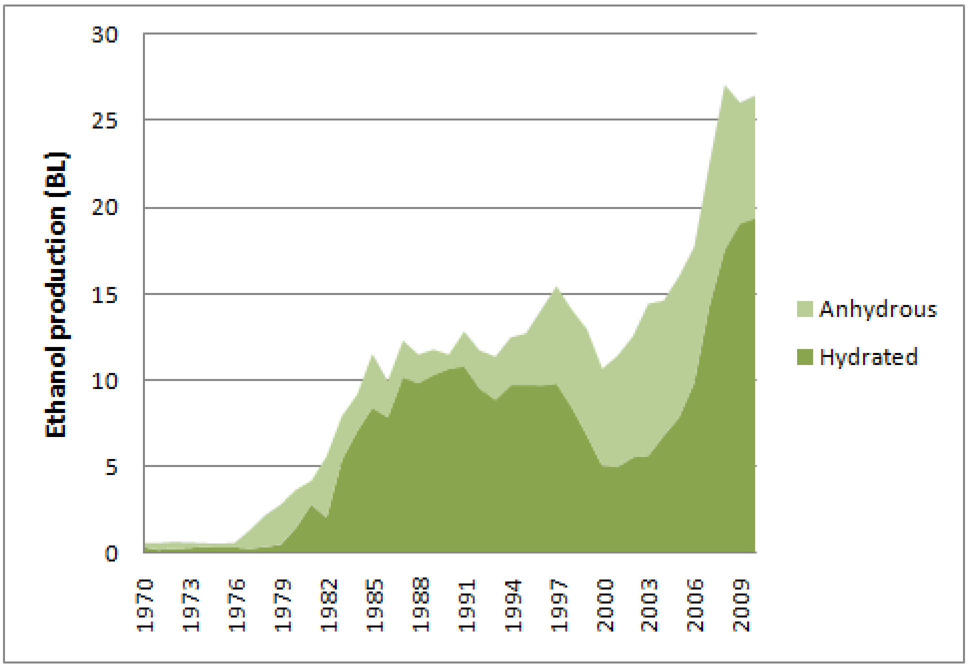


Figure 6 - National hydrated and anhydrous ethanol production evolution 1970-2010.
Source: EPE (2010), MAPA (2011), ANP (2011).

International trade of sugarcane as an unprocessed or raw feedstock is not common. Nevertheless, in 2007 Colombia was the main exporter with 55,245 tonnes, followed by Malaysia with 9,335 tonnes. The Columbian figures have oscillated from 26,154 to 72,257 tonnes, between 200 and 2007 (FAO, 2007).

Looking at the ethanol scenario, the exports from Brazil of anhydrous and hydrous ethanol reached 3.3 million m³ in 2009. Relatively to the year 2008, this volume decreased 35.1%. Between 1999 and 2009, there was an increase in the export of ethanol in all years except 2000 and 2009. Different from 2008; Brazilian exports of ethanol in 2009 were mainly targeted at Asia, which absorbed 31.1% of total exports increasing 89.4% (ANP, 2010). The second place was taken by the European continent, concentrating 28.2%. The third position fell to Central and South Americas, responsible for the purchase of 23.6% ethanol exported by Brazil.

As it is presented in table 4, in 2010 346 mills were located in the so-called Centre-South region of Brazil. In four years, from 2006 to 2010, 98 new mills started operation in Centre-South region.

Table 4 – Operating mills in 2010 and expected amount of sugarcane (2010-2011)

Region	State	Number of mills	Sugarcane crushed (1,000 t)
Centre- South	Minas Gerais	40	55,198.1
	Espírito Santo	6	3,484.0
	Rio de Janeiro	7	2,643.5
	São Paulo	197	359,235.5
	Paraná	30	43,905.2
	RG do Sul	2	85.6
	Mato Grosso	9	13,835.1
	MG do Sul	21	34,333.2
	Goiás	33	47,980.8
	Sub-total	346	560,701
North-Northeast	Alagoas	24	26,752.8
	Pernambuco	22	18,783.8
	Paraíba	9	5,349.9
	Bahia	4	3,259.2
	Maranhão	4	2,551.7
	Amazonas	1	345.7
	Piauí	1	836.9
	Tocantins	1	348.0
	Pará	1	540.0
	Rondônia	1	146.5
	Sergipe	6	2,200.9
	Ceará	3	180.4
	RG do Norte	4	2,994.2
	Sub-total	80	64,290.0
Brazil	**Total**	**426**	**624,991.0**

Source: MAPA (2011), Conab (2011).

In 2010, 245 mills were able to produce both ethanol and sugar, with some degree of flexibility between the two products (general sense, the production varies from 30% to 70% ethanol, and consequently, 70% to 30% sugar), 161 mills were only able to produce ethanol (autonomous distilleries) and 16 mills were able to produce only sugar (MAPA, 2011). "Brazilian model of ethanol production" refers to the combined production of sugar and ethanol, option that brings some advantages to producers, at least regarding risk reduction.

In 2010/2011 the bulk of sugarcane production (89%) occurred in the Centre-South region and a small share in the North-Northeast region (11% being more than 10% in the Northeast region). In the period 2000-2006 the production of sugarcane in states of the Amazon region was only 0.6% of the total, on average, and this share has decreased to 0.2% in the 2010/2011 harvest. Total sugarcane production (for sugar and ethanol) in the harvest season 2010-2011 is expected to be 625 Mt (an increase of 3.4% compared to the previous harvest season). The expected yield is 77.8 t/ha of sugarcane in Brazil.

In the state of São Paulo, the region with highest concentration of sugarcane mills – Ribeirão Preto, has the best conditions for this crop, considering soil quality, weather adequacy, rainfall and topography. This region has high concentration of sugarcane areas and land is relatively expensive there. In state of São Paulo the tendency is the installation of new producing units in the west side of the state, displacing pasture and, in a smaller extent, other traditional crops (e.g., orange).

An important characteristic of ethanol production in Brazil is that there is a high concentration of industrial capacity in large mills. The weighted average capacity in the Centre-South region has been close to 2 million tonnes of sugarcane crushed per year, and new mills tend to be even larger (about 3 million tonnes/year). Figure 7 shows were sugarcane production takes place.

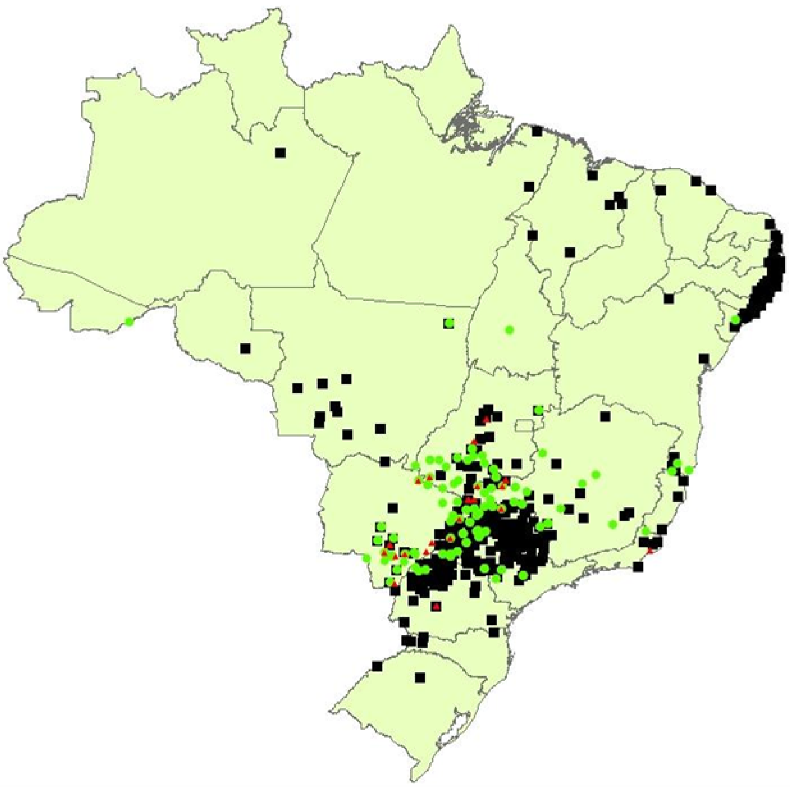


Figure 7– Sugarcane production sites in Brazil – The black dots represent the existing productions sites and the green dots the ones planned.
Source: EPE (2008).

3.1.10 Actors of the supply chain of sugarcane in Brazil

In the sugarcane supply chain, it is usual to find units that are responsible for producing the feedstock and converting it into its main products. In the Brazilian case, 10 sugarcane producers are responsible for 10% of the total production of the state of São Paulo, which is responsible for over 60% of the national production (UNICA, 2010).

When it comes to distributing ethanol to its final consumer, six companies detain 57.8% of sales: BR (19.3%), Shell (12.4%), Ipiranga Group – CBPI and DPPI (11.5%), Chevron (6.8%), Petrosul (5.1%) and Esso (4.9%). The remaining 42.2% are shared among 151 distributers (ANP, 2008).

Some of the main governmental institutions are: – National Agency of Petroleum, Natural Gas and Biofuels (ANP), which is the regulator of activities that integrate the industry of petroleum and natural gas and biofuels in Brazil, and acts as promoter of development of the regulated sectors. Collaborate for attracting investment, for technology improvement and training of human resources the following organizations: Ministry of Agriculture, Livestock and Supplies (MAPA), Ministry of Mines and Energy (MME), and the Sugarcane Industry Association (UNICA), the largest organization in Brazil representing sugar, ethanol and bioelectricity producers.

3.2 Case Study at the regional level: Northeast region

3.2.1 Land use

Northeast has a total area of 1,558,196 km², and its land use in 2006 was divided as follows, according to the Brazilian agricultural census (2006):

- Agricultural land;
    - Permanent crops: 3,512,112 ha;
    - Temporary crops: 10,072,922 ha;
    - Crops specifically for fodder: 1,563,414 ha;
    - Flower cultivation: 14,410 ha;
- Natural Pasturelands: 16,010,989 ha;
- Degraded planted pasturelands: 2,233,350 ha;
- Planted pasturelands in good conditions: 12,295,265 ha;
- Forests legally preserved: 6,537,380 ha;
- Natural forests and woods: 14,255,741 ha;
- Agroforestry: 4,638,458 ha.

In summary, about 15 Mha were occupied with different crops, almost 31 Mha with pastures and 25 Mha with natural and planted forests, representing about 46% of the total area of the region.

3.2.2 Economy

Northeast was responsible for 13.3% of the country's GDP in 2008, producing 274 billion Euro. The region has the lowest GDP per capita in the country, estimated in 2008 as 3,372.7 Euro. The region's Gini index was 0.556.

The region's economy is based on the three sectors, agriculture, industry and services. In agriculture, sugarcane and banana are the main products, with a total of 1.4 billion Euro (2006) worth of production each, followed by maize (786 million Euro) and cassava (636 million Euro) (IBGE, 2006). Coastal cities stand for their tourism. In livestock, there is an important presence of the activity in the states of Maranhao, Piaui, Pernambuco and Bahia. The large industries are present in big urban areas and the main activities are footwear, electrical and electronic products, petrochemicals (the North-eastern Complex) and weaving. In the region, important industrial poles are the Industrial District of Ilheus (Bahia), Suape Industrial Complex (Pernambuco) and the Industrial District Maracanaú (Ceará). Regarding technology, the Digital Port of Recife (largest technological hub in the country) can be highlighted with emphasis on producing software.

In 2009, 90% of the region's population lived with less than 238 Euro per year (household income per capita).

3.2.3 Population

The region's population in 2010 was 53,078,137 people with 18,050,780 formal workers. The demographic distribution is shown in table 5.

Table 5 – Population growth in northeast region 2000-2010

State	Population in 2000	Population in 2010	Growth (%) 2000-2010
Maranhão	5,561,475	6,569,683	18,13%
Piauí	2,843,278	3,119,015	9,70%
Ceará	7,430,661	8,448,055	13,69%
Rio Grande do Norte	2,776,782	3,168,133	14,09%
Paraíba	3,443,825	3,766,834	9,38%
Pernambuco	7,918,344	8,796,032	11,08%
Alagoas	2,822,621	3,120,922	10,57%
Segipe	1,784,475	2,068,031	15,89%
Bahia	13,070,250	14,021,432	7,28%

Source (IBGE, 2011)

The working population in the region is mostly concentrated in the services sector, with 58% of all occupied population. 60% of the occupied population in the region has studied less than nine years, while 90% has reached 12 years in Brazil; that means that 90% of the occupied population in the Northeast region did not even start college. The working force is mainly male, with 62% of men. 70% of all workers are black or brown.

3.2.4 Agricultural sector

The most important agricultural products, in planted area and quantity produced in the region are sugarcane, maze, cassava, and soy. Table 6 shows the quantity produced and area planted for each product in the year 2006.

Table 6 – Quantity produced and area planted for sugarcane, maze, soy and cassava in NE (2006)

Product	Planted area (ha)	Quantity produced (t)
Sugarcane	1,131,507	58,989,062
Cassava	1,590,133	8,170,935
Maze	3,142,881	5,488,858
Soy	1,121,107	2,943,043

Source: IBGE (2006)

The people working in the agricultural sector represent 20% of all workers in the region. They have the least number of years in school, with only 2.9 years of class attendance. The mean age of the agricultural worker is 40 years old, and the mean income is 153 Euro per month in 2009 (PNAD, 2009).

3.2.5 Forestry sector

The forestry sector in the Northeast region is based on eucalyptus and American pine trees. The total planted area of eucalyptus was 29,066 hectares in 2006 and the pine tree planted area was 11,423 hectares.

The production of firewood in the region was 23,728 thousand m^3. For paper production, 418,000 m^3 of round wood were cut.

3.2.6 Land ownership concentration

Keeping in levels similar or higher than the national index, Northeastern States express high levels of land concentration in the eastern portion of Maranhao and in large part of Piaui, of the São Francisco basin and west of Bahia. This concentration comes from historical and economical reasons. The process of occupation of the Northeast region, especially in the country side and the savannah regions, started with the large cattle properties, based on slave work and extensive cattle raising. The soy expansion based on a large scale production and monoculture also helped the concentration of land in the region (IBGE, 2006).

3.2.7 Food security

In the northeast region, 53.6% of the households have access to food, qualitative and quantitatively (IBGE, 2006). In 2006, there were 14 million people living in homes with high food insecurity in Brazil. 52% of all these people were in the Northeast region.

3.2.8 Energy sector

The energy sector in the northeast region has almost the same characteristics as the whole country's sector. In electricity production, 71% comes from hydro power plants, 26% from thermal units and 4% from wind power. When it comes to wind power, the northeast region represents 70% of the Brazilian wind energy use for electricity (BEN, 2009). In Brazil, the region had the largest growth in electricity production from 2008 to 2009, rising 18%. The residential electricity consumption is 339 kWh/inhabitant, a low consumption rate compared to Southeast, which a consumption index almost twice (678 kWh/inhabitant).

The energy production in the region is expressive. It detains 8% of the country's oil production (9,266 thousand m³), 26% of natural gas production (5,569 million m³) and 8.5% of ethanol production (2,211 thousand m³).

3.2.9 Policy framework

Sugarcane producers in the Northeast are entitled to a subsidy of 2.1 Euro per ton of sugarcane in order to level the production costs. This subsidy is limited to 10,000 tons. Other policies followed by the region are the same as for the whole country. Either small and large producers have the right for the subsidy.

3.3 Case Study at the local level: São Fransisco Mill

3.3.1 Location of the Case Study

The location of the São Francisco in state of São Paulo is shown in figure 8.

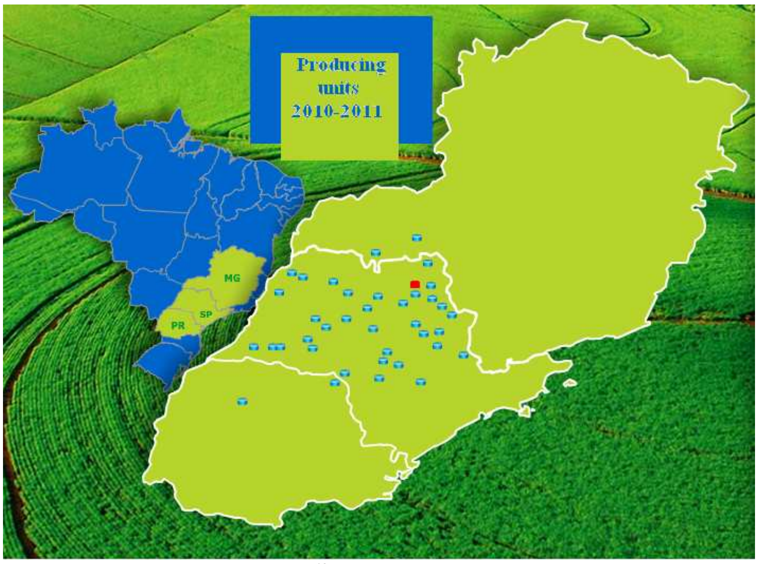


Figure 8: Location of the São Francisco Mill (represented in the red dot)

The Mill is located in the north region of the State of São Paulo, 356 km away from the capital, São Paulo. The total sugarcane production area is 7,500 hectares in the São Francisco mill, plus 6,000 hectares in Santo Antônio mill. According to UNICA (2009), São Francisco mill and its suppliers produced 1,291,223 tonnes of sugarcane in 2009, and the mill alone produced 83,941 tonnes of sugar.

3.3.2 Description of project/company

When São Francisco was established, the main objective was the development of a self-sustaining production system of sugarcane. After a decade of research, from 1987 to 1997, the San Francisco unit received the certificate of organic farmer. Organic production does not allow use of chemical fertilizers or pesticides. The control of pests is biological. The cane is cut raw. Special mechanical harvesters deposit straw and green leaves to the soil, optimizing the use of industrial organic wastes as sources of nutrients. There is practice of green manuring in a system of crop rotation.

3.3.3 Flowchart of the supply chain

Figure 9 shows the flowchart of the supply chain for the São Francisco Mill.

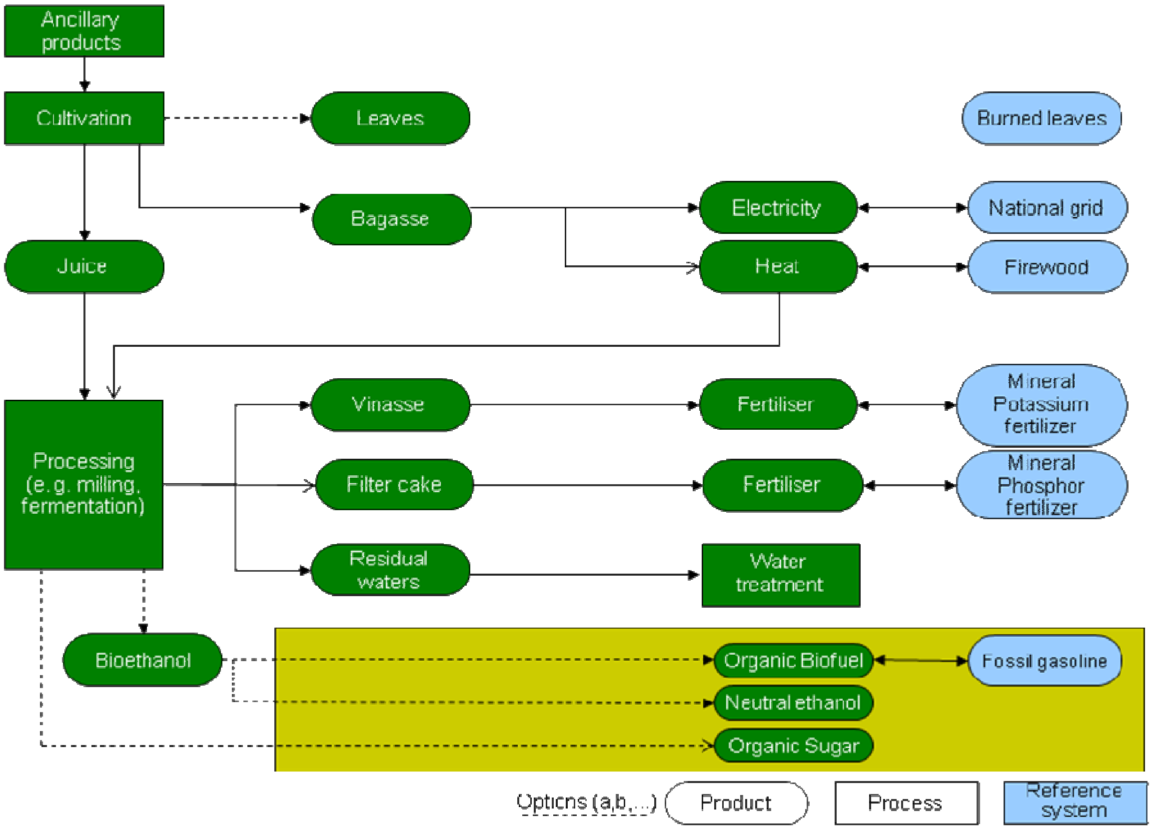


Figure 9 **São Francisco Mill supply chain flowchart.**

The production system developed by Grupo Balbo allowed harvesting cane without burning. The harvesters, while they take away the cane, promote the deposition of green grass in the soil, creating mulch that protects it from erosion and heat stroke. The land also receives liquid and solid organic waste from industry. As the production cycle of a sugarcane field is approximately six years, during which they get five crops, the soil is plowed only every six or seven years. Furthermore, machines and vehicles have mats and high flotation tires to minimize soil compaction. All these techniques help maintaining soil's fertility, creating a favourable environment for the action of beneficial microorganisms and the infiltration of air and water, essential for plant development. Coupled with actions such as the biological control of pests and diseases, green manure in crop rotation with legumes and other crops, the proper management of weeds and the creation of islands of biodiversity in the midst of culture, such practices ensure the balanced coexistence and harmony between the farmer and nature.

Besides all the agreed practice of organic agriculture, biodynamic farmers (part of the mills production is also biodynamic) also use:

- Lunar calendar based on astronomy;
- Use of biodynamic preparations.

The timing suggests the most appropriate time for planting, processing, fertilization, cutting and harvesting, according to the position of the moon and planets. The biodynamic preparations are homeopathic compounds made with medicinal herbs, minerals and manure. Undergo a special process of fermentation and under the influences of the rhythm of the

Earth and the Sun, these preparations are applied directly on the ground and on plants, helping the development of roots and fruit quality.

From sugarcane and organic industrial processes, Native (the brand behind the São Francisco mill) produces organic alcohol, which can be applied in industries such as cosmetics and pharmaceuticals, for example. Native also produces sugar and exports 85% of its production, being 90% to Europe and USA, and 10% to Asia, especially Japan.

São Francisco mill produces about 1,400,000 tons of cane per year, as said, in total 13,500 ha. Recently, the total production was 85,000 tonnes of sugar and 65,000 L of ethanol. From the total amount of ethanol, 14,000 L are of hydrated organic.

The total number of employees during the harvest season is 4,000 people, divided in agricultural, industrial and administrative sectors.

3.4 Case Study at the local level: Pindorama Mill

3.4.1 Location of the Case Study

Pindorama mill is located in Coruripe, in southeast Alagoas, as shown in figure 10.

Figure 10 – Pindorama Mill Location (represented in the red dot)

3.4.2 Description of project/company

Pindorama is a cooperative of agricultural farmers, created in December 6th of 1956, and located 120 km away from Alagoas main city, Maceio. It was founded by the Swiss Henri Renée Bertholet. In the 1950s there was a great exodus in the Northeast. People went to look for work in Sao Paulo and Parana, mainly in coffee plantations due to lack of opportunities in that region. It was in 1953 when the Henri Bertholet, who had arrived in Brazil in 1949 and was based in Guarapuava (PR), was invited by the Brazilian government to join a working group in order to colonize the northeast, retaining the rural workers in their natural habitat. He accepted the invitation, and when arrived at that region identified the lands that belonged to a local family and that was home to a bankrupt project financed by a state-owned bank Bertholet proposed the federal government to take the land on account of debt, developing a project that resulted the creation of the Cooperative Pindorama. In the period 1953 to 1956, he worked to organize the cooperative, with the recruitment of the first settlers and division and delivery of lots.

As a cooperative, it is formed by 1160 small producers, whom are the owners and the only providers of raw materials. The total cultivated area for fruits and sugarcane is 32,000 hectares. The size of the lots range from 9 to 25 ha. Today, Pindorama is a major producer in the region, being among the 100 largest tax contributors, having in 2009 revenue of R$125 million.

Initially its main product was passion fruit and slowly moved into juice production. Nowadays they diversified their products producing sugar, since 2003, and ethanol, since 1982. They also cultivate other fruits for juice production. The 2009/2010 production of sugarcane was 608,000 tonnes resulting in 32,549 tonnes of sugar and 35,579,550 liters of ethanol, while the production in the last harvest season is expected to be 900,000 tonnes, with 50% designated to ethanol production and 50% to sugar production.

3.4.3 Flowchart of the supply chain

Figure 11 shows the flowchart for supply chain of Pindorama mill.

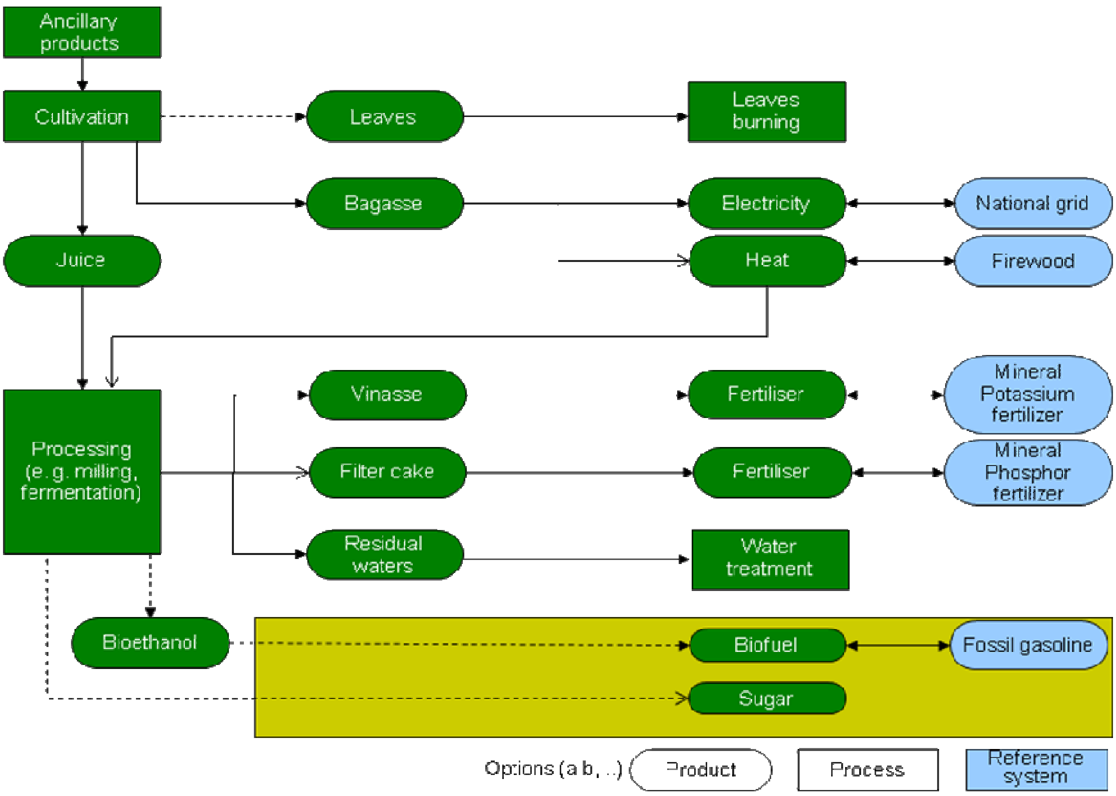


Figure 11 – Pindorama mill's Supply Chain Flowchart.

4 Socio-economic impacts of the sugarcane chain

4.1 Economics

4.1.1 Macroeconomics in the sugarcane chain in Brazil

The sugarcane industry has been present in Brazil over centuries, since early colonization periods. This long presence in the country has given the knowledge and experience to create an important economic sector. The sugarcane production in Brazil has grown and the land use for that purpose was 7.4 Million hectares in the 2009/2010 harvest period, reaching up to 8.05 Million in the 2010/2011 period (harvested area). In 2009, the production reached 604 Million tonnes of sugarcane, and went up to 623 Million tonnes in 2010.

Figure 12 shows the evolution of sugarcane production in Brazil. After 2003, with the introduction of FFVs (Flex Fuel Vehicles) in the national fleet, the sugarcane production increased intensively due to the demand for ethanol. In the year 2008, the revenue due to sugarcane production was 4,562.7 million Euros, just for the mills, and for independent plantations revenue reached 3,658.4 million Euros (44.5%).

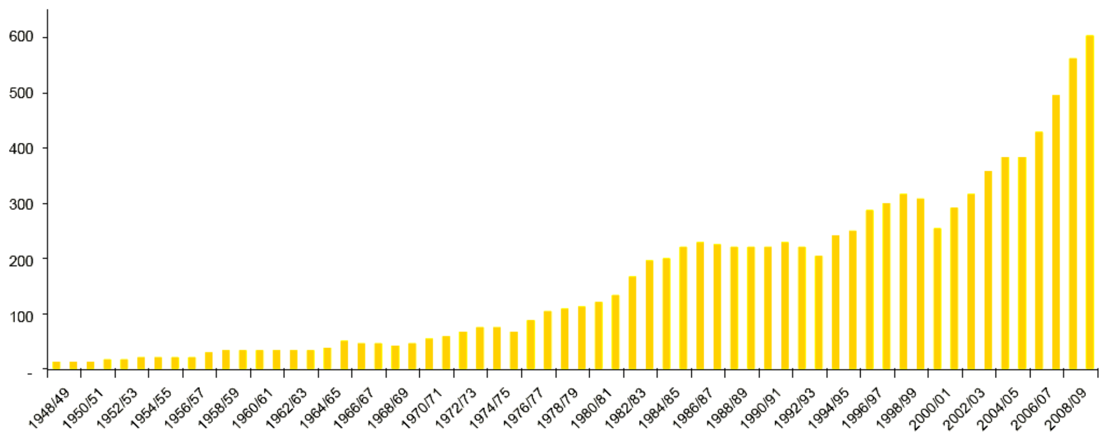


Figure 12 – Evolution of sugarcane production in Brazil (Millions of tonnes)
Source: MAPA (2011)

The average productivity has also increased along the years, as shown in figure 13.

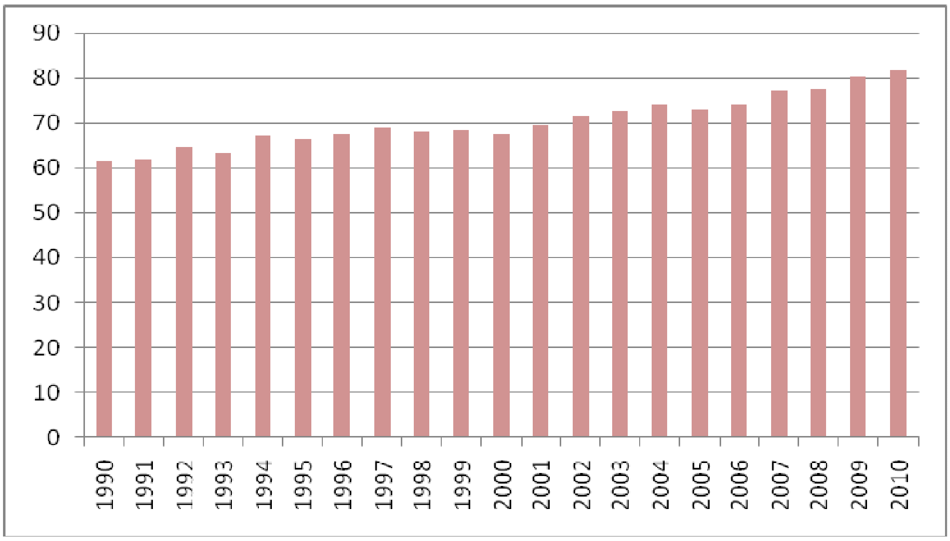


Figure 13 - Productivity in ton/ha from 1990 – 2011
Source: MAPA (2011), CONAB (2011)

With increasing productivity and high production levels, the production costs tend to be lower. The so-called learning effects on ethanol production, in Brazil, were studied by Goldenberg et. al. (2004) and Van den Wall Bake et. al. (2009).

General sense, as the costs lower, prices follow the same trend. The evolution of ethanol prices paid for the producer (not included the cumulative national production, meaning, not a learning curve assessment) is presented in figure 14, in Euros of January, 2011.

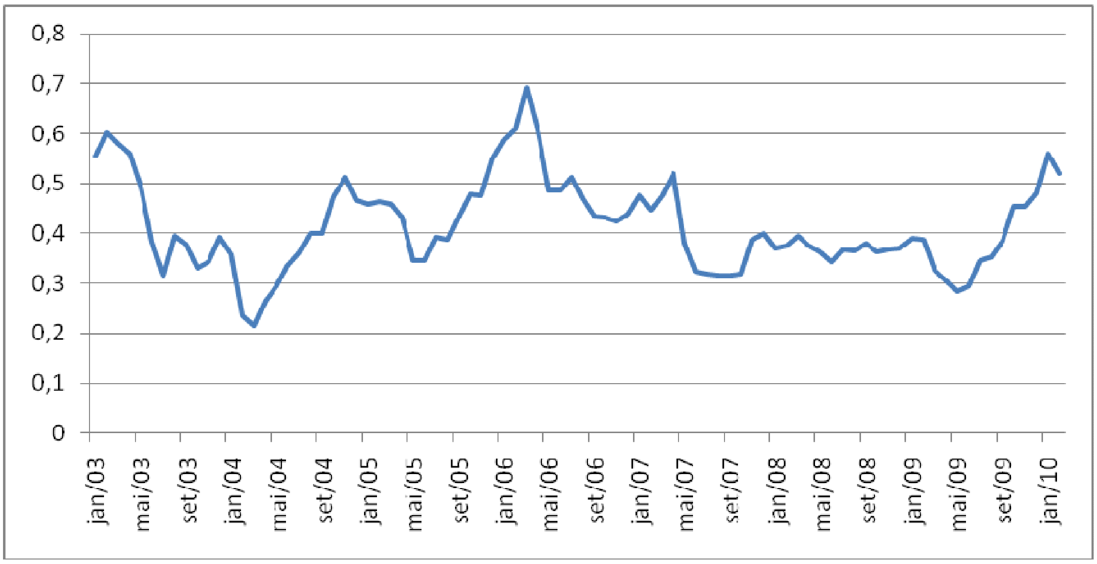


Figure 14 - Price paid to producer in Euros/L of hydrated ethanol.
Source: adapted from Unica (2011)

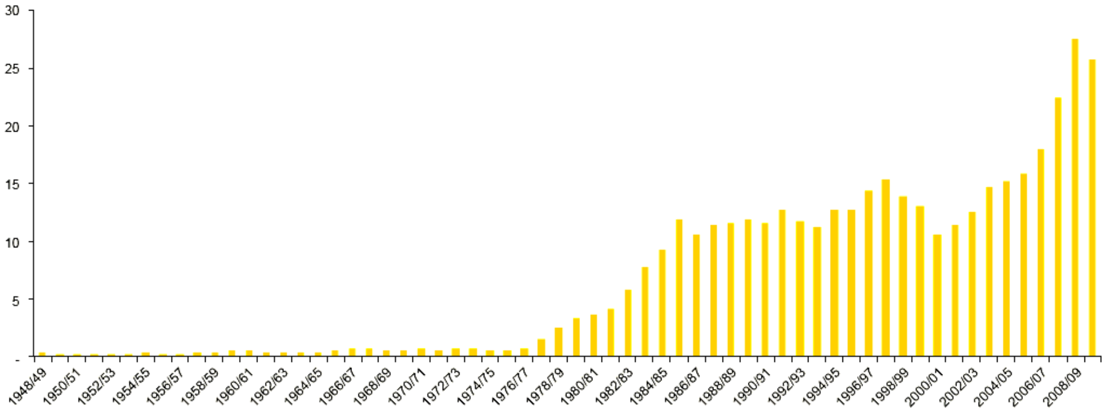


Figure 15 - Ethanol production evolution.
Source: MAPA (2011)

The growth of ethanol production is presented in figure 15 (hydrated and anhydrous). The industrial units earned 8.85 billion Euro with ethanol sales in 2008, counting domestic and export markets. The domestic market in 2008 consumed 1.41 billion liters of hydrous ethanol, generating 4.6 billion Euro in revenues for mills.

The sugarcane industry generates wealth for other sectors of the economy as shown by Neves et. al. (2011). The work done by the authors, using the methodology called Strategy Planning and Management of Agri-Industrial Systems, indicates that the sector, in 2008, generated 20.1 billion Euro that year, equivalent to 2% of Brazilian Gross Domestic Product (in 2008).

Ethanol and sugar are still the most significant products in terms of revenues, accounting for 8.9 billion Euro and 7 billion Euro in 2008, respectively. Bioelectricity generates 285 million Euros and it is expected to grow.

Figures 16 and 17 show the gross billing for different industries and their impacts on the production costs of the sugarcane sector.

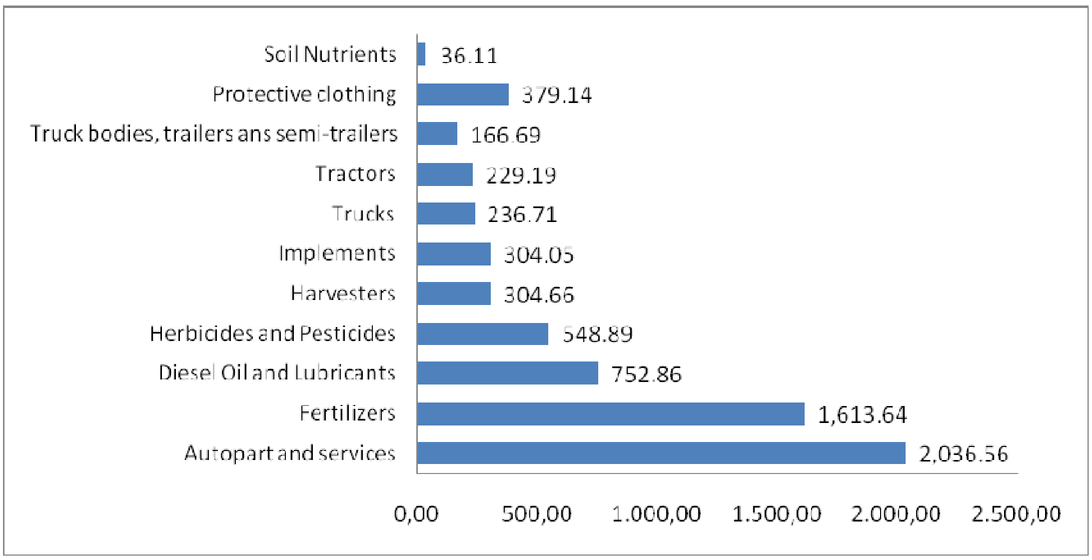


Figure 16 – Billings of agricultural inputs (millions of Euro)
Source: Neves et. al. (2011)

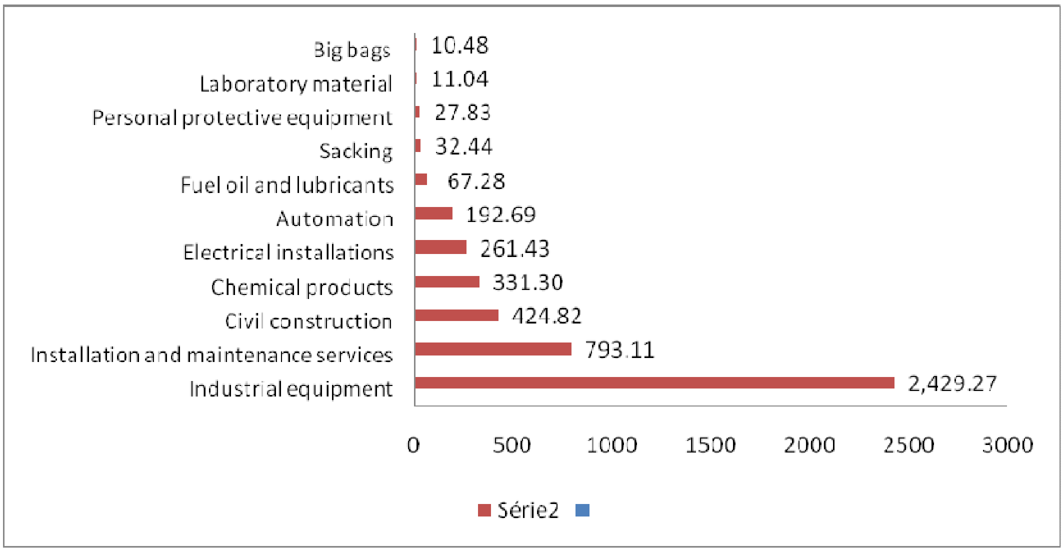


Figure 17 – Billing of industrial inputs (millions of Euro)
Source: Neves et. al. (2011)

Sugarcane cropping was responsible for 14% of fertilizers sales in Brazil in 2008, with a consumption of 3.14 millions of tonnes.

With the increase in mechanized harvesting the sales of new agricultural machines was 981 new units in 2008, i.e., a growth of 52% compared to 2007. The sector bought 22% of all harvesters sold in that year.

Also in 2008, mechanized operations in sugarcane agricultural production and transportation from the field to the mill consumed almost one billion liters of diesel oil and lubricants, according to Neves et. al. (2011).

To quantify the billing of industrial equipment suppliers and companies that provide assembly services, the authors (Neves et. al., 2011) considered the investments of the 29 industrial units that were built in 2008. The values shown in figure 17 represent the billings of these new units that started producing in 2008.

4.1.2 Economics in the Sugarcane chain in the Northeast region

The sector's GDP was estimated for the region using the country's average participation of the added value in the sugarcane, ethanol and sugar production.

The sector's production value in the Northeast region in the year 2008, and its added value are presented in figure 18.

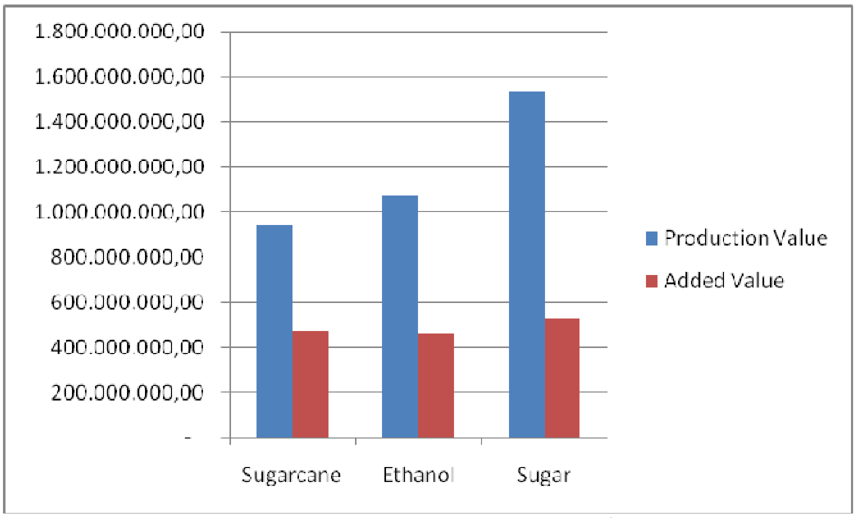


Figure 18 – Sugarcane chain's added and Production values (R$ - Brazilian currency in 2008)

With a total GDP of 191 billion Euro, the sector represented, in 2008, 0.76% of the region's GDP. Sugarcane contributed with 0.246%, ethanol with 0.239% and sugar production with 0.276%.

4.1.3 Microeconomics in the sugarcane chain in Pindorama mill

The Pindorama mill is a major producer in the region, being among the 100 largest tax contributors, having in 2009 revenue of R$ 125 million.

In the harvest season 2009/2010 the production of sugarcane was 608,000 tonnes resulting in 32,549 tonnes of sugar and 35,579,550 liters of ethanol, while the production in the last harvest season is expected to be 900,000 tonnes, with 50% designated to ethanol production and 50% to sugar production. These products are mainly sold in the internal market, and ethanol is sold to big companies like Petrobras, Ipiranga and Shell. About 15 to 20% of the sugar is exported. The expected sugar production is of 40,000 tonnes and ethanol production is expected to be 45,000,000 liters for the 2010/2011 harvest period.

Currently Pindorama's productivity is estimated as 70 tonnes of cane/ha (5,000 t/day) which is quite high due to the rains. The average yield in Northeast region is 55 t/ha. A 20% growth in productivity is expected in the next four years.

The disaggregation of the total sugarcane and ethanol costs at Pindorama mill are shown on table 7.

Table 7 - Disaggregation of the total sugar and ethanol costs provided by the financial department at Pindorama mill

	Contribution to total costs (%)
Raw material (sugarcane)	69.86
Labour	7.62
Direct materials	1.75
Industrial process	7.99
Harvest of sugarcane	8.59
Operation and maintenance	3.97
Other	0.22

4.1.4 Microeconomics in the sugarcane chain in the São Francisco Mill

Recently, the project demanded investments were estimated as US$ 6 million. From sugarcane and organic industrial processes, Native (, the brand behind the São Francisco mill) produces organic alcohol, which can be applied in industries such as cosmetics and pharmaceuticals, for example. Native also produces sugar, and exports 85% of its production being 90% to Europe and USA, and 10% to Asia, especially Japan.

São Francisco mill did not provide microeconomic data from their unit.

4.1.5 Summary of measurable units and indicators

The following parameters could be used as indicators of the economic activity and of its importance to the region.

- Revenue in the year;
- Participation of costs;
- Demanded investments.
- Participation in GDP.

4.2 Employment generation

4.2.1 Employment generation in the sugarcane chain in Brazil

There are two main sources of information regarding employment in Brazil: Rais (Annual Social Information), and PNAD (National Survey by Household Sampling). Rais is an administrative registration system that compiles yearly at least 97% of all formal market. Every company has the obligation of reporting how many employees they have, as well as other social information, as age, education level, length of service and revenue; the results are published according to the occupational level, geographical regions and economic sectors. The results also contain information on the number of jobs by size of establishment, payroll and nationality of the employee.

PNAD, on the other hand, investigates general characteristics of the population, like education, work, income and housing. It is based on a sample of the population and, using statistics methods, estimates for the whole country are provided. When used in employment studies, it has the benefit of capturing the informal labor market.

Both systems were used to estimate the number of jobs generated by the sugarcane sector. Under RAIS, the number of active employees (currently working at the moment data were registered) in the sugarcane sector in 2010 was more than 612,000 formal jobs, being 183,700 in the sugarcane fields. The ethanol industry had 111,300 active employees in the formal market. The number of termination in the year is an important information, since it gives an insight on how dynamic the sector is. End of contracts are very common due to the seasonal characteristics of sugarcane production. Table 8 shows the number of employees on the formal job market for the sugarcane sector, from 2007 to 2010; the data basis is Rais.

In order to capture the information regarding informal jobs, PNAD was also analysed. As it can be concluded from a comparison between table 8 and 9, it can be estimated that the informal job market represents 25% of all employees.

According to PNAD, sugarcane farming activity employed over 576 thousand people in 2009, while ethanol production employed over 135 thousand. This result includes the informal jobs.

The difference between the numbers of employees provided by both databases is clear. It is important to keep in mind that PNAD is a statistical analysis, done by interviewing a sample of the total population, and Rais a direct compilation from the government, with information provided by the companies and employers themselves. PNAD is made with a sample of 399,000 people in different regions of Brazil, and then a weight is used to generalize the information to the whole population.

Institutions used to mention the results by Rais in order to give a figure of employees involved with sugarcane sector, e.g., about 1.2 million people by the end of 2010, but from this total only 613 thousand were active employees at that moment and about 436 thousand have been dismissed or had their contracts finished.

On average, the sugarcane employee is 35.4 years-old, and has 5.7 years of study. They work on average 46.7 hours a week, and have an income of 387.7 Euro per month (the minimum wage in Brazil is 236.9 Euro). It is estimated that 68.8% of the workforce is concentrated in the fields, and 68% are brown or black, and 90% are men.

Table 8 – Active employees and terminations, 2007 – 2010 (Formal Jobs)

	Unjustified dismissal	End of employment contract	Resignation	Active employee	Other	Total
2007						
Sugarcane farming	134,898	97,512	50,891	181,847	32,522	497,670
Raw sugar production	105,748	86,896	37,883	295,188	39,183	564,898
Refined sugar	1,269	928	158	4,828	66	7,249
Ethanol production	42,073	31,446	18,428	90,331	8,616	190,894
Total	**283,988**	**216,782**	**107,360**	**572,194**	**80,387**	**1,260,711**
2008						
Sugarcane farming	138,378	73,994	51,694	188,036	29,560	481,662
Raw sugar production	117,763	87,640	42,601	296,708	16,580	561,292
Refined sugar	1,762	1,804	1,031	8,418	776	13,791
Ethanol production	52,132	33,034	23,238	107,300	10,809	226,513
Total	**310,035**	**196,472**	**118,564**	**600,462**	**57,725**	**1,283,258**
2009						
Sugarcane farming	115,364	64,898	35,544	191,306	17,915	425,027
Raw sugar production	115,167	76,017	31,399	314,435	17,603	554,621
Refined sugar	1,735	3,826	1,010	11,587	1,148	19,306
Ethanol production	48,183	28,654	16,049	111,883	8,548	213,317
Total	**280,449**	**173,395**	**84,002**	**629,211**	**45,214**	**1,212,271**
2010						
Sugarcane farming	118,071	63,392	32,741	183,742	22,114	420,060
Raw sugar production	104,595	70,291	33,620	310,206	17,201	535,913
Refined sugar	2,023	1,083	695	7291	1,673	12,765
Ethanol production	46,796	30,646	16,156	111,310	8,200	213,108
Total	**271,485**	**165,412**	**83,212**	**612,549**	**49,188**	**1,181,846**

Source: RAIS (2010)

Table 9 – Number of employees in the sugarcane sector (formal and informal) 2009

	Total	%
Sugarcane farming	576,353	68.88
Sugar production	125,311	14.98
Ethanol production	135,058	16.14
Total	836,722	100.00

Source: PNAD (2009)

Based on econometric analysis it can be concluded that white workers are better paid, and incomes are higher as higher is the educational level, meaning the more the person studied, the more he or she is paid. In general, men receive more than women, and the employee working in ethanol production has a higher income than in sugar production.

4.2.2 Employment generation in the Sugarcane chain in the Northeast region

It is estimated that the Northeast region has a total working force of more than 18 million people, with an average education of 7.1 years. Workers, on average, are 37 years-old, working 42 hours a week, with an income of 317.1 Euro (PNAD, 2009). Roughly, 58% work in the third sector, and 20% in agriculture. In agriculture the average education level is 2.9 only years (PNAD, 2009).

In the sugarcane sector, the formal job market has stayed almost constant in the past four years, as shown in table 10. The variation from 2007 and 2010 was only 2.4%. There is no more room for sugarcane expansion in the region and the mechanization is not entering because of high slopes terrains.

Table 10 – Active employees and terminations in the sector in Northeast region 2007-2010

	Unjustified dismissal	End of contract	resignation	Active employee	others	Total
2007						
Sugarcane farming	12,789	17,555	4,878	45,121	2173	82516
Raw sugar production	40,785	43,199	10,615	144,473	6684	245756
Refined sugar	753	807	52	3,433	32	5077
Ethanol production	4,991	6,323	1,607	22,130	610	35661
Total	**59,318**	**67,884**	**17,152**	**215,157**	**9499**	**369010**
2008						
Sugarcane farming	14,793	18,090	4,712	43,879	1,671	83,145
Raw sugar production	47,136	41,009	12,002	147,316	6,881	254,344
Refined sugar	1,254	1,425	722	7,205	300	10,906
Ethanol production	7,421	6,335	1,350	21,636	416	37,158
Total	**70,604**	**66,859**	**18,786**	**220,036**	**9,268**	**385,553**
2009						
Sugarcane farming	14,411	15,652	4,305	41,196	1,462	77,026
Raw sugar production	48,333	39,938	9,942	148,700	3,472	250,385
Refined sugar	1,285	3,499	858	9,764	801	16,207
Ethanol production	6,205	7,199	1,227	22,317	3,155	40,103
Total	**7,0234**	**66,288**	**16,332**	**221,977**	**8,890**	**383,721**
2010						
Sugarcane farming	16,671	22,352	4,221	48,060	1171	92,475
Raw sugar production	42,747	36,587	12,634	137,128	3,307	232,403
Refined sugar	1,207	981	517	5,783	1,204	9,692
Ethanol production	6,845	8,699	1,916	25,420	316	43,196
Total	**67,470**	**68,619**	**19,288**	**216,391**	**5,998**	**377,766**

Source: Rais(2010)

In the sugarcane sector, in Northeast, workers are on average 34.6 year-old, working 46 hours a week, with 3.7 years of education. The average income is 245.42 Euro. It is estimated that 80.5% of the working force is brown or black, 83% work in the fields and men represent 95%. In 2009, the total number of employees for the sector in the region, including informal workers was 310,722 active employees (PNAD, 2009).

When treated separately from the whole sector, workers at the sugarcane farming activity have on average 3.3 years of education, earn 216.5 Euro of average per month and the average age is 34 years.

4.2.3 Employment generation in the sugarcane chain in the Pindorama Mill

Pindorama has a total of 1,823 employees. From the total, more than 50% are fixed employees and the complement temporary workers, working 8 hours a day (from 7 am to 4 pm). In the mill sector there are 250 workers, divided in 3 shifts of 8 hours each. From all the cane cutters, 56% have less than 8 years of education. For the other 44% there is no information. In the last harvest, only 15 accidents were registered, resulting leave of absence, being 11 in the field and 4 in the industrial sector.

4.2.4 Employment generation in the Sugarcane chain in the São Francisco Mill

According to the information provided by the company, São Francisco mill has 4,005 employees. They work 44 hours in the field, in three shifts of 8 hours.

4.2.5 Summary of measurable units and indicators

The following parameters could be used as indicators of jobs created and workers profile.

- Number of employees;
- Hours of work;
- Average age;
- Participation of women;
- Participation of races;
- Working hours;
- Number of unjustified dismissals/end of contract/resignations;
- Average income.

4.3 Working conditions

4.3.1 Working conditions in the sugarcane chain in Brazil

In the sugarcane sector, which includes the cultivation of sugarcane and ethanol and sugar production, the participation of rural workers, especially cutters, represents approximately 68% of the total.

The work of cutting cane depends basically on the strength, dexterity and agility of the worker. Activities are of high risk for health and Rocha

(2007) indicates that the main diseases are linked to execution of movements that require adoption of poor posture and to being exposed to adverse environmental conditions, such as solar radiation, intense heat and large amounts of dust and soot. The work performed by the cutter exceeds the tolerance limits of the musculoskeletal system and may cause diseases such as back pain, neck pain, tenosynovitis, tendonitis, bursitis and arthritis. Many studies also indicate deaths in the cane fields, after the worker's activity (nine deaths in 2010, according to Rais). Besides the deaths occurring in the cane fields, there are those not registered, and occurring over a given time. Diseases such as cancer, caused by the use of poison sugarcane soot, respiratory illnesses and those related with column, impacted the workers also because their lack of financial resources (Mendonça, 2006).

The effort made by the cutter is considered by many as forced because it is directly linked to their salary. The worker is paid according to the amount cut and the cutter is becoming more efficient. Productivity has nearly doubled in 20 years, with no change in the working tools (Alves, 2006). Currently, 10 t/day per cutter is expected.

In manual harvesting system, selection demands are physical and the type of employment contract is for a fixed term, or temporary contracts. In this type of contract, workers do not receive unemployment insurance at the end of the contract (Novaes, 2007). The cutter does receive three meals a day, and some plants have projects to encourage production providing the workers with basic food aid or cash, in addition to salary. Meals are considered poor in nutrients by Rocha (2007), as do not contain vegetables or even meat to supply the protein needs of a job that requires high physical effort, but this varies from plant to plant.

Forced labor is also a concern within the industry. According to the 1930 Convention 29 of ILO (International Labor Organization), forced labor is defined as "all work or service exacted from any person under the menace of any penalty and for which has not offered himself voluntarily." Despite representing only 7% of reported cases across the country, these cases account for 31% (1,911) of all workers involved in cases similar to slavery. In São Paulo there were no cases of forced labor until 2009, but several cases of labor irregularities were found, according to audit done by the State Farm Group. In these audits, cases of lack of rest after six consecutive hours of work, excessive hours, extending the journey without authorization, failure to record entry and exit of employees, work on Sundays without authorization and irregularities due to unhygienic toilet were found (Reporter Brazil, 2010).

On the other hand, there are indications that the plants do their part for the comfort and improvement of working conditions. Table 11 shows the benefits provided by plants, taking a sample of 47 establishments.

Regarding education, UNICA (Sugarcane Industry Union) and its associates promote retraining workers for new jobs created with the growth of mechanized harvesting. In two years were invested almost R$ 11 million in agriculture and more than R$ 13 million in the industrial area, together representing 0.09% of total declared income of associates for the year 2009.

Table 11 – Benefits provided by plants (2008)

Benefits	% of sample
Health insurance	95.7%
Dental plan	93.5%
Transportation	93.3%
Group life insurance	91.5%
Meal	87.0%
Pharmacy aid	85.1%
Hearing treatment	63.8%
Christmas basket	59.1%
Credit cooperative	37.8%
Staple food	43.5%
Education aid	35.6%
Illness aid	20.0%

Source: Adapted from Barbosa (2008)

4.3.2 Working conditions in the sugarcane chain in the Northeast region

No data on working conditions in the sugarcane chain, specifically for the Northeast region, were found.

4.3.3 Working conditions in the sugarcane chain in the Pindorama mill

According to the company, Pindorama makes a big effort to provide social benefits to their employees, associates and their families. The so-called CETRUP (Centro de Treinamento Rural de Pindorama), offers professional training to local people. They have educational projects such as reading and computer classes, as well as sewing, hand-craft and silk screen printing classes. A group of approximately 45-50 local seamstresses makes and provides the uniforms for all the employees in Pindorama which includes individual protection equipments. An additional project in Pindorama includes a vegetable garden run by locals where the products are for own consumption. Another important project is the pepper garden. The participants are mostly young students, who can sell their production every week for R$ 500. The participants in the social programs receive psychological support if needed and receive also education for regular school. Most of the local people enjoying these benefits have a high chance to stay working at the cooperative.

The cooperative Pindorama is an example of well succeed land reform in the country. To reach its goals of social inclusion, the cooperative develops, aside its partners, projects that seek education, professional capacity and employment and income growth.

The sugarcane cutters are provided with fresh water, bathroom facilities shadow, tables and chairs and two snacks during the working hours. The workers are brought to the field by special buses. They also have one hour of lunch break. The cutters have a leader, who controls the amount of sugarcane they cut each day. The average harvesting per man is 8 t per day, sometimes reaching 10 t/day. The amount of sugarcane cut influences the cutters salary. They are all guaranteed with a basic salary of 557 R$/month (242.1 Euro) but if the cutter's productivity is high its salary would be also higher. The current tariffs paid for the amount of sugarcane cut for Alagoas region is given in table 12.

Table 12 – Price paid per ton of cane cut

Sugarcane cut	
Burned cane, minimum price for 4 tonnes	R$ 4.35 (1.89 Euro)
Burned cane, minimum price for 4- 8 tonnes	R$ 4.60 (2.00 Euro)

Source: FETAG (2010)

4.3.4 Working conditions in the sugarcane chain in the São Francisco mill

In 2009, Balbo group's organic sugar and ethanol division received the Ecosocial seal. Conceded by IBD, it establishes minimum social and environmental criteria to be completely accomplished, as well as improvement programs in these aspects.

To receive the Ecosocial seal, all employees must ve under the CLT regime, which is the main legislative provision related to the Brazilian labor law. The temporary workers (mainly those who work on the harvest) are hired under a "harvest contract", with a specific duration of 180 days. These rural workers are protected by NR – 06, a regulatory standard for personal safety equipments (known as EPI, in Portuguese), and are paid considering "traveling hour", which means they start getting paid the moment they get into the bus.

The social projects conducted by São Francisco mill are divided in two areas: the employees and their families, and the external community, under a 50 km distance from the mill.

The company has a profit sharing program, based on a productivity incentive that aims to establish a form of recognition of the Company to its employees for the effort expended in meeting or exceeding corporate goals.

Table 13 – Expenditures with social care and benefits (2009)

Item	Expenditure (1000 €)	%
2009 payments (wages)	28,856.59	70.23%
Total vacation	3,182.13	7.74%
Social security contribuition	2,800.15	6.81%
13th salary	2,623.33	6.38%
Private pension	1,551.20	3.78%
In traffic hours payments	939.31	2.29%
Maternity leave, paternity leave, and other leaves	3.67	0.01%
Health inssurance	1,031.61	2.51%
Pharmacy aid	93.51	0.23%
Dental care	8.22	0.02%
Total	41,089.71	100%

4.3.5 Summary of measurable units and indicators

The following parameters could be used as indicators of jobs created and workers profile.

- Expenditures with benefits;
- Breaks during working hours.

4.4 Health issues

4.4.1 Health issues in the sugarcane chain in Brazil

When it comes to accidents and occupational diseases, sugarcane cultivation uses to be a big concern, and it was recently. The activity was responsible between 1997 and 1999 for 40% (14,661) of accidents-type (accidents resulting from the workers activity) that occurred in agriculture in the state of São Paulo, and 52.12% (2069) of occupational diseases (any disease peculiar to a particular activity). When looking at the total work-related incidents in the state, the cultivation of sugarcane was responsible for 28% of accidents and 38% of diseases. Fortunately only 0.15% of total cases of accidents resulting in death in the state and only 0.11% permanent arrest (Teixeira, 2003). When it comes to accidents, UNICA (Union of Industries of

Cane Sugar) shows, in recent data, that in 2010 there were 6,075 accidents in the agricultural area, and 2,552 in the industrial/management of its associated companies (88 plants for these data). Investments in associated health and safety by the UNICA reach more than $ 87 million in 2010. This represents 0.3% of sales of declared plants (UNICA, 2011).

The number of retirements and deaths due to labor accidents and labor diseases in sugarcane production is displayed in table 14. A comparison between the agricultural and livestock sector is also made.

Table 14 – Labor accidents and retirements in 2010

	Death due to labor accident	Death due to working rout (residence-work place)	Death due to labor related diesese	Retirement due to labor accident	Retirement due to labor related diesese	Total
Sugarcane farming	9	0	0	11	20	40
	10.34%	0.00%	0.00%	8.21%	12.27%	9.80%
Grains farming	3	0	3	6	17	29
	3.45%	0.00%	42.86%	4.48%	10.43%	7.11%
Cotton and other fibers farming	1	2	0	0	1	4
	1.15%	11.76%	0.00%	0.00%	0.61%	0.98%
Tobacco farming	0	0	0	1	0	1
	0.00%	0.00%	0.00%	0.75%	0.00%	0.25%
Soy farming	12	0	0	10	6	28
	13.79%	0.00%	0.00%	7.46%	3.68%	6.86%
Other temporary crops	6	2	0	2	3	13
	6.90%	11.76%	0.00%	1.49%	1.84%	3.19%
Agriculture, livestock and related services	87	17	7	134	163	408
	100%	100%	100%	100%	100%	100%

Source: RAIS (2010)

The sugarcane sector does not lead the number of deaths caused by labor accidents, but it does lead the number of retirements due labor diseases and accidents.

In addition to labor related health problems, sugarcane burning also affects the health of people living in areas where burning is intense (Arbex et al. 2000, 2007). Epidemiological studies conducted in two counties in the state of São Paulo (Araraquara and Piracicaba), which are surrounded by sugarcane fields, show that respiratory morbidity increased significantly with the concentration of aerosol particles from sugarcane burning (Arbex et al., 2000, and 2007; Cançado et al., 2006). During the sugarcane burning season of 1995 in Araraquara, a study found a significant correlation between the daily number of patients who visited hospitals in the region for inhalation treatment for respiratory diseases, and the mass of particle aerosols (Arbex et al., 2000, and 2007). In a second study, conducted in the Piracicaba region, Cançado et al. (2006) found a significant correlation between PM2.5 (particulate matter ≤2.5µm), PM10 (particulate matter ≤10 µm), and black carbon concentrations, and the number of children and elderly patients admitted to hospitals. According to their results, increases of

10 µg/m³ of the PM2.5 concentration lead to an increase of 20% in the number of hospital admissions.

4.4.2 Health issues in the sugarcane chain in the Northeast region

In the Northeast region, the number of accidents is much lower than in other regions where sugarcane production is important, and it represents less in comparison with the total agricultural activity.

Table 15 - Labour accidents and retirements in the Northeast region in 2010

	Death due to labor accident	Death due to working rout (residence-work place)	Death due to labor related diseases	Retirement due to labor accident	Retirement due to labor related diseases	Total
Sugarcane farming	1	0	0	1	0	2
	5.26%	-	-	7.69%	-	0.03
Grains farming	0	2	0	0	1	3
	0.00%	66.67%	0.00%	0.00%	4.17%	5.00%
Cotton and other fibers farming	1	0	0	2	5	8
	5.26%	0.00%	0.00%	15.38%	20.83%	13.33%
Tobacco farming	0	0	0	1	0	1
	0.00%	0.00%	0.00%	7.69%	0.00%	1.67%
Soy farming	1	0	0	0	0	1
	5.26%	0.00%	0.00%	0.00%	0.00%	1.67%
Other temporary crops	0	0	0	0	0	0
	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Agriculture, livestock and related services	19	3	1	13	24	60
	100%	100%	100%	100%	100%	100%

Source: RAIS (2010)

4.4.3 Health issues in the Sugarcane chain in Pindorama mill

Pindorama mill has life insurance to all workers including the temporary workers. 15 accidents with leave of absence were registered in 2009/2010 harvest period, being 11 among rural workers and 4 in the industrial site.

4.4.4 Health issues in the Sugarcane chain in São Francisco mill

São Francisco has ambulance support for the rural people in the field for first aid treatments and transport to health facilities in cases of emergencies. The group has, for this activity, two ambulances. In 2009, 3,393 attendances were made.

4.4.5 Summary of measurable units and indicators

The following parameters could be used as indicators of jobs created and workers profile.

- Number of accidents during work, as proportional to the total number of workers;
- Number of deaths during work, as proportional to the total number of workers;
- Number of retirements due to working accidents, as proportional to the total number of workers.

4.5 Food issues

4.5.1 Food issues in the sugarcane chain in Brazil

In Brazil, food production and consumption are at normal levels. Brazil is a “low hunger” level country in the Global Hunger Index, with 2% of children undernourished and 6% of the population. Even so, the calories per capita supply is 3,300. In addition, Brazil is worldwide one of the main exporters of food and the country has large land extensions available for food production.

In this way, the food issue is not often treated in the sugarcane chain.

4.5.2 Summary of measurable units and indicators

The following parameters could be used as indicators of jobs created and workers profile.

- Percentage of undernourished children/people;
- Calories per capita;

4.6 Land use competition and conflicts

4.6.1 Land use competition and conflicts in the sugarcane chain in Brazil

Land use for sugarcane in Brazil represents 14% of all cultures farming, but its expansion throughout the country can generate conflicts with food other crops and natural vegetation.

According to Ortiz (2007), the land market is an important component in the monoculture expansion with consequent pressure on small and medium lands. In that sense, the expansion of sugarcane is facilitated by a weakly ordered land market, legally and socially, which leads to positive effects on production costs, while concentrates land ownership and prevents the practical uses by family farms. Since the increase in sugar industry’s production is related to the expansion cultivation in new areas, this leads to a reconfiguration of the geographic space and a pressure on livelihoods and rural activities.

As shown in tables 2 and 3, the supply of sugarcane in Brazil is mainly done by small producers, with an average production range from 1,000 to 6,000 tonnes and an average area of 60 ha. This is due to the high levels of land leasing in the sector. For the author, the land lease is the foundation to the expansion of sugarcane plantations and triggers a change in the complex types of production, the availability of jobs, in the migration to cities, food supply and the possibility of demarcating land for agrarian reform.

In the state of Mato Grosso do Sul, land conflicts which are acts of resistance by possession, use and ownership of the territory grew 87.5% between the 2003-2005 period rising from 16 to 30 conflicts In this direction, the number of occupations in rural properties had a 100% growth from eight occupations in 2003 to 16 in 2005. The author points out that during the year 2004 24 occupations were performed, with 15 of these in municipalities where new sugarcane plantations are being designed.

Reporter Brasil (2010) points out the expansion over food crops and livestock in Brazil, especially in the states of Minas Gerais, Goiás, Paraná, Mato Grosso do Sul e Mato Grosso. Although the Ministry of Agriculture and the National Supply Company show that the expansion occurs mainly over pasture lands, due to increase in livestock productivity, the report from Reporter Brasil based on data from Canasat, a software developed by the National Institute for Space Research to identify sugarcane plantations, shows something else. In the study by Reporter Brasil, the sugarcane expansion took place in 75% of the agricultural lands in the state of Goiás, 57% in Mato Grosso, 65% in Minas Gerais, 56% in Paraná and 44% in Mato Grosso do Sul. This is very different from the study by Conab, represented in figure 19, where most of the expansion (65%) is located on pastures, differently than showed in the Brazilian average.

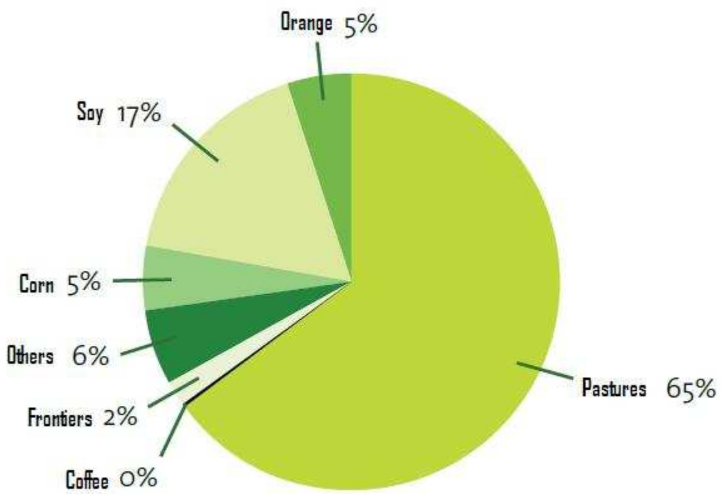


Figure 19 - Change in crops in the fields of sugarcane expansion
Source: MAPA (2009)

4.6.2 Land use competition and conflicts in the sugarcane chain in the Northeast region

No specific information on land use competition and conflicts in the sugarcane chain in the Northeast region was found.

4.6.3 Land use competition and conflicts in the Sugarcane chain in Pindorama mill

No specific information on land use competition and conflicts in the sugarcane chain in the Pindorama mill was found.

4.6.4 Land use competition and conflicts in the Sugarcane chain in São Francisco mill

No specific information on land use competition and conflicts in the sugarcane chain in the São Francisco mill was found.

4.6.5 Summary of measurable units and indicators

The following parameters could be used as indicators of jobs created and workers profile.

- Number of conflicts due to biofuels expansion;
- Expansion area over other cops.

4.7 Gender issues

The information available on gender issues was previously presented in the employment generation section.

5 Environmental impacts

A number of environmental impacts are usually associated with the production and use of biomass for biofuel/bioenergy or biomaterial purposes. These include impacts on **human health** (e.g., release of toxic substances, emission of photooxidants and ozone-depleting gases), on the **quality of ecosystems** (e.g., release of toxic substances, emission of acidifying and eutrophying gases, land-use impacts on biodiversity, water and soil) on **climate change** (global warming) and on **resources** (non-renewable energy carriers and minerals).

Out of this list, Article 23(1) of the European Renewable Energy Directive (RED, 2009/28/EC) specifically mentions the impacts on global warming (greenhouse gas emissions), biodiversity, water resources/quality and soil quality (EP & CEC, 2009).

Within the Global-Bio-Pact project, these four environmental impacts were addressed. The same environmental impacts have also been selected for the analytical framework within the FAO-funded Bioenergy Environmental Impact Analysis (BIAS) project (FAO, 2010).

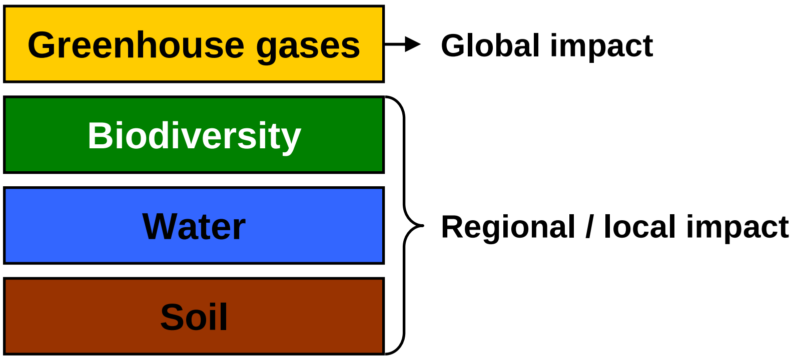


Figure 20: Environmental impacts assessed within the Global-Bio-Pact project (IFEU, 2010).

Environmental impacts are occurring at different geographical scales, e.g. at global level (impacts on climate change and on the depletion of the ozone layer) or at regional and local level (impacts on biodiversity, water and soil).

Since the 1970s, environmental assessment has been developed as a systematic process to identify, analyze and evaluate the environmental effects of products or activities to ensure that the environmental implications of decisions are taken into account *before* the decisions are made. Environmental assessment allows effective integration of environmental considerations and public concerns into decision-making. There are several environmental management techniques (e.g., risk assessment, life cycle assessment, environmental performance evaluation, environmental auditing, and environmental impact assessment). Each of these techniques is appropriate for specific situations.

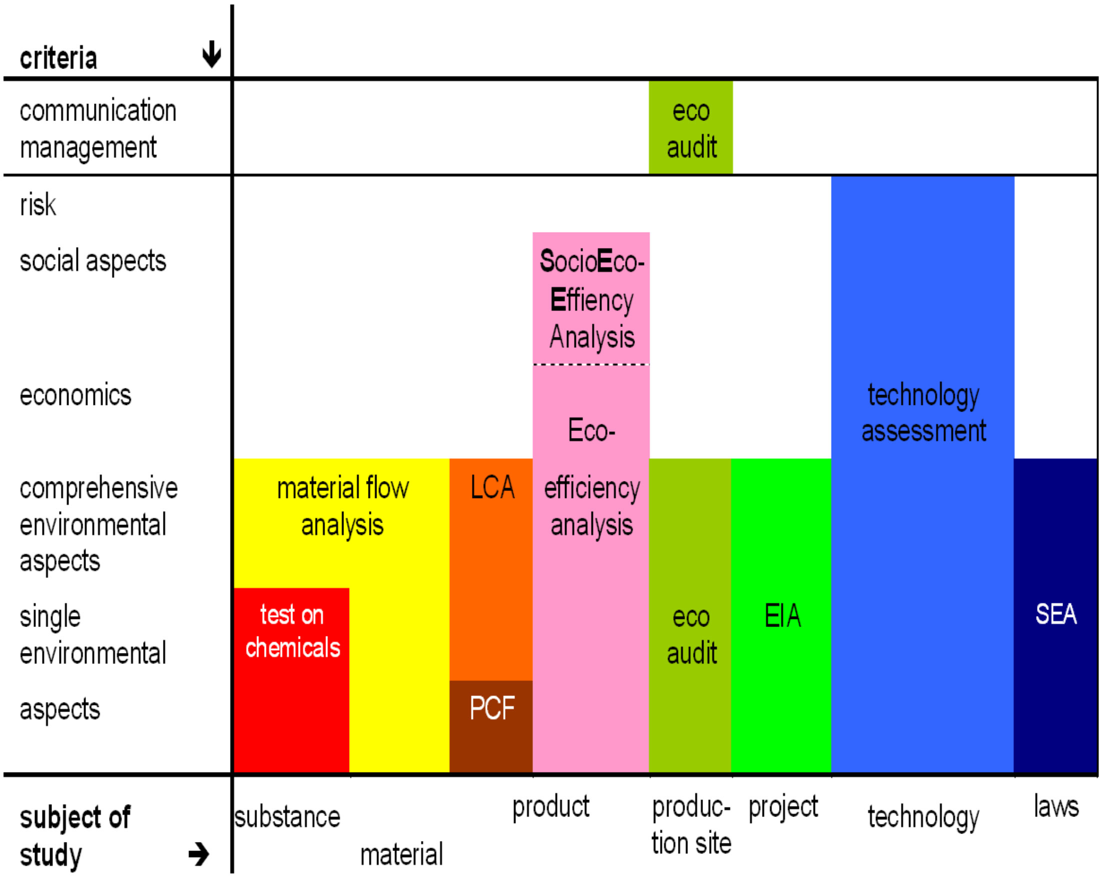


Figure 21: Environmental assessment techniques

The main areas of concern within the Global-Bio-Pact project are the use of land and related ecosystem impacts (biodiversity), the quality of soils, the availability and quality of water, and greenhouse gas emissions. While the latter can be quantified, others can only be described on a qualitative basis (e.g. biodiversity).

Consequently, the environmental assessment within the Global-Bio-Pact project combines elements of Life Cycle Assessment (LCA) with elements of Strategic Environmental Assessment (SEA) and/or Environmental Impact Assessment (EIA). LCA will be used for the quantification of greenhouse gas emissions (having a global impact), whereas SEA and/or EIA will be applied to the other three key environmental impacts (having a regional / local impact).

Elements of Environmental Impact Assessment (EIA) will be used to describe the local environmental impacts of biomass cultivation and conversion. Figure 22 depicts the conventional procedure of an EIA.

As stated in the EIA Directive (85/337/EEC), an EIA shall identify, describe and assess in an appropriate manner, in the light of each individual case […], the direct and indirect effects of a project on the following factors:

- human beings, fauna and flora;
- soil, water, air, climate and the landscape;
- material assets and the cultural heritage;
- interaction between the factors mentioned in the first, second and third indents.

Elements of the EIA were used to determine the impacts on biodiversity, water resources / quality and soil quality.

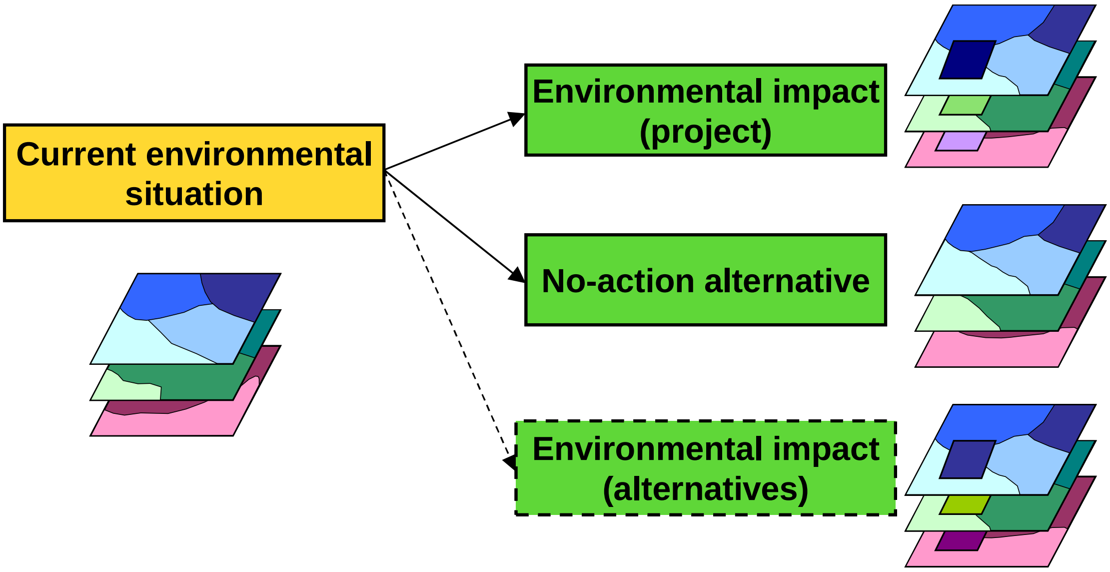


Figure 22: Conventional procedure of an EIA

For the quantification of greenhouse gas emissions, which are having a global impact, the life cycle assessment (LCA) methodology was used. The calculation rules laid down in Annex V of the Renewable Energy Directive (RED, 2009/28/EC) were taken into account.

5.1 Greenhouse gas emissions

5.1.1 Greenhouse gas emissions in the Sugarcane Pindorama mill

The impact of GHG emissions is global. However, the GHG emissions are caused by projects at company or local level.

Greenhouse gas emissions from carbon stock changes

Carbon stock changes due to direct land use changes can have a significant impact on the greenhouse gas balance/carbon footprint of biofuels and bio-based products.

The European Commission (EC) has provided calculation rules[1] which are mainly based on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories[2].

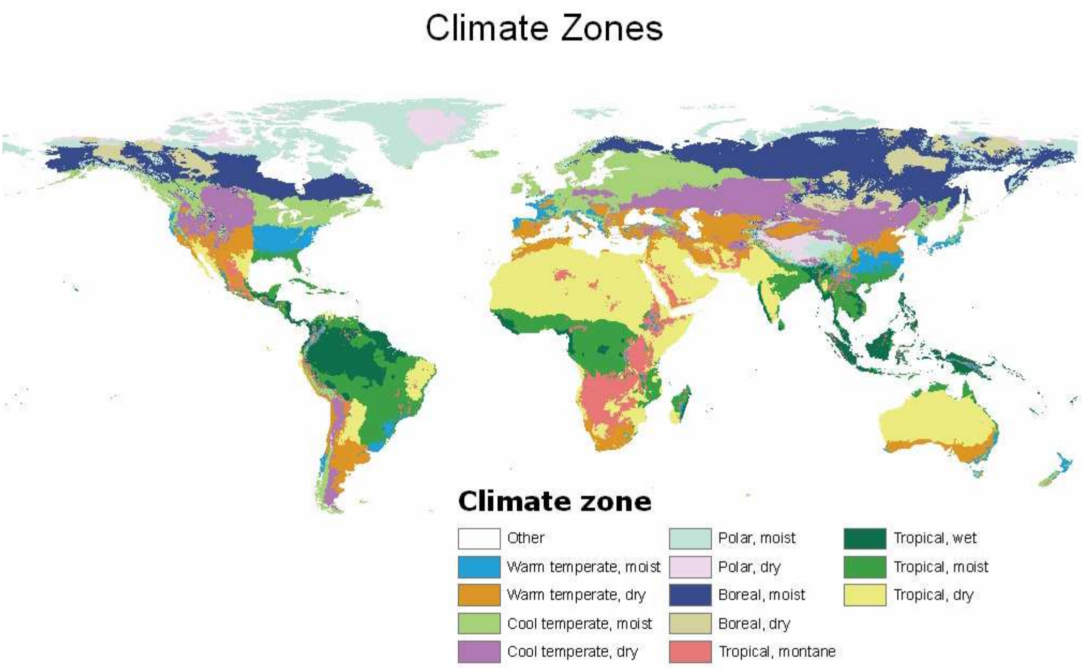
[1] For details, see the web page (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:151:0019:0041:EN:PDF). For further information can be found in the annotated example provided by the EC: http://ec.europa.eu/energy/renewables/biofuels/doc/ecofys_report_annotated_example_carbon_stock_calculation.pdf

[2] See the web page (http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html).

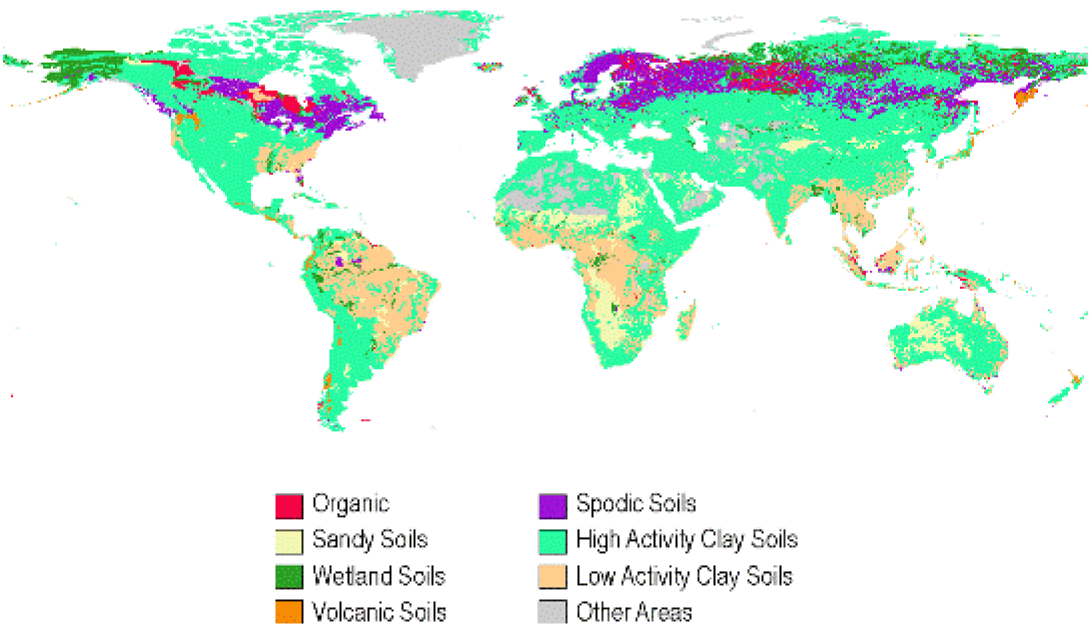
Basically, the soil carbon stocks and carbon stocks in above and below ground biomass are calculated for two different points in time: 01/01/2008 and today.

For the calculation of soil carbon stocks on 01/01/2008, the case study partners were asked to provide the following information:

- **Climate zone/region**: In the case of the two case studies presented in this report, the climate zone/region is Tropical, moist.



- **Soil type**: In the case of the two case studies presented in this report, the soil type is Low activity clay soil;



- **Land use factor (F_{LU}): 0.48; management factor (F_{MG}): 1.15; and input factors (F_I): 1**

For the calculation of carbon stocks in above and below ground biomass on 01/01/2008, the case study partners were asked to provide the following information:

- **Vegetation type**: In the case of the two case studies presented in this report, the vegetation type is cropland;
- **Ecological zone**: In the case of the two case studies presented in this report, the ecological zone is tropical rain forest;
- **Continent**: In the case of the two case studies presented in this report, the continent is South America;

For the calculation of soil carbon stocks of energy crop plantation, the case study partners were asked to provide the following information:

- Land use factor (F_{LU}): 0.48, management factor (F_{MG}): 1.15 and input factors (F_I): 1

For the calculation of carbon stocks in above and below ground biomass of energy crop plantation, the case study partners were asked to provide the following information:

- **Vegetation type**: sugarcane, for both case studies.

The main information regarding the Pindorama mill, that is the first case study in this report, are presented in the following tables.

Table 16: Greenhouse gas emissions from biomass cultivation

Yield per ha per year		
Yield	70	tonnes per ha per year
Size of the cultivation area		
Size	15,000	ha
Fertilizer applied per ha per year		
N-fertiliser	80	kg N per ha per year
P_2O_5-fertiliser	16	kg P_2O_5 per ha per year
K_2O-fertiliser	83	kg K_2O per ha per year
CaO-fertiliser	364	kg CaO per ha per year
Pesticides applied per ha per year		
Pesticides	0.24	kg active ingredient per ha per year
Herbicides	3.2	kg active ingredient per ha per year
Diesel use per ha per year		
Diesel	8.42	L per ha per year

Table 17: Greenhouse gas emissions from biomass transport

Average distance from the energy crop plantation to the conversion facility		
	15	km
Type of vehicle used to transport the biomass		
	truck	e.g. traktor+trailer, truck, train
Fuel used by this vehicle		
	Diesel	

Table 18: Greenhouse gas emissions from biomass conversion 1

Tonnes of feedstock processed per year		
Sugar production	650,913	t /year
Hydrous Ethanol production	17,237,189	L/year
Anhydrous ethanol	18,342,356	L/year
Amounts of by-products produced per year (consumed as fertilizer)		
Vinasse	852,030.20	m³/year
Filter cake	8,520,302	kg/year
Energy consumption of the mill per year		
Electricity produced/consumed (all electricity produced is internally consumed)	16.41	GWh
Electricity (external)	0	kWh per year
Electricity mix		Brazil

Table 19: Greenhouse gas emissions from final product transport

Average distance from the final conversion facility to the end sales point		
	100	km
Type of vehicle used to transport the biomass		
	Truck	e.g. traktor+trailer, truck, train
Fuel used by this vehicle		
	diesel	e.g. Diesel

The data used in tables 16-19 regarding production (ethanol, sugar and electricity), distances from facility, vehicles used and fuel used was obtained directly from the mill. Other information, specially inputs (pesticides, fertilizers, herbicides) and outputs of by products (vinasse, filter cake), were obtained from CTBE database (which is based on general data).

5.1.2 Greenhouse gas emissions in the sugarcane chain in São Francisco mill

It was not possible to get the information for the São Francisco mill that was considered confidential by the company.

5.2 Biodiversity

Of course, the climatic differences in Brazil lead to major ecological variations, forming distinct biogeographic zones or biomes: the Amazon Rainforest, the largest tropical rainforest in the world, the Pantanal, the largest wetland, the Cerrado's savannas and forests, the forests at the Caatinga semiarid region; the fields of the Pampas, and the tropical rainforest of the Atlantic. In addition, Brazil has a seacoast of 3.5 million km², which includes ecosystems such as coral reefs, dunes, mangroves, lagoons, estuaries and marshes.

The next three maps show the priority areas for biodiversity conservation, and the most important biomes in the country. Figure 23 shows Brazilian biomes as a whole. Pindorama mill is located in a region where the main previous biome is the Atlantic Forest, while São Francisco mill is located in a region where the main previous biome was Cerrado.

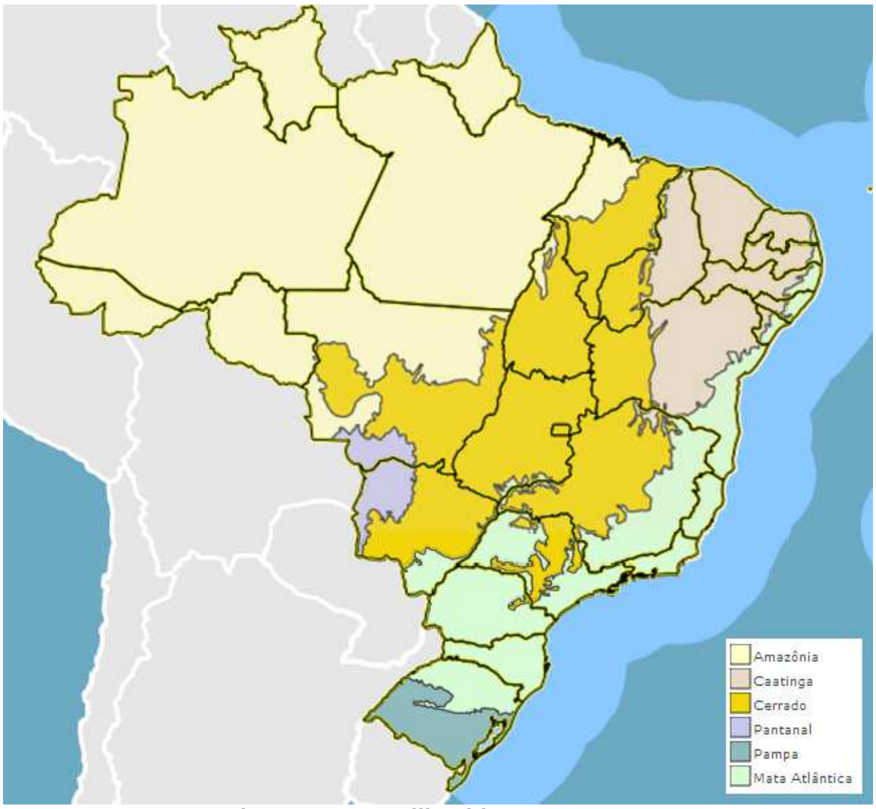


Figure 23 – Brazilian biomes.
Source: MMA (2011)

Figure 24 indicates de priority areas for biodiversity conservation, and figure 25 has included the protection areas and special natural areas. In Figure 24 the location of Pindoram mill is indentify by an arrow in the right-upped side of the map, while the second arrow identifies São Francisco mill.

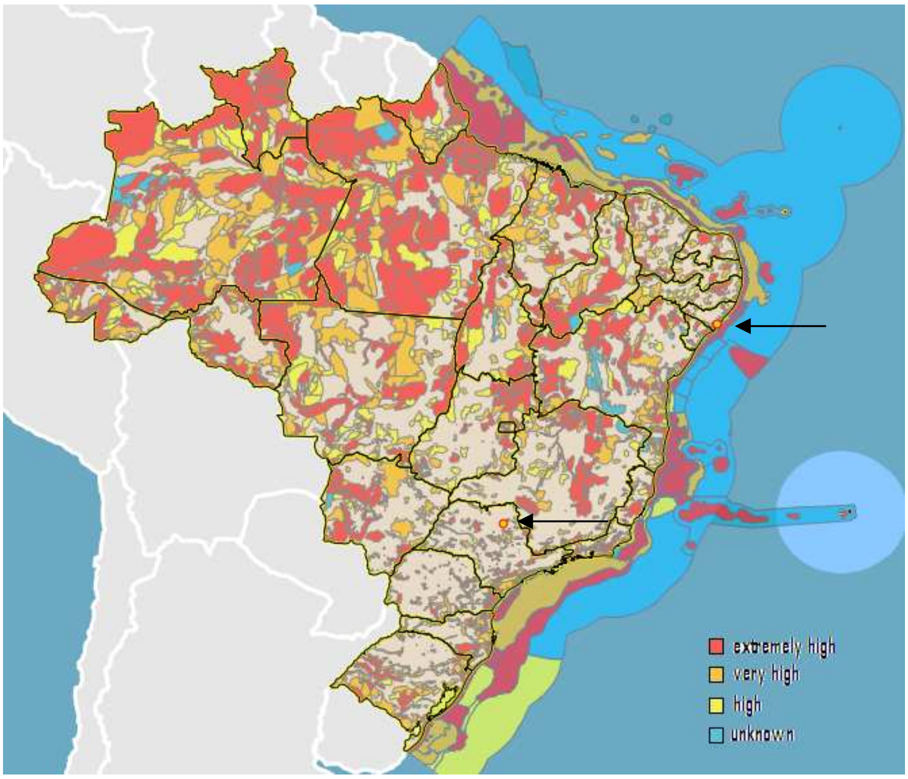


Figure 24 – Biodiversity conservation priority areas
Source: MMA (2011)

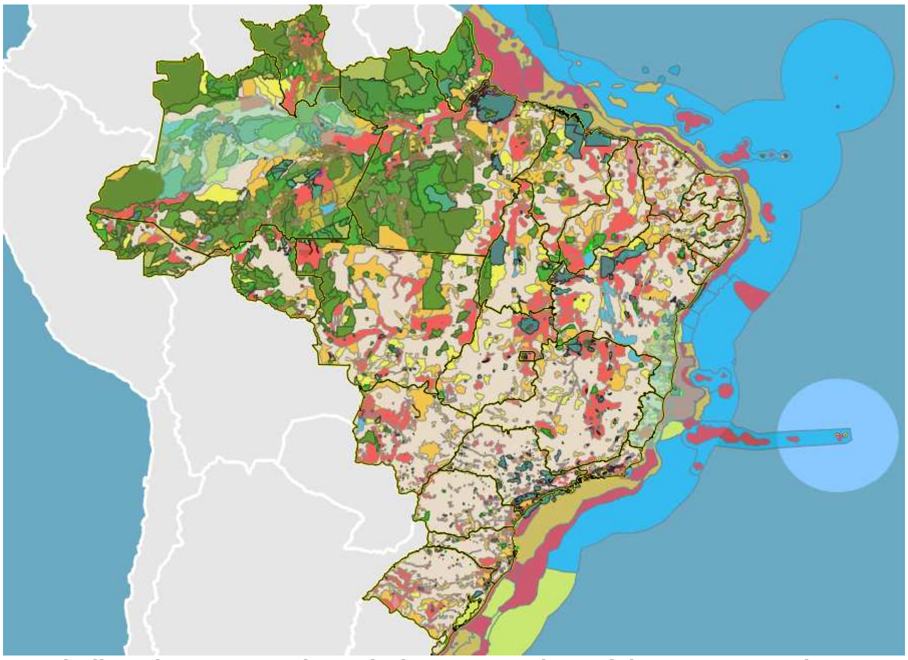


Figure 25 – Biodiversity conservation priority areas and special nature protection areas
Source: MMA (2011)

Details of the priority areas for biodiversity conservation in the case of the two mills that correspond to the case studies are presented in figure 26, for Pindorama mill, and figure 27, for São Francisco mill. The mills are identified by arrows in each map.

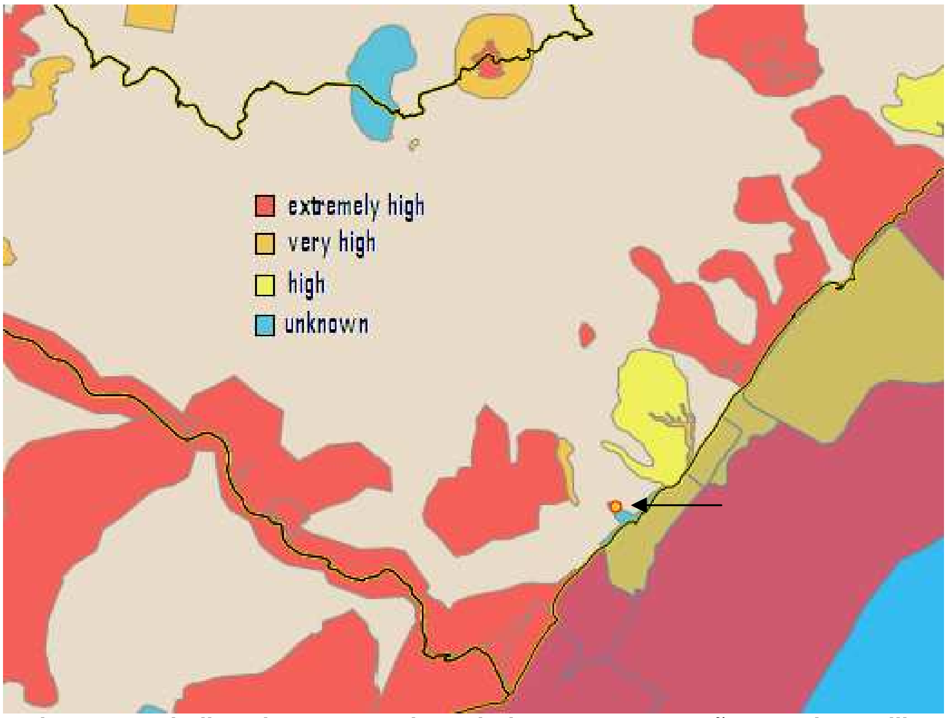


Figure 26 - Biodiversity conservation priority areas next to São Francisco Mill
Source: MMA (2011)

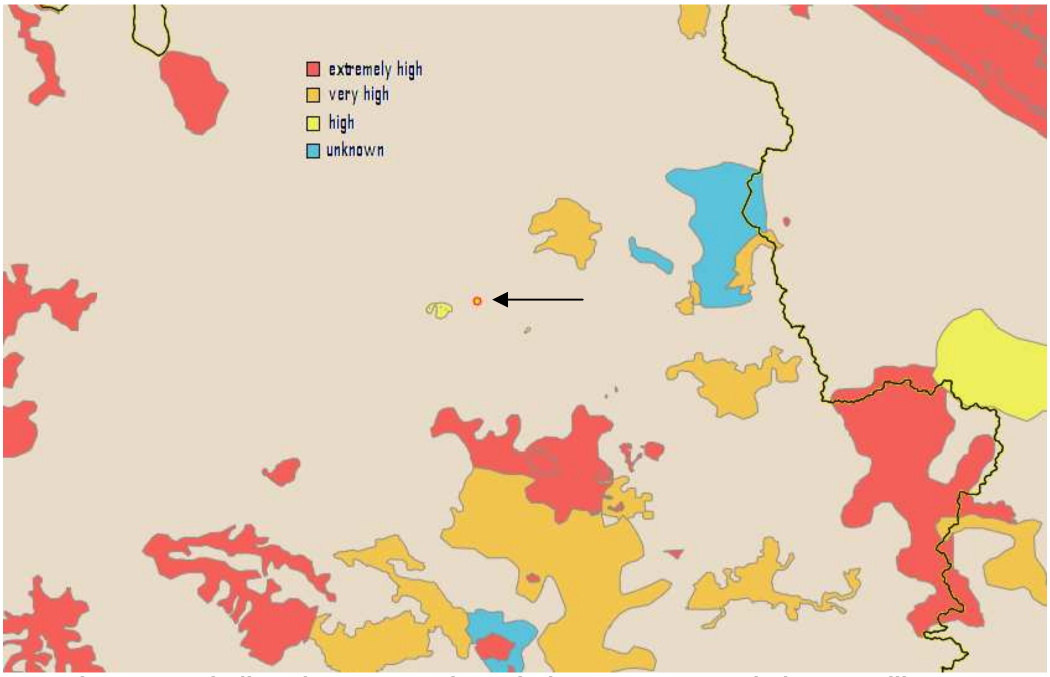


Figure 27 - Biodiversity conservation priority areas next to Pindorama Mill
Source: MMA (2011)

In the case of Pindorama mill, the average distance between the plantations and the mill is 15 km, and the mill itself (Pindorama) is located only seven km away from an extremely high priority region of biodiversity conservation. In this sense, a closer look at the areas planted with sugarcane would be necessary.

In case of São Francisco mill, the mill and the plantation areas are more distant from extremely high an high conservation areas, as can be seen in figure 27. Based on the images of Canasat software (images not available for the Northeast region), a closer look of sugarcane cropping areas is possible. Figure 28 shows the areas with sugarcane cropping nearby São Francisco mill. It can be seen that most of the area is covered with sugarcane and possibly the 20% of the area that should be kept with natural vegetation – defined by the National Forest Code - is not enforced. However, the map resolution does not allow an ultimate statement regarding a single mill, as is the case of São Francisco.

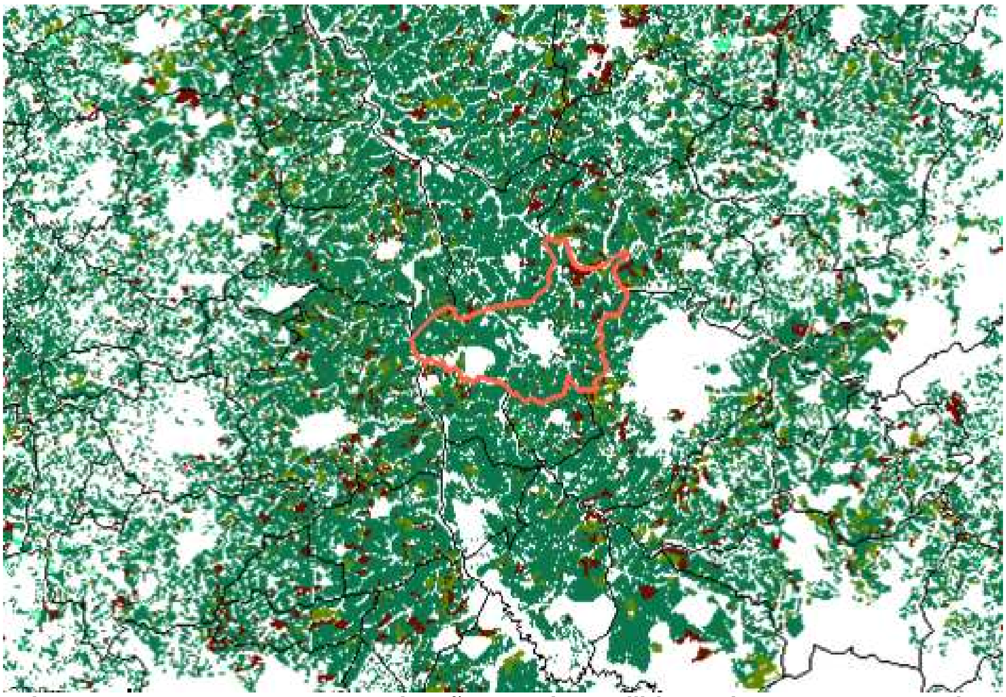


Figure 28 – Sugarcane areas nearby São Francisco mill (areas in green correspond to sugarcane cropping; white areas are those with other crops or natural vegetation)
Source: Canasat (2011)

The conservation priority areas and areas for special nature protection that are close to São Francisco and Pindorama mills, respectively, are presented in figures 29 and 30. The conclusion is that Pindorama mill is closer to sensible areas form a biodiversity point of view.

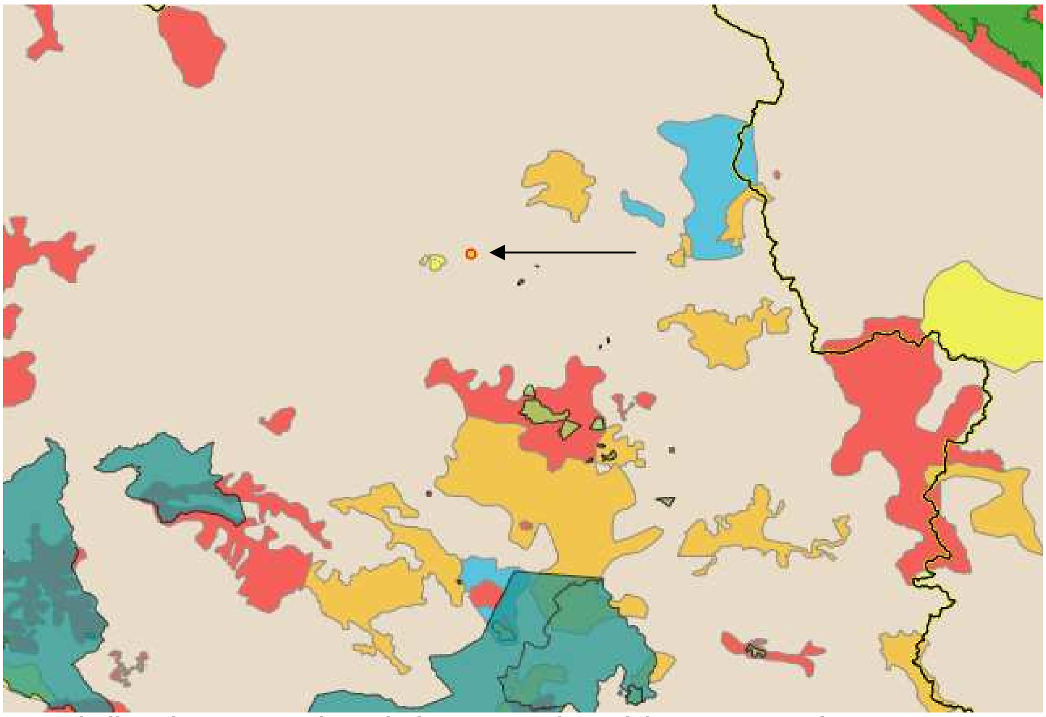


Figure 29 - Biodiversity conservation priority areas and special nature protection areas near São Francisco mill
Source: MMA (2011)

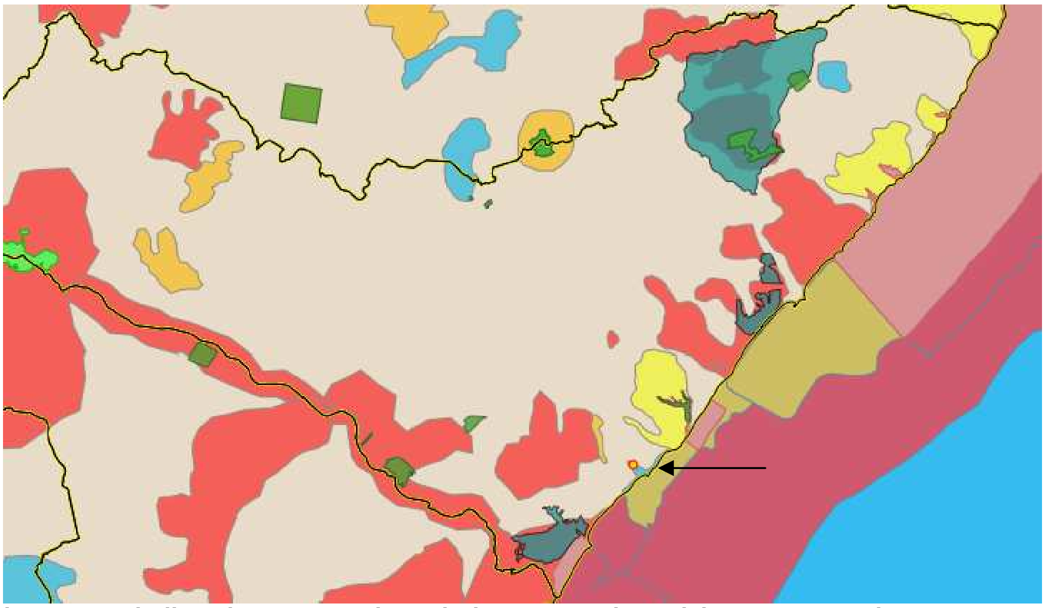
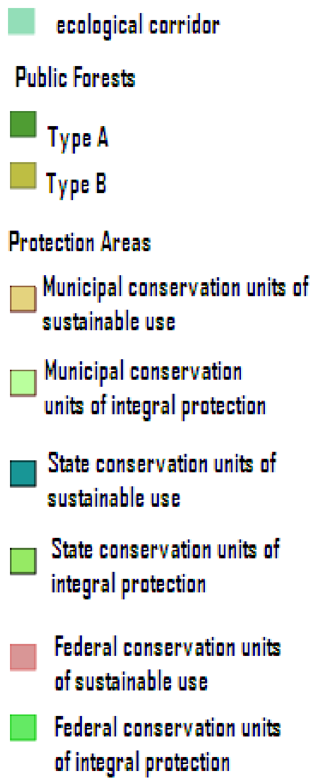


Figure 30 - Biodiversity conservation priority areas and special nature protection areas near Pindorama mill
Source: MMA (2011)

The color-legend for the previous figures is presented bellow. Type A forests have public ownership and specific destination, while type B forests do not have specific destination.



In 2003, Brazil had 209.7 Mha of nature reserves, national parks and wilderness areas; 11.9 Mha of natural monuments, areas for species management and protected landscapes and plus 120.4 Mha of areas considered for sustainable use (WRI, 2011).

5.3 Water resources and water quality

Information on water resources and water quality specifically for bioenergy or sugarcane production is not available, but overall information on water quality and availability for the country is gathered by the National Water Agency (ANA).

According to ANA, Brazil is in a comfortable situation, in overall terms, regarding water resources. The per capita water availability, determined from aggregated values for the country, indicates a satisfactory situation when compared to the values of other countries, according to the United Nations (UN). However, despite this apparent comfort, there is an uneven spatial distribution of water resources in Brazil. About 80% of the Brazilian water resources (water availability) are concentrated in the Amazon Basin region, where there is a small population, as well as lower values of consumptive demands.

Figure 31 shows the superficial water availability in Brazil, according to ANA. Considering the location of Pindorama and São Francisco mills, both are in regions with low water availability, one average up to 1 m^3/s.

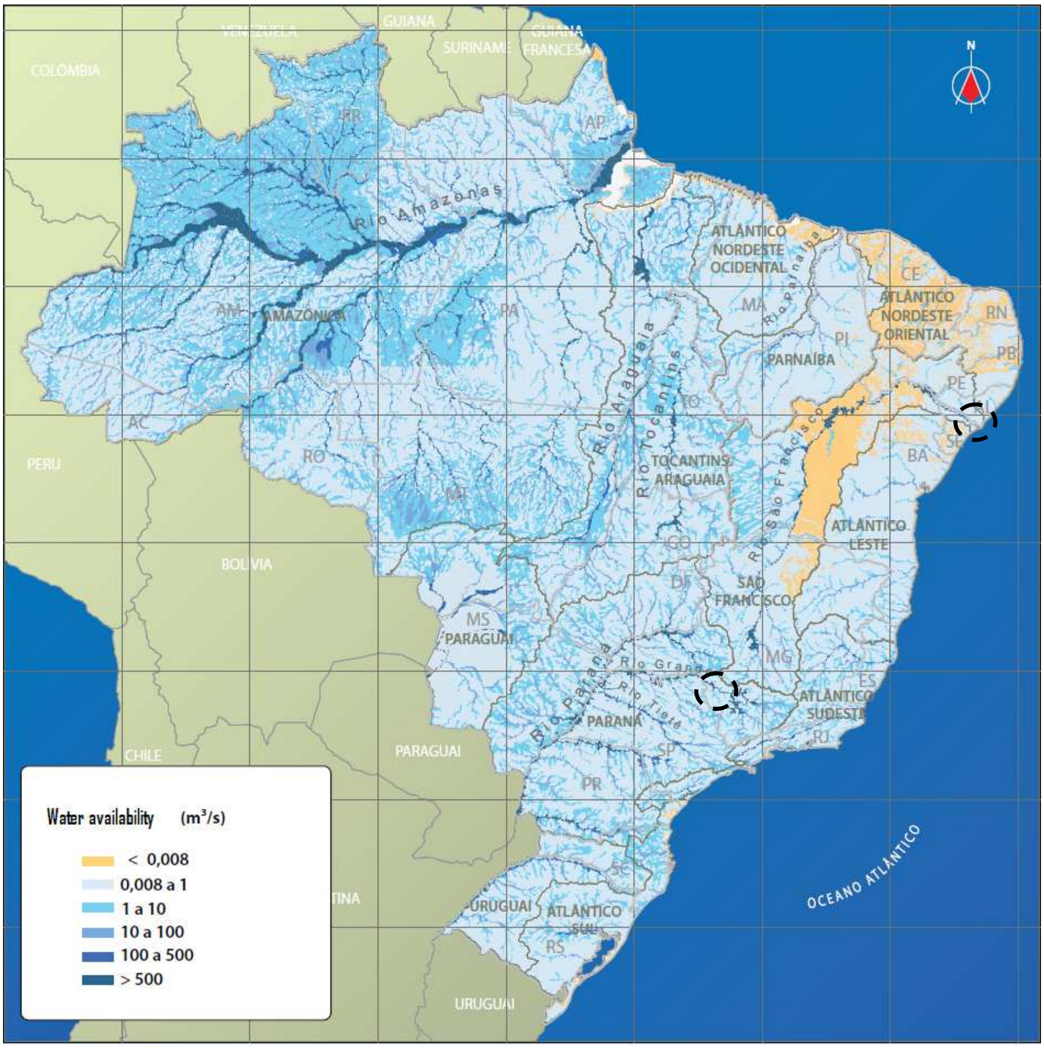


Figure 30 - Spatial distribution of surface water availability by microbasin
Source: ANA (2011)

For water quality, ANA studied the trophic state index. The main aspect taken into account is the eutrophication due to the increase of in water bodies, nutrients such as nitrogen and phosphorus.

Among the undesirable effects of eutrophication it can be mentioned the excessive growth of aquatic vegetation, clogging of hydroelectric turbines, death of fish, changes in aquatic biodiversity, the navigation restrictions and increasing frequency of blooms of microalgae and cyanobacteria. The later can cause dense green layer floating on the water surface and can also cause production of lethal toxins to humans and animals, affecting the water supply for human and animal watering.

Figure 31 shows the areas collected by ANA in Brazil, indicating the endangered areas. Close to São Francisco mill there are constrains regarding water quality, possibly due to the high concentration of sugarcane cropping areas.

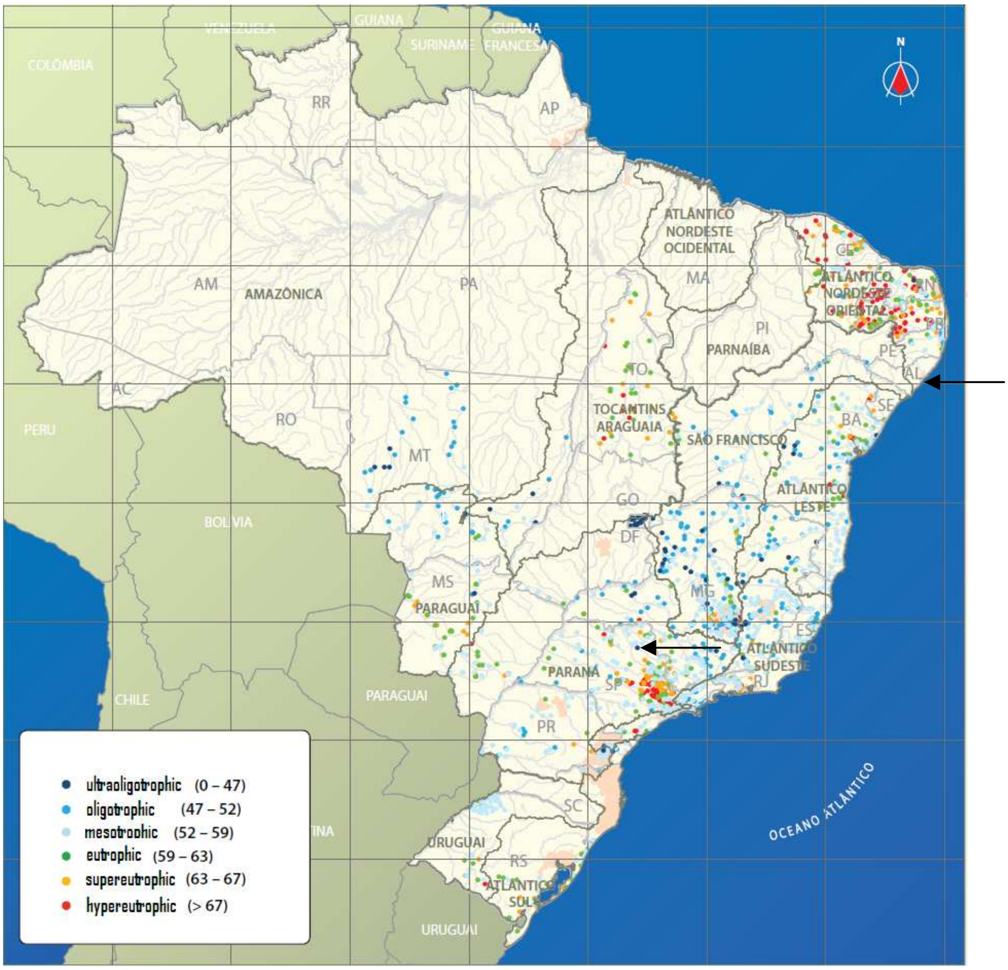


Figure 31 –Trophic State Index in 2009.
Source: ANA (2011)

When it comes to water consumption, irrigation represents 69% of total water consumption in the country. Roughly, 60% of the total irrigated area is located in the Paraná, South Atlantic, and São Francisco river basins.

Figure 32 shows the shares of different water uses in Brazil, in 2009 (withdrawn and consumption).

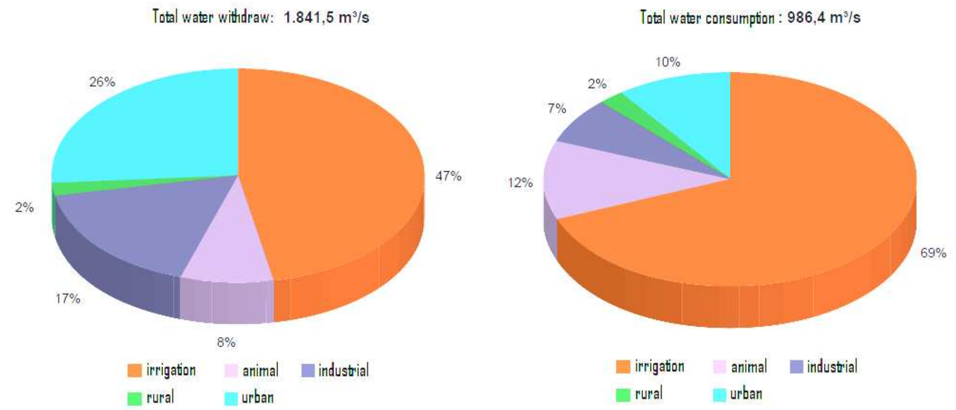


Figure 32 – Water withdraw and water use in Brazil in 2009.
Source: ANA (2011)

5.4 Soil

Considering both case studies, the information available is just related to the São Francisco mill, located in state of São Paulo. Figure 33 shows the map that corresponds to the required agricultural practices in the state, and it can be seen that the site of São Francisco mill corresponds to a region with low erosion risk

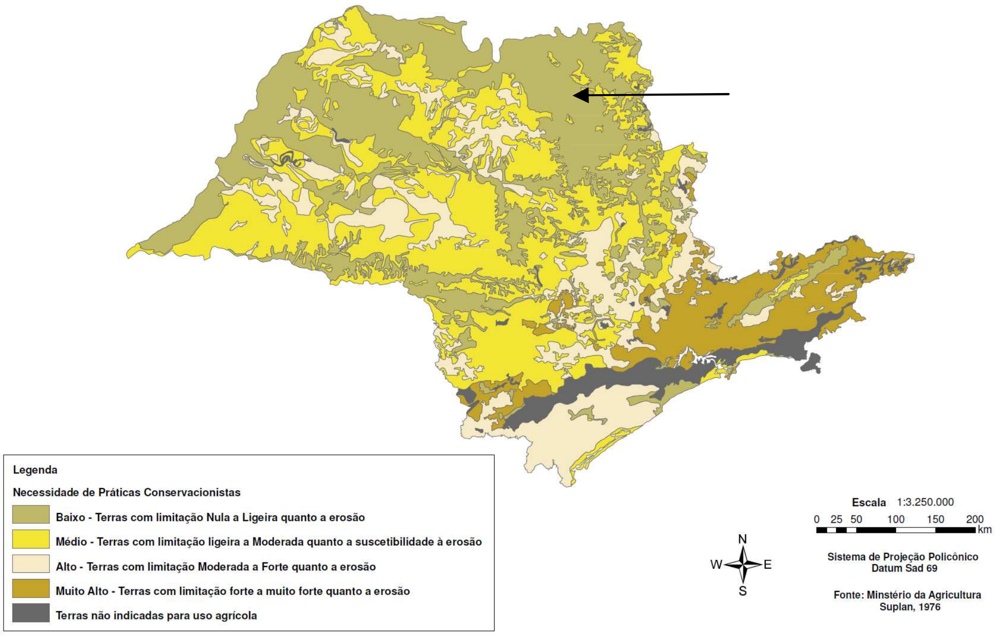


Figure 33 - Required agricultural practices as function of erosion risk

Source: Franco (2008)

Figure 34 shows a map for state of São Paulo highlighting required application of nutrients due to the soil quality for sugarcane cropping. It can be seen that the site of São Francisco mill is very suitable for sugarcane cropping, and requires small amount of nutrients addition.

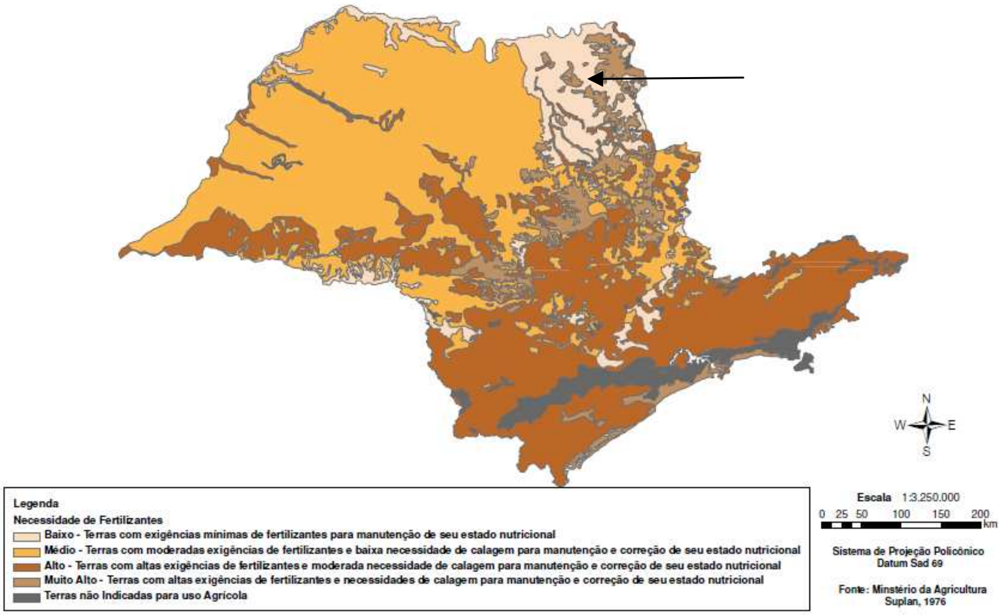


Figure 34 - Required used of fertilizers for sugarcane cropping

Source: Franco (2008)

Finally, figure 35 shows a map for state of São Paulo based on soil declivity, highlighting the areas feasible for full mechanization. Again, it can be seen that the site of São Francisco mill is very suitable for full mechanization of sugarcane cropping.

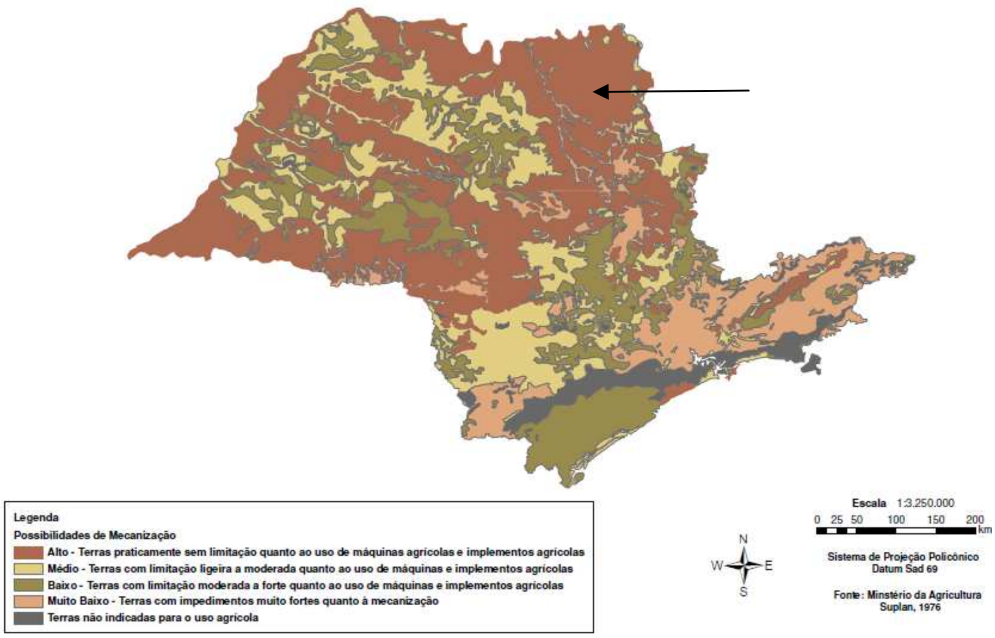


Figure 35 – Soil declivity and feasibility of full mechanization

Source: Franco (2008)

6 Evaluation of the measurable units and indicators

6.1 Relevance of impacts

The focus of the Global-Bio-Pact project is on evaluating socio-economic impacts due to biomass production and conversion systems. In this sense, the focus of the current analysis is on this aspect. Sugarcane production, in general, and ethanol production from sugarcane, in particular, are important economic activities in Brazil. The importance of such activities on the regional and national GDP are meaningful, and the number of jobs created, mainly for people with low educational skills, is equally important. The problem that is related with the tough working conditions of sugarcane harvesting has been minimized, as the tendency in about 5-6 years is full mechanization in most of the producing areas.

General sense, working conditions and social and economic indicators are better in Centre-South region of Brazil, in comparison to those in Northeast. One case study was developed in Alagoas, in northeast Brazil, and a second in São Paulo, in the southeast region. In both cases it was possible to identify that the wages are better than in other agricultural activities. In case of the Pindorama mill, as a cooperative, the suppliers of sugarcane are also the owners of the industrial unit and, in this sense, the benefits are clear.

In both cases it was possible to identify the existence of social programs that are relatively common, nowadays, at least in the sugarcane units that are better managed.

In summary, the information gotten from the two case studies allow the conclusion that both companies are in the superior group among sugarcane and ethanol producers. Unfortunately, it was not possible to confirm the hypothesis that the working conditions and socio-economic impacts are better because, in case of Pindorama mill, it's a cooperative, and in the case of São Francisco mill, that the priority given to organic production could have positive side effects in regard social aspects. The authors visited other mills close to the units chosen for the two case studies, but the information gathered is not enough for any specific conclusion (for confirming or rejecting the hypothesis).

Regard GHG emissions, it was possible to get information for a preliminary assessment in case of Pindorama mill, but it was not possible to get similar information – classified as confidential – in case of São Francisco mill.

In what relates to impacts on water resources, sugarcane production is rain-fed in both cases, and it was not possible to assess the specific impacts over water availability and quality in the rivers and basins close to the mills. Based on non-detailed the information available for each region, it can be concluded that the both production units are in regions with moderate to low water availability, considering Brazilian conditions.

Both production units are close to regions that are considered priority for biodiversity conservation, but it seems that the distance is large enough for avoiding major problems. It is know that there is a specific study regarding impacts on biodiversity at São Francisco mill.

Finally, regarding soil property and quality, it was only possible to get information for São Francisco mill, and the conclusion is that erosion risk is low and that soil quality is good enough for requiring low fertilization.

6.2 Determination of thresholds

Regarding socio-economic impacts, what is reported in Brazil is the number of jobs (permanent and temporary), wages, incidents related to working activities and the benefits received by the workers. Most of this information is available in national data basis, but not for a specific company. It is known that labor rights are completely observed by both producing units studied, and the criteria and indicators of the most important certification schemes are fully observed.

GHG emissions due to ethanol production and use can be evaluated in both cases, but this information is not presented in this report. Considering general figures of ethanol production in Brazil, and as sugarcane production occurs in both cases in traditional areas (thus, land use impacts do not occur), avoided GHG emissions regarding gasoline consumption are in accordance with the thresholds defined by RED-EU.

Regarding water use, soil quality and biodiversity, the information gathered in both cases is not enough for comparison with thresholds available in literature or defined by certification schemes.

6.3 Impact mitigation options

Regarding socio-economic impacts, mechanical harvesting will allow the improvement of working conditions, in general, but the negative impacts of unemployed people with low educational skills need to be properly addressed in the following years. Sugarcane producers and mill's owners in Southeast Brazil have specific programs in this regard, but it is not sure that the existing re-qualifying programs would be effective.

On the other hand, it would be important to have more cooperatives in Brazil, like Pindorama. It was not possible to observe better working conditions in comparison to other producing units in the same region, but clearly sugarcane suppliers, who are also owners of the mill, have larger income.

Concerned to GHG emissions, the reduction of fertilizers use and lower diesel oil consumption are important issues for improving the balance, that is already good.

There is still lack of good information regarding the impacts both on availability and on quality of water resources and specific actions are required. Sugarcane crops are mostly rain-fed in Brazil, but the impacts on water availability shall be meaningful.

Finally, regarding biodiversity, the most important actions for reducing adverse impacts are the following: first, enforcement of the Forest Code, preserving natural vegetation (and consequently reducing of the area cropped with sugarcane areas) and water bodies; second, creation of biodiversity corridors in sugarcane areas; third, reduction of fertilizers use, taking advantage of the residues available (including sugarcane trash) and use of agricultural practices for nitrogen fixation.

6.4 Impact and biomass certification

Certification schemes won't have a negative impact on ethanol production in Brazil. Indeed, the most important ethanol producers in Brazil are working for having certified production, and to fulfil all criteria and indicators related, for instance, with RED-EU. In short-term, the BONSUCRO certification scheme, that is close related with sugarcane production it the one that is considered the best option for ethanol producers in Brazil.

It seems that for the most organized companies, the costs of certified production won't be very high. For sugarcane suppliers, at least for the smallest producers, the impact can be more relevant in short term.

General sense, it is predicted that the impacts of certification schemes will be positive in Brazil, both considering social and environmental aspects.

7 Conclusions

In this report two specific case studies related with ethanol production from sugarcane, in Brazil, were presented. One case study was developed in Alagoas, in northeast, and a second in São Paulo, in the southeast region. It was not possible to confirm the hypothesis that the working conditions and socio-economic impacts are better because, in case of Pindorama mill (in Alagoas), it's a cooperative, and in the case of São Francisco mill (in São Paulo), the priority given to organic production induces positive side effects in regard social aspects. However, in both cases it was possible to identify that working conditions and socio-economic indicators are similar to the best sugarcane and ethanol producers in Brazil.

In both cases, due to the classified nature of some information, it was not possible to go into details in the assessment of socio and economic aspects.

Despite the previous actions and positive results, in both cases it is possible to identify improvements for reducing negative impacts. On the other hand, the examples of a cooperative of sugarcane producers, and the production of organic sugarcane, shall be disseminated in Brazil

Finally, an important conclusion is that certification schemes won't have a negative impact on ethanol production in Brazil. On the contrary, the impacts should be positive, inducing improvements and the adoption of best practices.

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