LABORATORY ON INTERNATIONAL
LAW AND REGULATION

ILAR Working Paper

#5

August 2011

WATER AND LAND MANAGEMENT OF THE PRODUCTION OF SUGARCANE ETHANOL IN São Paulo STATE

PATRICIA GUARDABASSI

School of International Relations
and Pacific Studies
University of California, San Diego

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Laboratory on International Law and Regulation
School of International Relations and Pacific Studies
University of California, San Diego
9500 Gilman Drive
La Jolla, CA 92093-0519
http://ilar.ucsd.edu

About the Author

Patricia Guardabassi is currently a PhD candidate on Sciences at the University of São Paulo, Brazil with a research focus on the sustainability of Brazilian sugarcane ethanol production. She has also been working as a researcher at the Brazilian Reference Center on Biomass developing studies in the utilization of different types of biomass as energy resources. Prior to pursuing her doctoral degree, Patricia worked as a chemical engineer. She holds a master degree in Energy from the University of São Paulo.

Executive Summary

This study examines the allocation of water and land resources in the production of sugarcane ethanol in São Paulo, the state responsible for 60% of Brazil's sugarcane output. Over the last decade about half of the country's total sugarcane production has been devoted to ethanol, with the rest converted into sugar. The analysis surveys the impact of sugar cane growing and expansion within the state as well as the role of policy in affecting the water consumption and land footprint of sugarcane ethanol production. Not only is the state the most important for Brazil's sugarcane ethanol industry but it also has the country's most strict environmental legislation. The historical patterns in Sao Paulo are a good indicator of how an expansion of sugarcane ethanol in the country is likely to unfold. The study makes four main arguments.

First, while the water use of sugar cane has attracted substantial attention, essentially all of the water requirements of sugarcane crops in São Paulo are rain fed without, in most cases, need of additional irrigation. In addition, conversion of raw cane to ethanol requires, on average, 22 m^3 of water per ton of sugarcane processed —although most of those industrial processes are closed loop and the net withdrawal (ie, consumption) from water bodies such as lakes and rivers is much smaller.

Second, the sector has seen substantial technological innovation. Water consumption in the conversion of sugar cane to ethanol has substantially decreased in the last years, from around 5.6 m^3/ ton of sugarcane collected in 1990 and 1997 to 1.83 m^3/ ton of sugarcane in 2004 (figures from a sampling in São Paulo). Current policy goals aim for reducing water consumption to 1m^3/t of sugarcane, and in areas of the state where water is scarce policy already limits consumption to 0.7 m^3/t of sugarcane. Driven by regulation, water consumption is declining sharply and that pattern is likely to continue.

Particularly notable are the accomplishments in recycling. Water reuse levels during the industrial processing of cane into ethanol are very high, and the wastewater treatment efficiency has risen to more than 98 percent. Even more important than improvements in the efficiency of wet cane process is the introduction of dry cane washing process, which

uses essentially zero water compared with the standard 5 m^3 of water/t of cane for wet processing. Most of the reduction in the industry's average water consumption has come from shifting from wet to dry cane processing.

Third, while there are dramatic improvements in water consumption, the situation with the footprint on land is more complicated. The main concerns related to expanding the amount of land under cultivation for energy crops (or any other use) are the irreversible conversion of virgin ecosystems and the competition over land for the production of food crops. None of these have been observed in the case of new sugar cane areas since they have mostly been planted on already degraded land where there is little competition for food and where there is no discernible equilibrium effect on crops elsewhere in the country (or the world) that could displace virgin forests.

Sugarcane growth does not seem to have impact on food. Looking across the country the area used for food crops has not decreased. Within the state new sugar cane crops were planted in degraded lands that were previously used as pasturelands. Through intensification of cattle production the state's cattle population has increased in density from 1.28 heads/ha (2004) to 1.43 heads/ha (2009) (IEA, 2010) while at the same time releasing 0.88 million hectares of pasturelands to other crops, especially sugar cane.

Sugarcane is not a particularly demanding crop in terms of soil, adapting reasonably to soils of average fertility. More fertile soils lead to higher productivity levels and reduced demand for costly fertilizers and corrective products—but high grade soils are expensive in Brazil due to the many other competing agricultural demands for land and thus usually not cost effective. Indeed, land in the State of São Paulo is becoming more expensive; costs increased in average 113.66% from 2001 to 2006, in regions traditionally devoted to sugarcane production, showing a growth in a range of 160 to 170%.

Fourth, aiming to ensure the sustainable production of sugarcane ethanol and prevent environmental damages, the State Secretary for the Environment has established a set of policies, of which two have proved to be particularly important in influencing sugarcane ethanol practices are analyzed in detail here.

The first one is a 2002 Law establishing a timetable for the phase-out of sugarcane burning as a pre-harvesting technique. The rationale for the adoption of this law was the reduction of local air pollution that posed health risks (especially respiratory problems) to the population living in the cities nearby sugarcane crops. This Law was the main driver for the development of harvesting machines, and today 60% of the sugarcane area is harvested mechanically. A complete elimination of burn practices is expected by 2017.

The other new policy arrangement examined in this study is the state's agro-environmental zoning tool used in determining the award of production licenses. This zoning comprises information about soil and climate potentials, surface water availability, underground water vulnerability, restrictions to mechanized harvesting, biodiversity protection areas, biodiversity connectivity, biodiversity protection importance and integral protection units. This new zoning approach has made it possible for state regulators to adopt an ecosystem-wide approach to planning—something that has been particularly difficult for many governing authorities that have control over individual projects whose affects aggregate to important system-wide impacts.

1. Introduction

This study examines the allocation of water and land resources in the production of sugarcane ethanol in São Paulo, the state responsible for 60% of Brazil's sugarcane production. The analysis surveys the impact of sugar cane growing and expansion within the state as well as the role of policy, for the state's environmental legislation is the strictest in the country.

São Paulo has an area of 24.5 million hectares and a population of approximately 40 million inhabitants. It is the most developed state in the country with a very good infrastructure where all kinds of products are manufactured, mainly high tech items. Despite that agriculture and livestock farming are important activities. São Paulo is responsible for 31% of Brazil's GPD.

The State faced the challenges of economic development impinging upon environmental resources earlier than the rest of the country, and it developed a distinct environmental framework with policies that were more innovative and strict than in all other Brazilian states (Goldemberg & Lucon, 2010).

São Paulo has introduced innovative policies in different areas, such as: (a) forestry protection and recovery; (b) state lawsuit on sulfur in diesel; (c) "air basin" decrees that cap local pollutants (and allow for trading); (d) sustainable bioethanol production, including the voluntary certification scheme and agricultural zoning; (e) proposals for increase the participation of renewable energy in the world up to 10%; and a climate change policy that mandates GHG emissions reduction targets across the state (Goldemberg & Lucon, 2010). The present report focuses on sugarcane ethanol, but it is important to be aware that the state's strict regulation of sugar and ethanol arises in the context of Sao Paulo's broader environmental leadership within Brazil.

Regarding sugar/ethanol sector, according to the Brazilian Ministry for Agriculture (MAPA, 2010[1]), 196 out of the country's 432 facilities are installed in the state. They were responsible for the production of 346 million tons of sugarcane, 19.7 million tons of sugar and 16.7 billion liters of ethanol, using an area of 3.9 million hectares. The São Paulo production accounts for 61% of Brazilian sugarcane and similar shares of the country's refined sugar and ethanol.

The country's sugar production is concentrated in the Centre-South region as these areas (with Sao Paulo in the epicenter) have the highest agricultural and industrial yields and are also closest to markets.

2. A Brief History of Brazil's Alcohol Fuels Program

The sugar sector was established in Brazil in 1532 and has evolved to include a large ethanol fuels program. Originally this fuels program was focused entirely on the domestic market although over the last decade Brazil has poised to be a large exporter of biofuels. (In recent years it has exported about 17% of national production.) The sector is currently responsible for a GDP of $ 28.15 billion, or 2% of national gross domestic product (Neves, Trombini, & Consoli, 2009).

The use of anhydrous ethanol blended with gasoline was authorized for the first time in 1938 (Decree-Law 737/38) and became mandatory in 1941, when the Federal Government has had to determine the percentage of blend.

In 1975, the Alcohol Program has been established (Decree 76593 of 14 November 1975), which goal was to expand the production of anhydrous ethanol.

[1] Relação das Unidades Produtoras Cadastradas no Departamento da Cana-de-açúcar e Agroenergia POSIÇÃO 30/08/2010. Available in: http://www.agricultura.gov.br/pls/portal/docs/PAGE/MAPA/SERVICOS/USINAS_DESTILARIAS/USINAS_CADASTRADAS/UPS_30-08-2010_0.PDF

The country has continued using only anhydrous ethanol blended with gasoline until the late 70s, when the production of dedicated ethanol vehicles started.

In the 80s, ethanol consumption grew and 85% of new cars were dedicated to this fuel—a pattern that reflected a combination of favorable regulation for ethanol along with subsidies. However, in 1985, due to the increase of sugar prices on the international market at a time when oil prices where low, changes in policy along with market forces led to a reduction in ethanol production. The result was shortages of fuel for the country's internal market, which led the Federal government to import methanol and lower the requirements for blending of anhydrous ethanol with gasoline. Anyhow there were a shortage of ethanol in the market, consumers formed long lines gas stations, and consumers' confidence was greatly affected. As a consequence, the production of ethanol dedicated cars decreased to almost cease in the late 90's. This radical shift in demand forced the sugarcane ethanol industry to become more competitive. Indeed, the entire country's energy policy shifted during the 1990s to a larger role for market forces and reduction in subsidy; the ethanol industry was no different, and by 2001 the special pricing and regulatory supports that had sustained the industry since 1975 were removed and the gasoline/ethanol market was fully liberalized.

The origins of the Alcohol program were rooted in the country's dependence on imported oil. By the time of 1973 Yom Kippur war, Brazil imported 80% of the oil used domestically. (Brazil's status as an oil producing giant is relatively recent.)

From an economic point of view, the estimated cost Proalcool's implementation, in the period between 1975 and 1989, was approximately US$ 7.1 billion, of which US$ 4 billion were financed by the government and the rest by the private sector. On the other hand, valuing the volume of ethanol consumed between 1976 and 2005 at gasoline prices in the world market (adjusted for inflation) yields an estimate of US$ 195.5 billion in foreign exchange savings, US$ 69.1 billion in avoided imports and US$ 126.4 billion in avoided foreign debt interest (BNDES & CGEE, 2008).

In 2003, the car industry launched the flexible fuel engines, which can run with any blend of ethanol and gasoline (from E25 to E100). This shift helped restore confidence in the viability of ethanol; by 2010 91% of new cars sold in Brazil are flex-fuel, and the fleet of such vehicles counts of approximately 10 million units.

To meet the demand of domestic market, ethanol sector has increased its sugar cane production. Attracted by the prospects in international market, especially due mandatory blends of biofuels, companies like BP, Shell, ADM, among others, joined traditional national groups of ethanol producers.

3. Water Use in the Ethanol Sector

a. Water availability and consumption in the state of São Paulo

In general terms the state of São Paulo main characteristics regarding the availability of water resources is the following:

- There is water abundance within the state, facing scarcity problems in certain areas of excessive demand.
- Groundwater resources, where present, represent the most flexible of the permanent water sources due to the extent of aquifers, the flow rates per well and its good quality;
- Surface water - rivers, lakes and dams - are threatened by the disposal of domestic sewage, untreated industrial effluents, by agricultural activities with intensive chemical’s consumption and high soil erosion.
- Although this abundance situation, one must recognize that additionally, in some regions, development brought a growing population which may require future allocations of water incompatible with local availability or endanger water transfers from neighboring regions.

In average, surface water production within the state of São Paulo is 3,120m^3/s, being the maximum theoretical potential to be explored within the state (DAEE, 2006). Not all this water can be used, due economic and legal constraints.

Table 1 describes the main water demands in the state and its evolution since 2007. Urban consumption was the only sector where the share of total demand has increased; however, as befits a state with an important agriculture activity, irrigation continues to be the most water demanding sector.

Water consumption in sugar and ethanol production activities has decreased in the period, as well as the entire industrial sector, mainly due the rationalization of water resources use. (Table 1 covers just pumped water and thus there is no entry for sugarcane growth. All sugarcane crops are rain fed, as explained below.)

Table 1: Managed surface water availability and demand, São Paulo (ANA, FIESP, UNICA, CTC, 2009)

Availability and Demand		PERH - 1990		PERH 2004/07	
		1990		Estimates 2007	
		m^3/s	%	m^3/s	%
Availability	Q reference	2105 m^3/s		2020 m^3/s	
	$Q_{7,10}$	888 m^3/s		893 m^3/s	
Demand	Urban	87	25	137.32	30.3
	Irrigation	154	44	177.87	39.2
	Industrial	112	32	138.53	30.5
	Of which ethanol production	*47*	*13*	*35**	*7.7*
Total		354	100	453.73	

PERH = Sao Paulo State Water Resources Plan.
Q 7,10 = minimum average flow on 7 consecutive days and 10-year period
* Estimation based on an average consumption of 1.85 m3 of water per ton of cane

The following chart, shows the shares of water consumption by activity in the state.

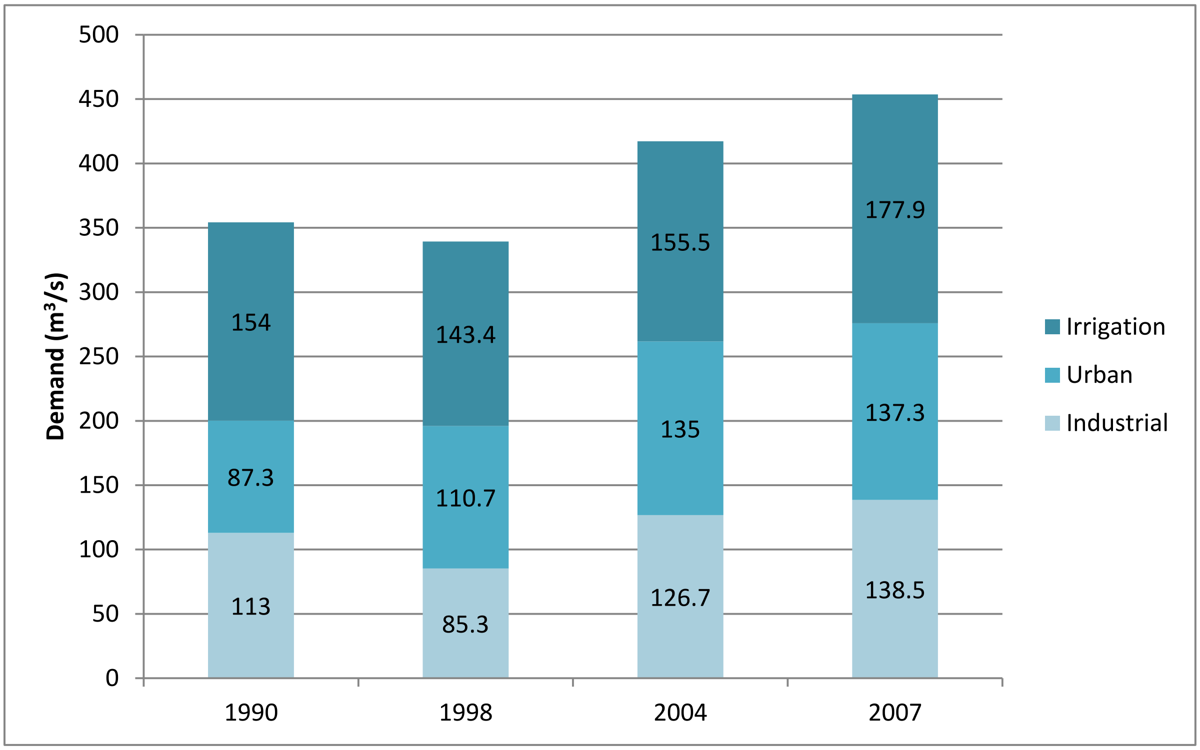


Figure 1: Water consumption in the state of São Paulo (DAEE, 2006). Industrial activities include ethanol production (see table 1).

b. Water consumption in the sugar cane sector

In the production of sugarcane and ethanol water is used in the sugarcane crops (agricultural demand) and in the industrial operations.

Water consumption decreased rapidly due the environmental legislation and the imminent billing for the use of water.

Agricultural demand

The use of crop irrigation is very small in Brazil, mainly in Northeastern region, due to the dry climate. Sugarcane production is mainly rain-fed in the rest of Brazil.

Nearly all São Paulo sugarcane production does not make use of irrigation (Matioli, 1998).So, unlike other parts of the world, sugarcane irrigation is a minor problem in Brazil (Rosseto, 2004).

The evapotranspiration[2] of sugarcane is estimated at 8-12 millimeters/tons of cane and the total rainfall required by sugarcane is estimated to be 1,500-2,500 millimeters/yr, which should be uniformly spread across the growing cycle (Macedo, 2005).

Industrial demand

Conversion of cane to ethanol requires large amounts of water. The total use of water is calculated to be 22 m^3/ton of cane. It does not mean the amount of water withdrawn, because most of the processes occur in close looped circuits, leading to low net withdrawal from water bodies (ANA, FIESP, UNICA, CTC, 2009).

Figure 2 shows the average water consumption patterns in sugar/ethanol industry. It shows that while the consumption of water has remained about the same (22 m^3/ton of cane) the uses have shifted, which reflects changes in the processes for sugarcane milling. Notably, new processes have been added—for example, electricity production, which requires water for steam production, washing exhaust gases and cooling activities, as Brazil's restructured power market has created stronger incentives for sugar mills to use waste biomass to generate electricity efficiently. Despite the improvements in sugar and ethanol production technologies new demands have been responsible for the stabilization of water consumption in the mills in the level of 22 m^3/ton of cane, although due to recycling of water the net consumption today is only 1.83 m^3/ton.

[2] transpiration that occurs in the leaves, corresponding to the water losses; higher evapotranspiration means higher losses

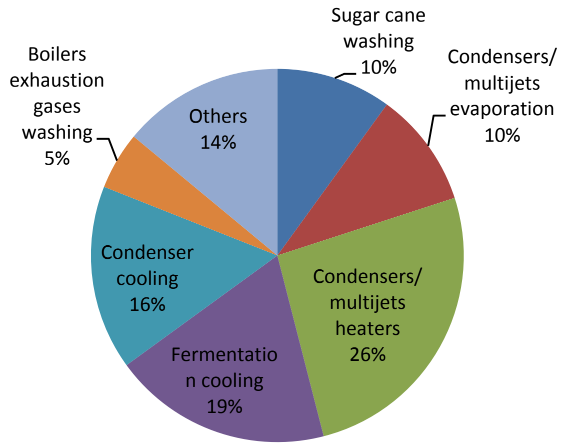
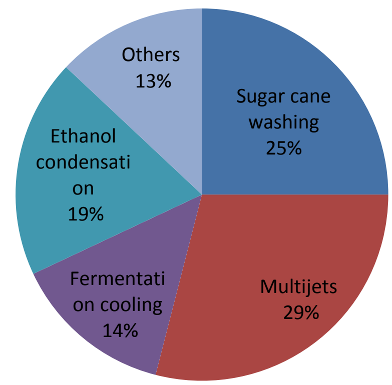
Current situation (year 2009) (ANA, FIESP, UNICA, CTC, 2009)	**Past situation (year 1996)** (Elia Neto, 2005)
	

Figure 2: Water consumption in the sugarcane mills (shares of 22m^3/ton of cane)

There are four processes that are responsible for 90% of water consumption. Sugarcane cane washing has decreased considerable from 25% to 10% due the introduction of sugar cane dry cleaning technologies, and a new demand – washing of exhaustion gases – has increased due more strict environmental requirements. Cooling processes are high water demanding. These are the main processes where technology development, rationalization and conservation programs shall point.

Second, the sector has seen substantial technological innovation. Water consumption in the conversion of sugar cane to ethanol has substantially decreased in the last years, from around 5.6 m^3/ ton of sugarcane collected in 1990 and 1997 to 1.83 m^3/ ton of sugarcane in 2004 (figures from a sampling in São Paulo) (Elia Neto, 2005).

The São Paulo Agro-Environmental Protocol (described in details on chapter 5) establishes goals for reducing water withdraw to 1m^3/t of sugarcane in non-stressed areas, and in areas of the state where water is scarce policy limits consumption to 0.7 m^3/t of sugarcane. These targets were defined by the government after consultations to UNICA and the Sugarcane Technology Center (CTC[3]); the 1m^3 of water /t of sugarcane target is achievable with basic engineering, however lower levels will require the implementation of new technologies such as dry cane cleaning process.

Particularly notable are the accomplishments in recycling. Water reuse levels during the industrial processing of cane into ethanol are very high, and the wastewater treatment efficiency is more than 98 percent. Even more important than improvements in the efficiency of wet cane process is the introduction of dry cane cleaning process, which uses essentially zero water compared with the standard 5 m^3 of water/t of cane for wet processing (Macedo, 2005).

According to the CTC [4] the main drivers to technological development in the sugar/ethanol industry are: (a) the payment for water use (a policy that already has been implemented in some water basins in São Paulo); (b) the high cost and technical difficulties of wastewater treatment previous to its disposal in water bodies: (c) CETESB's monitoring actions; and (d) the environmental marketing showing to society that the sector is moving towards a sustainability pathway (e.g., saving water resources).

Modern agricultural practices include the recycling of washing water and ashes to the crops via fertirrigation[5], together with the vinasse (pollutant by-product from ethanol distillation).

Environmental problems related to water quality, which result from irrigation (water run-off, with nutrients and pesticides, erosion) and industrial use, have not been reported in São Paulo.

The main liquid effluents of ethanol production are: the vinasse and the wastewaters used for cleaning sugarcane stalks. The vinasse disposal represents the most important

[3] CTC is the largest sugarcane technology center in Brazil. It develops innovative research on all aspects of the sugarcane production chain, from planting to the final production of sugar, ethanol and energy (www.ctc.com.br).
[4] Personnal communication, Eng. André Elia Neto (andre@ctc.com.br)
[5] Fertirrigation is the use vinasse (a byproduct of ethanol distillation process, produced in the rate of 10 litres of vinasse per litre of ethanol) to irrigate sugarcane crops.

potential impact due to the large amounts produced (0.011 to 0.014 m^3 per m^3 of ethanol), its high organic loads (BOD - Biochemical Oxygen Demand and COD - Chemical Oxygen Demand) and pH of 4 to 5 (Rodrigues & Ortiz, 2006).

Disposal costs are high and the vinasse used to be released into rivers, polluting the water in every harvesting season. Nowadays such disposal is forbidden all over the country and fertirrigation uses vinasse in the sugarcane crops together with wastewaters.

Also, a number of studies on leaching and possibilities of underground water contamination with vinasse indicate that there are in general no damaging impacts for applications of less than 300 m^3 of vinasse/hectare. The state environmental agency (CETESB) technical standards regulate the disposal of vinasse and determine risk (prohibition) and permitted areas.

Agrochemicals such as herbicides, insecticides, mitecides, fungicides, maturators, and defoliants are inorganic pollutants applied in ethanol production. The application procedures and monitoring programs of such products are regulated by Law.

Genetic research has allowed the reduction of sugarcane diseases through the selection of resistant varieties. Genetic modifications (at field test stage) have also produced plants resistant to herbicides, fungus and the sugarcane beetle. In fact, there are more than 500 commercial varieties of sugarcane (Macedo, 2005).

The most important factor is the nutrient recycling through application of industrial waste (vinasse and filter cake), considering the limiting topographic, soil and environmental control conditions. So, substantial increases in productivity and in the potassium content of the soil have been observed. Nutrient recycling is being optimized, and the trash utilization is yet to be implemented.

4. Land

The main concerns related to expanding the amount of land under cultivation for energy (or any other use) are the irreversible conversion of virgin ecosystems and the competition over land for the production of food crops. None of these have been observed in the case of new sugar cane areas since they have mostly been planted on degraded land where there is little competition for food.

Sugarcane growth does not seem to have impact on food. Looking across the country the area used for food crops has not decreased. Within the state new sugar cane crops were planted in degraded lands that were previously used as pasturelands.

Sugarcane is not a particularly demanding crop in terms of soil, adapting reasonably to soils of average fertility. More fertile soils lead to higher productivity levels and reduced demand for costly fertilizers and corrective products—but high grade soils are expensive in Brazil due to the many other competing agricultural demands for land and thus usually not cost effective. Indeed, land in the State of São Paulo is becoming more expensive; costs increased in average 113.66% from 2001 to 2006, in regions traditionally devoted to sugarcane production, showing a growth in a range of 160 to 170%.

The most important cane producing state is São Paulo, with an area of 1.9 million hectares in 1993 that increased to 5.5 million hectares in 2009 are used for sugarcane crops. In 2009, 4.9 million hectares were harvested, half of it dedicated to ethanol production and the other half for sugar (Figure 3).

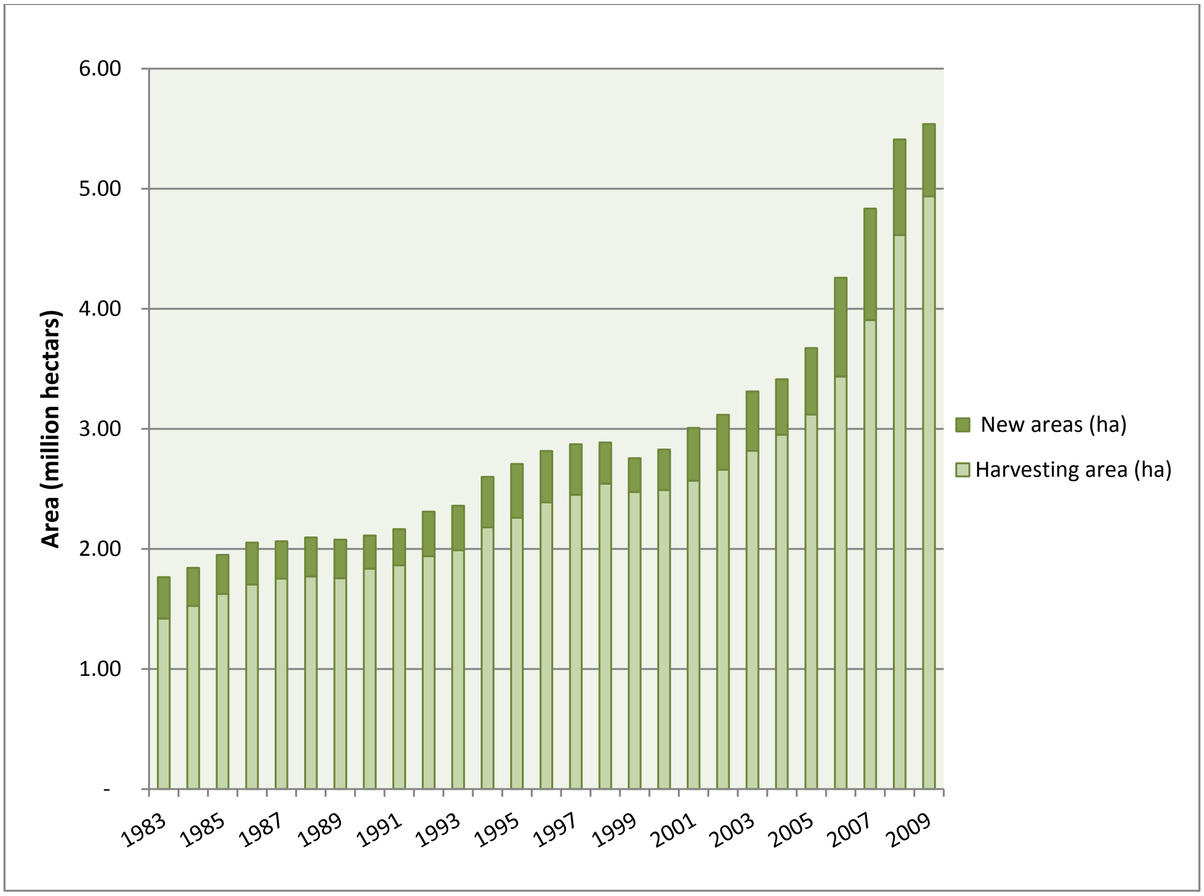


Figure 3 Sugarcane crops in the state of São Paulo (IEA, 2010)

The Brazilian environmental legislation is based on the National Forestry Code (Federal Law 4,771/65), and the Environmental Crime's Law (Federal Law 9,605/98), there is also legislation to licensing and recovery projects. A legal reserve of 80% is required for rural properties in the Amazon region, 35% in the Amazonian *Cerrado* (savannas) and 20% for the rest of the country, including São Paulo state.

So, sugarcane plantations (or other crops) in São Paulo must guarantee at least 20% forestry cover on native trees (or reforested with native trees); for that purpose, São Paulo state Decree 50,889 from June 16th, 2006, establishes rules to create and protect the legal reserve in the state. São Paulo has also special requirements on riparian forests maintenance for environmental licensing, since there is, in the state Secretariat for the

Environment, a special program funded by World Bank/GEF (Global Environment Facility), launched in 2005, on recuperation of the 1 million hectares of riparian forests.

a. Land competition: ethanol versus food crops

In the 70's and 80's ethanol caused a shift in land use patterns from food crops to sugarcane. In São Paulo from 1974 to 1979 the expansion replaced food crops. Maize and rice had the biggest decrease, of which the planted area declined by 35%. Current use of agricultural land in São Paulo is shown in Figure 4.

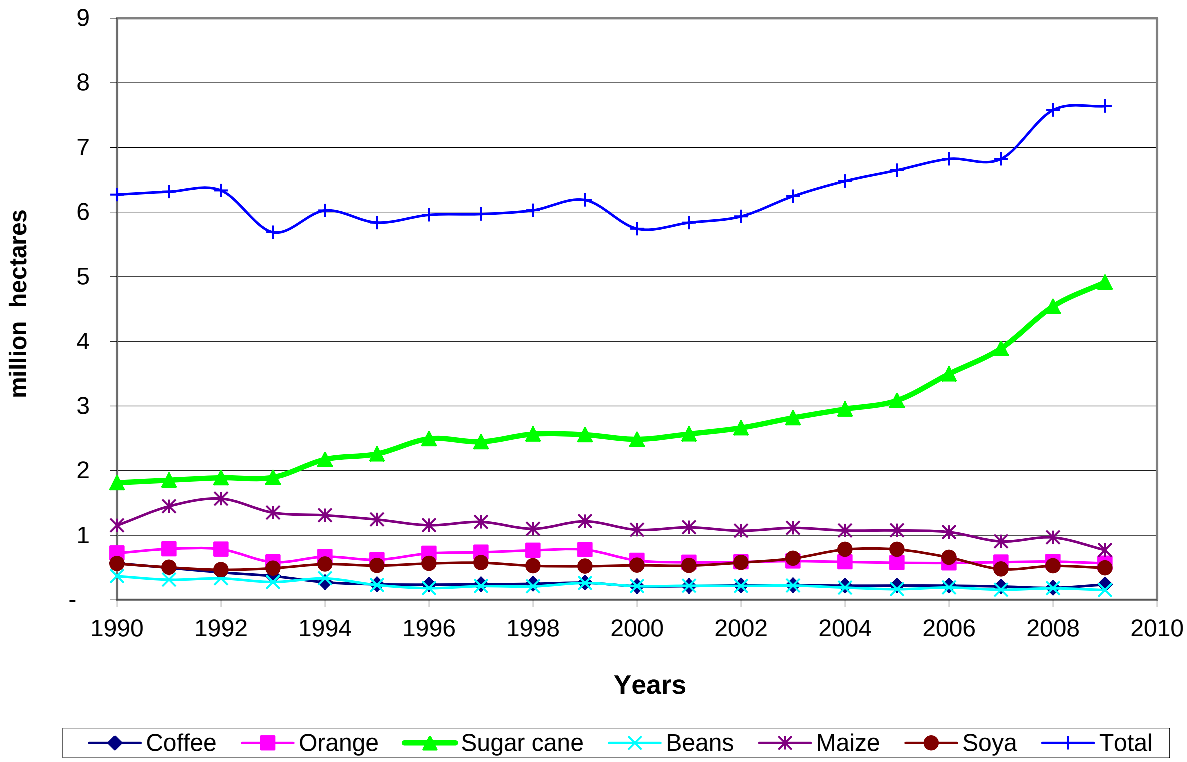


Figure 4. Main crops in São Paulo State (IBGE, 2010)

Figures 4 and 5 shows that sugarcane growth does not seem to have impact in food areas, since the area used for food crops has not decreased. The expansion in the state is taking place over pasturelands.

Besides the expansion of sugarcane area, the increase on ethanol production in the state was also due to the growth of overall productivity (both agricultural and industrial). Also, genetic improvements allow cultures to be more resistant, more productive and better adapted to different conditions. Such improvements allowed the growth of sugarcane production without excessive land-use expansion.

As mentioned, sugarcane expansion during the period 2002-2009 occurred in São Paulo mainly on land previously used for cattle feed not pressuring food crops. Also because rotation system is used to the sugarcane crops, during every harvesting season; 20% of the sugarcane crop is removed and replaced with other crops like beans, corn, peanuts, etc. In order to allow the soil recovery, this practice is being used throughout the country.

Considering the replacement of cattle areas it is important to notice that the number of animals in the pasturelands presently has very low densities in Brazil (1 head/ha) when compared to developed countries average. Through intensification of cattle production the state's cattle population has increased in density from 1.28 heads/ha (2004) to 1.43 heads/ha (2009) (IEA, 2010) while at the same time releasing 0.88 million hectares of pasturelands to other crops, especially sugar cane.

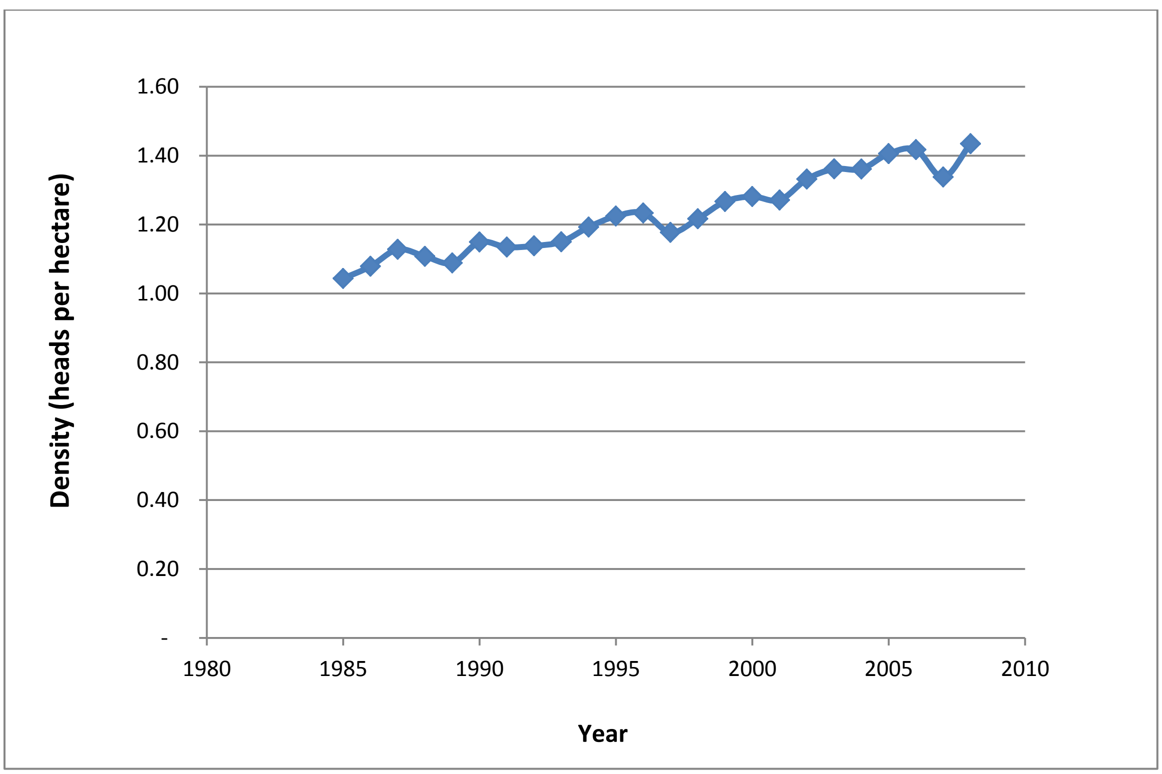


Figure 5 Evolution of Cattle Ranching Intensification in the State of São Paulo

5. Resources management

The organization in charge of environmental permits in São Paulo State is its Secretariat for the Environment. Ethanol production is a key matter of local concern in São Paulo considering its economical importance and expansion, i.e. area grew 98.3% in the period 2000-2009, as can be seen in Figure 2.

a. Water management

In 1987, state Decree 27,576 established the first "Water Resources State Council", composed exclusively by state bodies and entities, aiming to propose the state water resources policy framework and structure a "Water Resources Management Integrated System" (SIGRH).

Thus, in 1989, the state Constitution determined the institution, by law, of the "Water Resources Management Integrated System" (SIGRH) guaranteeing the participation of state and municipal bodies as well as representatives of civil society, with the aim of ensure the rational use of eater and the priority of public supply; a decentralized, participative and integrated management of natural resources; multiple uses of water and the apportionment of its relative works costs.

Following the implementation of the legal framework, in 1991, Law 7663, established the norms and principles for Water Resources State Policy as well as the "Water Resources Management Integrated System" (SIGRH). This law determined the management instruments: concession of permits for water uses, payment for water use, the periodic publication and update of a Water Resources State Plan, the establishment of Basin Water Committees and the Water Resources State Fund.

The basin water committees were created by the law that established the Water Resources State Policy (Law 7.663/1991) in order to manage water in a decentralized and integrated way with the participation of society.

Committees are boards composed of representatives of municipalities (mayors), state bodies and civil society representatives (NGOs, universities, associations) in equal number. The tripartite composition is intended to ensure all members of the college the same rights and power to act in decision process that will influence life quality improvements of the region and the sustainable development of the basin. Therefore, the basin water committees are considered "waters' parliament."

Before its creation, water management was conducted isolated by municipalities and state. The information was scattered in the technical bodies connected to the subject and data were not compatible. It was very difficult to have access to concrete information. It was a major bottleneck on water planning, supply, distribution, disposal and treatment that resulted in the development of projects, conceived in isolation, often wasting public money. The lack of comprehensive public policies and efficient management of natural resources has caused degradation of many rivers.

With the creation of committees, the state of São Paulo was divided into 22 management units, according to watersheds and geopolitical affinities. Each of these parts was renamed Water Resources Management Unit (UGRHI).

The water authorizations in the state are controlled by the Department of Water and Electric Energy (DAEE) that issues the permits for water withdraw based on Federal and state legislation guidelines, with the participation of basin water committee.

b. The Agro-Environmental Protocol

To ensure sustainability of sugarcane ethanol related activities; São Paulo State has established a voluntary scheme in May 2007: the Agro-Environmental Protocol, under the São Paulo State Green Ethanol Program[6]. This Protocol has been signed by the Governor, the state secretary for the Environment and also by the secretary for Agriculture and Food Supply, the president of UNICA (Sugarcane Producers Union) and

[6] http://www.ambiente.sp.gov.br/etanolverde/

the president of ORPLANA (Organization of Sugarcane Growers of Brazil's Centre-South Region).

The aim of the Protocol is to promote best practice and prepare producers to other certification schemes that are being established worldwide. The text has set a number measures to be followed as presented in Box 1.

Box 1

Environmental Directives of SP Sugar Cane Sector Protocol (Guidelines)

Directive a: to anticipate, in the lands with declivity lower than 12%, the final period for the elimination of sugar cane harvest burning, from 2021 to 2014. Anticipate the percentage of not burned sugar cane in 2010, from 30% to 70%.

Directive b: to anticipate, in the lands with declivity higher than 12%, the final period for the elimination of sugar cane harvest burning, from 2031 to 2017. Anticipate the percentage of not burned sugar cane in 2010, from 10% to 30%.

Directive c: do not burn any sugar cane harvest in expansion areas.

Directive d: do not burn any sub-product of sugar cane without a control system.

Directive e: to protect the Riparian Forest of the sugar cane farms due to it´s relevance for the environment and biodiversity protection.

Directive f: to protect the water springs of rural areas of sugar cane farms, recovering it´s vegetation.

Directive g: to implement a Technical Plan of Soil Conservation, including the erosion control and the contention of water runoffs on intern roads.

Directive h: to implement a Technical Plan of Water Resources Conservation, respecting the hydrological cycle, including a Water Quality Program and Water Reuse Program

Directive i: to adopt good practices for agrochemicals packaging waste, promoting the triple washing practices and storing it accordingly. Train the operators correctly and certificate the use of individual workforce protections equipment.

Directive j: to adopt good practices to minimize air pollution from industrial process and optimize the recycling and reuse of industrial process solid waste.

There are formal commitments to fulfill guidelines. All adherents must present detailed plans and a simplified table with baselines and action targets. Protection of natural species and biodiversity is a special chapter in the Protocol. All defined in a detailed plan, it covers: (i) definition and recovery of riparian forests next to plantations ; (ii) improved protection of conservation units; (iii) rigorous enforcement against deforestation and; (iv) protection of water springs. Detailed plans include maps with location of forests, watersprings and cultures.

Compliant adherents receive a Certificate of Conformity from the Government – and lose it if directives are not followed. Verification is made by government (environmental bodies), producers and civil society. As of February 2011, 149 out of the 196 ethanol plants in the State had adhered to the Protocol. These represent more than 90% of total cane crushing. From the 149 plants, 132 have finished and delivered their Action Plans (2007-2017), establishing how they will follow the Protocol´s Directives.

The non-adherent plants are being focused by environmental inspections since the refusal to sign a voluntary agreement may indicate the lack of compliance with legal requirements. The licensing processes for these plants are stricter and include the same guidelines established within the Protocol. Moreover, international companies aiming to import ethanol from São Paulo require the Certificate of Conformity from the Government as a precondition.

In the recent years it has been observed a change of sugar/ethanol business profile, traditionally constituted by family-owned enterprises, new enterprises controlled by national and international companies entered into the market (Goldemberg, 2009). This fact could be relevant to the increasing compliance with environmental sustainability criteria since such companies use to have in-house procedures to ensure good practices. Additionally, most of these companies are also interested in the external market.

The relevance of external market to Brazilian mills can be observed by the number of companies applying for registration at both EPA and CARB (California Air Resources

Board), aiming to sell their products in the United States market. In the case of California, 43 Brazilian mills have been authorized by CARB to sell sugarcane ethanol within the Low Carbon Fuel Standard (LCFS). In the case of Renewable Fuel Standards (RFS2), by January 2011, more than 50 mills have complied with EPA's requirements – these mills are responsible for 25% of Brazilian ethanol production.

Further actions include the signature of the protocol with cane suppliers. This second phase was signed in March.2008 with 27 associations, representing more than 13,000 suppliers. For the cane producers are applied basically the same guidelines of ethanol plants.

Practical results were already observed. In the season 2010/ 2011 approximately 3 million out of 5 million hectares were harvested mechanically (Figure 6).

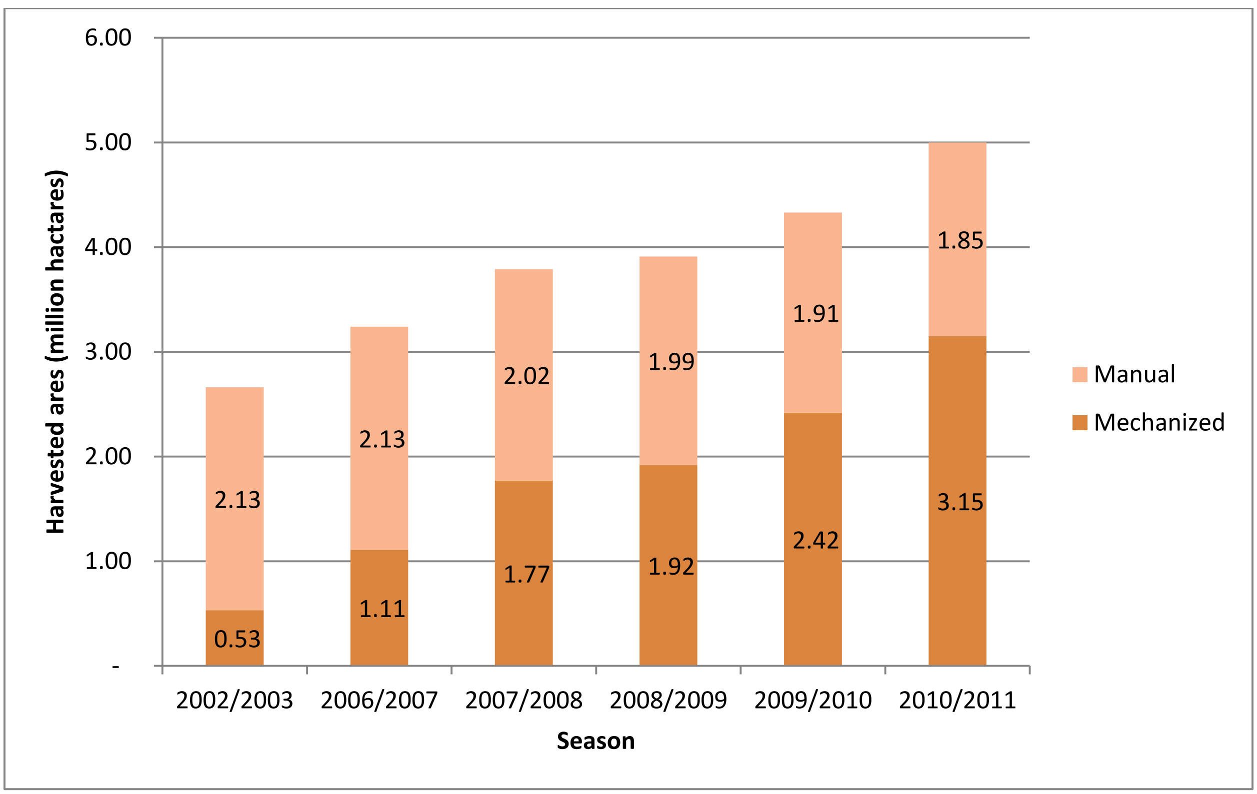


Figure 6. Evolution of Mechanical Harvesting in the State of São Paulo

Preliminary results obtained estimate that by 2012 all mechanizable areas will phase-out harvest burning, anticipating the legal deadline of 2021. For non-mechanizable areas the legal deadline of 2031 will be anticipated to 2017.

Despite the high investment costs – each harvesting machines costs about R$ 1 million[7] (US$ 600,000.00) – the operational costs are reduced and productivity gains obtained.

Mechanical harvesting will prevent releases of 3.9 thousand tonnes of particulates (~28% of emissions from diesel vehicles in the Sao Paulo Metropolitan Region – SPMR); 45.3 thousand tonnes of carbon monoxide (12% of diesel emissions in SPMR) and 6.5 thousand tonnes of hydrocarbons (11% of diesel in SPMR). Riparian forests defined to be protected were around 400 thousand hectares (~10% of cultivated land). Results are verifiable through satellite images.

The counterpart of the Agro-environmental Protocol is governmental support in topics like (i) R&D on cellulosic ethanol, recovery of leaves and straws, bagasse cogeneration, genetic improvements etc.; (ii) Infrastructure, logistics, exports: transport optimization (pipeline, waterways, railways, ports, roads); (iii) Electricity cogeneration: regulation, grid connection; (iv) Certification to Agro-environmental Protocol conformities; (v) Incentives to adequate transition from manual to mechanized harvesting, especially small and medium enterprises (up to 150 hectares).

c. The Agro-Environmental Zoning

In September 2008, São Paulo State Secretariat for the Environment in a partnership with the state Secretariat for Agriculture and Food Supply, launched the sugarcane agro-environmental zoning aiming to discipline and organize the expansion and land use by sugarcane sector, in addition to subsidize public policy.

This zoning comprises information about soil and climate potentials, surface water availability, underground water vulnerability, restrictions to mechanized harvesting, biodiversity protection areas, biodiversity connectivity, biodiversity protection

[7] US$1.00 = R$ 1.70 (January 2011)

importance and integral protection units. All the information has been consolidated in thematic maps that overlaid determine the suitability of areas to sugarcane cultivation within the state.

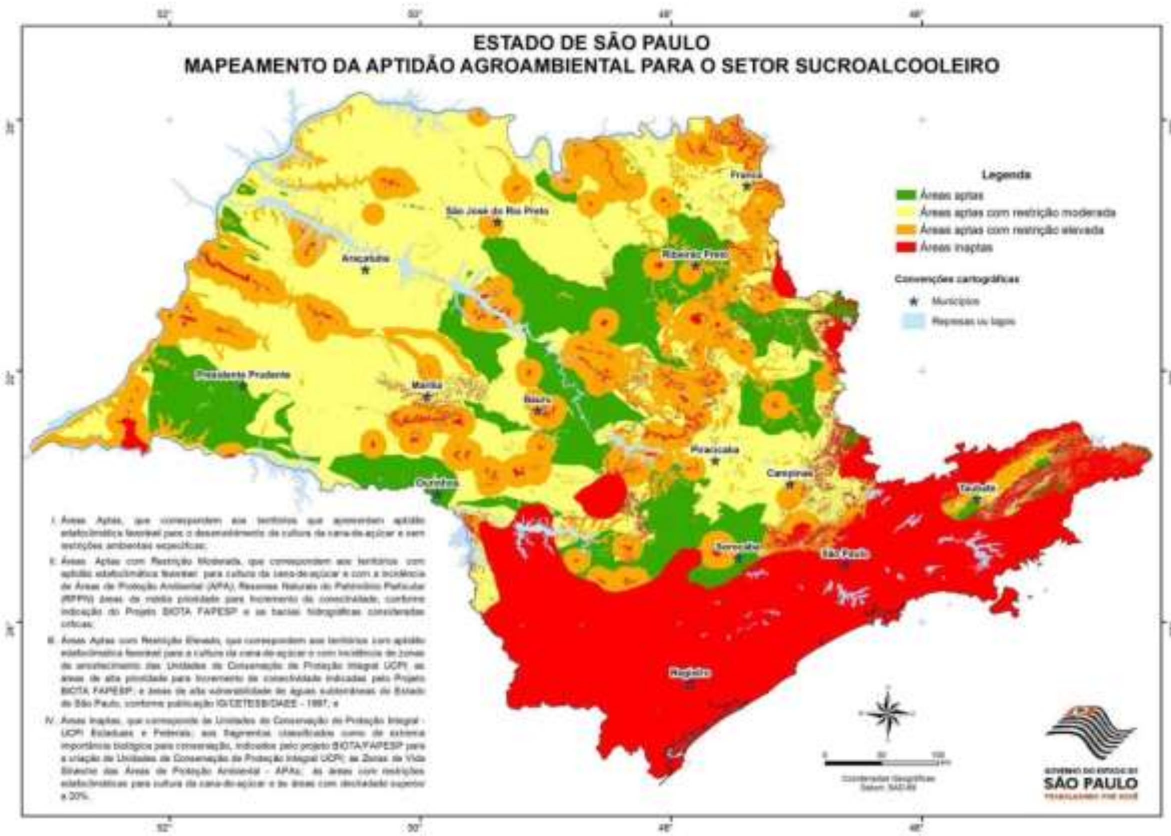


Figure 7. Final sugarcane agro-environmental zoning in São Paulo

The Resolution SMA 88/ 2008 that defines parameters and guidelines for environmental licensing of sugarcane facilities has been based on the agro-environmental zoning information. For example, applications for permits in the red zone of the map (Figure 7) are not even accepted. Each area (colors) of the map has specific requirements to be accomplished by the entrepreneurs. The parameters established in the Resolution must be accomplished by existing mills and new ones.

According to the Resolution, mills adherent to the Environmental Protocol have special treatment in the renewal of operation license. Since all mills must comply with the Resolution requirements, a "Plan of Adaptation" with targets and timetables should be presented. Mills adherent to the Environmental Protocol, have a deadline of 15-years to implement their plans of adaptation, however non-adherent plants must follow regular rules. Furthermore, adherent mills complying with all the regulations established can extend their licensing period of validity in 1/3 (one third) in relation to the maximum period established in the legislation.

6. Conclusions

From the researchers developed during the process of this report one can take main following conclusions.

In the case of water reduction in consumption patterns the main drivers are payment for water use, the environmental requirements of international markets for sustainable products and the growth of country's economy that increases the trade-offs. However strict control from environmental and water agencies is still required. Moreover, despite massive growth, biofuels remains small part of overall water usage.

Regarding land use the competition between food crops and pasturelands do not seem to be a concern in the region since the increase of cattle stocking in the areas currently in use is possible.

Generally speaking, governmental policies have been effective in the introduction and improvement in the requirements for environmental protection. However, proper enforcement and control actions are required.

As previously mentioned international market demands for sustainable goods and the social awareness have been major drivers to the development of a sustainable pathway in sugarcane ethanol production.

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