

## **Agri-environmental policies of Brazilian energy sector: national growth and local environmental vulnerability**

Carolina de Oliveira Jordão<sup>a</sup>, Evandro Mateus Moretto<sup>b</sup>.

a Core Studies on Environmental Policies (NEPA), University of Sao Paulo, São Paulo, Brazil and Center of Life Institute (ICV), Mato Grosso, Brazil.

b Core Studies on Environmental Policies (NEPA), University of Sao Paulo, São Paulo, Brazil

**Abstract:** The knowledge about a territory's environmental vulnerability is crucial to understand the sustainability and viability of the existence of human activities, through this type of analysis is possible to obtain data about the environment's attributes that will be changed due the existing activities. In this context, a problem now emerging in Brazil, and specifically in the state of São Paulo, which tends to significantly increase the vulnerability of economic and ecological systems, in an integrated way, refers to the expansion of the monoculture farming of sugarcane, because the negative impacts and changes in the territory toward a decrease in systemic resilience. Accordingly, this research aimed to analyze how issues related to environmental vulnerability were included in the spatial planning of this activity expansion, focusing on the agri-environmental zoning of São Paulo's sugarcane sector, as the currently main public policy for the sector in the State. It has been concluded that the zoning recommends only the physical potentialities for sugarcane farming, disregarding the restrictions related to environmental vulnerability in the landscape, therefore, can't be seen as a means of inducing sustainability, in its widest sense

**Key-words:** environmental vulnerability, landscape, planning, agri-environmental zoning, sugarcane.

## **1. Introduction**

Ecological economics provides a systemic perspective on the relationship between economy and ecology, in which the economic system is seen as a subsystem of the ecological system (Alier, 1998). This allows the development of theoretical and empirical knowledge about the properties that emerge from the relationship between these systems in search of solutions and management policies to tackle the environmental problems that even affect human well-being.

Within this context it is possible to discuss the matter of environmental vulnerability, since the human-induced changes in ecosystems and ecosystem services generate situations in which people and places become more vulnerable and less resilient to environmental changes (Kasperson et al., 2005). The vulnerability of coupled human-environment systems has diverse and complex linkages, therefore, the definition of a framework is essential to a comprehensive vulnerability analysis (Turner et al., 2003).

The current efforts to identify the environmental vulnerabilities of a given territory have proven to be an essential tool for directing management efforts to natural resources conservation and the provision of ecosystem resilience. In addition, generates subsidies to actions that seeks the reduction of the environmental vulnerability of areas which already have low resilience (SOPAC, 2004a). Moreover, is relevant to understand the sustainability and viability of the existence of human activities in a territory.

In the Brazilian agriculture context, it is possible verify territorial expansion of some crops with that have several impacts in the natural system. One of those is the sugarcane for the production of sugar, as well as, of ethanol fuel. This expansion happens with the help of State policies that promote incentives to the sector, a strategically issue for national economic growth, but this generates changes in the territory toward a reduction of the ecosystem resilience.

These problems are considered negative externalities resulting from the economic process of agricultural activities. These can be seen as market failures that generate the need for State intervention to internalize them in the production process by environmental policy instruments, such as zonings.

Thus, environmental policy instruments act as adjustments in the functioning of the economic system in order to reduce the environmental vulnerability of the affected territories. In this context, it is plausible to consider that public policies, related to the sugarcane sector,

should include the matter of environmental vulnerabilities of the territories that has the sugarcane activity. These with the purposes of balancing socioeconomic potentialities with environmental sensitivity, through reducing the environmental impacts, ensuring the perpetuation of ecosystem functioning and of the intervening activity itself.

In this perspective, this paper has the following guiding question: Public policies that aim to the expansion of monoculture of sugar cane, as an incentive to the sugar and ethanol sector, have been established with attention to the environmental vulnerability of the affected territories?

Therefore, this study aimed to develop a framework to analyze the internalization of local environmental vulnerability issues in agri-environmental policies for national growth. For that, it was used as a case study one of the main policies focused on Brazil's sugar production, the agri-environmental zoning of the State of Sao Paulo's sugarcane sector (AEZ)

## **2. Environmental vulnerability**

The vulnerability of people and places is a complex phenomenon defined by the long history between humans and the environment (Luers, 2005), and represented by patterns of population growth, urbanization, spread of disease, economic development and globalization that express their effects in the global, regional and local scales (Kasperson et al., 2005).

The idea of environmental vulnerability has become one of the central topics in the dialogue and research on sustainability, resulting in the emergence of important issues such as: Who and what is vulnerable to many environmental and human changes, and where?; How do the changes and their consequences are attenuated or amplified by environmental and human conditions?; What can be done to reduce vulnerability to changes? (Turner et al., 2003).

In this context, the environmental vulnerability can be understood as the potential that a system has to modulate their responses, over time and space, in the face of stressors. This are related to the ecosystem characteristics, including the different levels of organization (Williams & Kaputska, 2000).

The resilience is important part of the vulnerability concept, since the negative changes in the vulnerability of a system leads to a reduction in resilience. This, from the ecologically and according to Gunderson (2000), is an emerging property connected to the self-organizing behavior and the idea of multiple states of stability. In which, instabilities can lead the system

to a different behavior regime. Resilience is measured by the magnitude of disorders that the system can absorb without changing its stability, and society changes the system's resilience, ie, produce a change of stable state to another (Gunderson, 2000).

The knowledge of a territory's vulnerabilities can provide a valuable indication of the sustainability of human life within their environment, from a focus on current conditions and risk analysis and to prevent the trend of how the environment will face future events (SOPAC, 2004a).

Surveys and vulnerability assessments occur at different scopes and scales (Figueiredo et al., 2010), such as climate change (PIK, 2009;), impacts on quality of life (SEI, 2009), ecological indicators (SOPAC, 2004a; SOPAC, 2004b; SOPAC, 2005), regional planning (Smith, 2000; Jackson et al., 2004; ABT & Schaberg, 2004), performance evaluation of technological innovations (Figueiredo et al., 2010), environmental degradation in mountainous areas (Li et al., 2006) and watershed (Zielinski, 2002), risks and natural disasters (Santos, 2007) agriculture, desertification and food security (Kasperson et al., 2005).

Luers & Eakin (2006) highlight the need to consider the institutional context in researches on the issue of vulnerability, since it is important to turn our attention to questions of how and why people have different capacities to manage risks, and how the implications of current decisions alter the vulnerability of present and future. Thus, we must work on the of bridge science/policy, then the theory will be translated into practice and decision making.

In Brazil, the discussion of environmental vulnerability is recent and little explored, but there is an interesting experience in vulnerability assessment for technological innovations performance, carried out by Embrapa (Brazilian Agricultural Research Corporation), University of Brasilia and Ceara Federal University. There were conducted a vulnerability assessment in river basins were occur the any of the different life cycle stages of coconut substrate production, with the purpose of integrate it into an existing life cycle analysis methodology (Figueiredo et al., 2010) .

### **3. The sugarcane monoculture as public policy**

Sugar production was the main Brazilian economic activity since the colony until the second half of the eighteenth century, when the export to the European market suffered a big drop, especially because of the increase production of sugar in the Antilles (SANTOS, 2010). With changes in production cycles, in the nineteenth century, there was a decrease in sugar

production and the country ceased to be the largest sugar producer in the world, falling to fifth place (UNICA, 2009).

The sugarcane cultivation historically received state intervention to maintain this sector that has always been important to the national economy. For many years the Institute of Sugar and Alcohol controlled the production and marketing of those two products, making it possible the activity continuity, even with the many crises that affected the industry over the years, mainly influenced by the international context.

Public policies, such as the Alcohol Program, implemented strongly in the 70's, had no consideration of the environment aspect. The goal was to contribute to maintain the economic attractiveness of the sugarcane cultivation. According to Santos (2010) these policies had consequences in the growth of mills and techno-scientific research in the agriculture field. Also, they contributed to the modernization of all production phases (soil preparation, planting and harvesting), mainly because of pesticides use and introduction of sugarcane genetically modified varieties.

Only more recently, public policies with some concern about the environmental impacts of cane sugar appeared, such as zonings at the national and state (Sao Paulo). But it is critical that these take into account some minimum environmental criteria when applied, generating clear benefits to the environment and society.

This is even more important if one considers that currently Brazil is the largest producer of sugarcane and sugar, and the second of ethanol, only behind the United States (INPE, 2010). In 2006, 425 million tons of sugarcane were processed in 310 mills, with a production of 30 million tons of sugar and 17 million cubic meters of ethanol. Estimates show that in the years 2012-2013 will be 685 million tons of sugarcane, which would be produced in 35, 7 million cubic meters of ethanol. Therefore, it is necessary to use 6.4 million hectares and the deployment of 77 new plants in the Brazilian South Central region, with the investment of \$ 14, 6 billion (Macedo, 2007).

Data, from a sugarcane satellite monitoring project from INPE (National Institute for Space Research) called CANASAT INPE, shows that the crops of 2005/06 and 2006/07 increased in about 9.66% in sugarcane plantation area (Coelho et al., 2007). And if the estimates of territorial expansion of this crop are confirmed, it means more than double the area by 2016.

#### **4. Local environmental impacts of sugarcane cultivation**

With the growth of sugarcane production, this activity entered the discussion agenda about their historical problems related to environmental and social impacts in locations where it is already present, and about the consequences of its expansion. Thus, some socio-environmental issues need to be properly discussed and the problems resolved, so the vast expansion doesn't occur with great losses to society.

These issues involve the various phases of activity, and it can be highlight those related to the practice of burning cane before cutting, soil degradation, water pollution, pressure on other cultures and areas of native forests, the application of pesticides and fertilizers. There is also the destruction of the legal reserve (percentage of farm land that by law has to be maintained with vegetation) and permanent preservation areas (river side vegetation also protected by law), with important negative affects in the landscape and biodiversity loss.

The sugarcane manual cutting raises questions about the conditions of workers, due to irregularities in the service, the lack of documentation, lack of personal protective equipment, lack of sanitary facilities and the unsafe and illegal transportation (Noel, 2007; Novaes, 2007). Besides these questions, since it was adopted the method of payment by productivity, sugarcane workers cut up to 15 tons of cane per day to earn about \$800 (local currency) monthly. In many plantations, workers are fired if they fail to cut more than 10 tons of cane per day (Novaes, 2007).

On the subject of the many impacts on the environment, first there is the use of burning as a practice used to facilitate manual cutting and repel poisonous animals like snakes and spiders. But this can create a risk of disease for the own cane, destruction of organic matter, soil structure damage due to erosion and drought, and endangerment of electrical systems, railways, roads and green areas. Another important impact is the air quality in the region of plantations, with possible consequences for the health of the population, after all, there are emitted pollutants such as CO<sub>x</sub>, CH<sub>4</sub> and particulate matter, and there is an increase of tropospheric ozone (Goldemberg et al., 2008).

Soil degradation due to compaction and erosion is a major problem of cane cultivation, the erosion is associated with large areas of exposed soil that are susceptible to heavy rains and winds, during the initial conversion of land use and the intermediate process between harvest and new growth that the soil is exposed for several months. The compaction is due to the constant traffic of heavy agricultural machinery, destroying soil physical properties such

as porosity and density, consequently there is a decrease in water infiltration and a contribution to the erosion (Martinelli & Filoso, 2008).

Erosion also contributes to the deterioration of aquatic systems due to particle loading of sediment to the watercourses (Martinelli & Filoso, 2008). Waste water is also a problem because they contain large load of organic matter from the sugarcane processing and inorganic pollutants from pesticides used (Goldemberg et al., 2008).

The production of vinasse, a byproduct of the sugarcane processing, which is produced in large quantities, is also a significant issue. This has a high organic load and pH between 4 and 5. By having an expensive disposal, was for many years released into rivers and causing serious problems of water pollution in the harvest season. This practice was banned throughout the country, an alternative is to use vinasse for irrigation of plantation itself, but there are studies on the possibility of this practice causing groundwater pollution (Goldemberg et al., 2008).

Regarding the expansion of sugarcane plantations, the Brazil's Midwest region has ideal climatic (drought periods) and topographic conditions for this crop, but this region has half the country's soybean production. Thus, depending on the land market and the price of these crops, soy can be substituted for sugarcane, causing a pressure to soybean producers to move toward the North, towards the Amazon, with a consequent increase in deforestation in the region (Martinelli & Filoso, 2008).

The pressure on other crops (not only soybean) is a topic of preoccupation, even though most of the new sugarcane plantation is located in degraded pastures that became more efficient (Goldemberg et al., 2008). After all, some data shows that in Sao Paulo the maize growing are giving way areas to sugarcane, so the substitution of other crops to sugarcane monoculture, causing a shift on territorial structure, can lead to deforestation of native forests and decreased food production. In this sense, it is necessary to control the cane expansion, so this does not push the activities of soybeans, corn and even cattle ranching on the Amazon Forest and Savana areas (Coelho et al., 2007).

But even if the cane is not directly responsible for large-scale deforestation, one cannot disregard this question, especially when talking about places like Sao Paulo State already that has a low rate of native vegetation. According to Goldemberg et al. (2008) Sao Paulo's Northwestern stands out as an area with great potential in the short term to cane expansion. This is due to the fact that sugarcane cultivation is traditional in these areas (Coelho et al., 2007).

On the topic of pesticides use, this is worrisome from the environmental point of view in all types of farming based on large monoculture plantations, including sugarcane. Where are applied herbicides, insecticides, fungicides and others, which are sources of inorganic pollutants that affect soil and bodies of water (Goldemberg et al., 2008). In addition, the practice of the aircraft application may cause damage to other crops (Noel, 2007).

The growing use of fertilizers also cause environmental problems, these is associated with the expansion and intensification of sugarcane cultivation. As more fertilizers are used, the greater the possibilities of excessive nutrients, such as nitrogen, accumulate in the environment and be transported to the aquatic ecosystem, contributing to eutrophication (Martinelli & Filoso, 2008).

With reference to the problems of legal reserves and permanent protection areas, these relate to the failure history of the cane sector to respect the Forest Code (WWF, 2008). This law establishes the need to maintain in rural properties a percentage of legal reserve with native vegetation equivalent to 20% of the area in most of the country, including Sao Paulo, 35% in the Amazon's Savana and the 80% in the Amazon rainforest. In terms of the riparian vegetation, these need to be preserved on both rivers side, where the minimum is 30m and 500m maximum of the width according to the river size (Brasil, 1965).

Silva et al. (2007) show that only 25% of what should be river's permanent protection areas, in the seven major river basins of Sao Paulo with agriculture areas, has natural vegetation. The remaining 75% is covered with agricultural crops and pasture.

In this sense, is an important to discuss the relocation and compensation mechanisms of legal reserves and plans for restoration of permanent preservation areas on the river's borders (WWF, 2008). But that's not enough, one must create mechanisms to ensure compliance with legislation so that these areas do not continue to be destroyed.

It is also crucial to highlight the issue of landscape change, since the extension of the sugarcane monoculture, which occupies large areas of a single plant species, also affecting the biodiversity of the sites where it is present.

The sugarcane production is widely present in the State of São Paulo, among the 15 Administrative Regions 11 are considered major producers (Coelho et al., 2007). And 74% of the municipalities have produced sugarcane in 2009/2010 (INPE, 2010).

The recent interest in ethanol as an automotive fuel has led to territorial expansion of sugarcane monoculture. This is associated with the expansion of industrial plants and construction of new mills, as a result of the private sector vision about the importance of

biofuels in the Brazilian energy matrix (Camargo et al., 2008). According to analyzes of CANASAT between harvests of 2003/04 and 2009/10 there was an increase of 2.326.444 hectares in the sugarcane area available for harvest in São Paulo, an increase of 90.5% (INPE, 2010).

In Sao Paulo the pressure for new areas of sugarcane cultivation has been occurring primarily on pastures, not affecting significantly the area of food growing in the state as a whole, except for the dry beans and rice.

This situation drives the creation of new regional settings in rural areas, mainly in the Western state (Camargo et al., 2008). Moreover, the expansion of the cane cultivation has an effect on increasing land ownership concentration, since the situation of small and medium-sized leasing properties, which mainly produces basic food. This leads to a destruction of existing improvements, practically making unfeasible for owners return to their land when the lease ends. It has also problem of the purchase of the land from small and medium producer for sugarcane growing, and in this case is the end of the producer permanence in the land, because they will not be able to buy back (Camargo et al., 2008).

## **5. Methodological approach**

This study was molded by the structure presented by Baumgärtner et al. (2008), in which the operationalization of ecological economics proceeds simultaneously on three levels of analysis: (a) concepts, (b) models and (c) case studies.

The central concept is the one of environmental vulnerability proposed by Turner et al. (2003). The authors defined three main components that constitute a framework for vulnerability analysis: exposure, sensibility and resilience. This compartmentation is a pragmatic way to understand the vulnerability, since the exposure is composed of the hazards that holds the potential to affect the system, including the ways in which this experiences perturbations and stressors. The sensitivity to any set of exposures is determined by the system's human–environment conditions, i.e., social and biophysical capital that influences the existing coping mechanisms, which take effect as the impacts of the exposure are experienced, as well as those coping mechanisms adjusted or created because of the experience know as resilience.

Following, a conceptual framework (Figure 1) was developed to analyze in which degree agri-environmental policies are internalizing the environmental vulnerability. Subsequently, the model was tested in a case study of policies related to the spatial planning of sugarcane expansion, focusing on the agri-environmental zoning from the sugarcane sector of São Paulo's state – an important region for national context of sugarcane production.

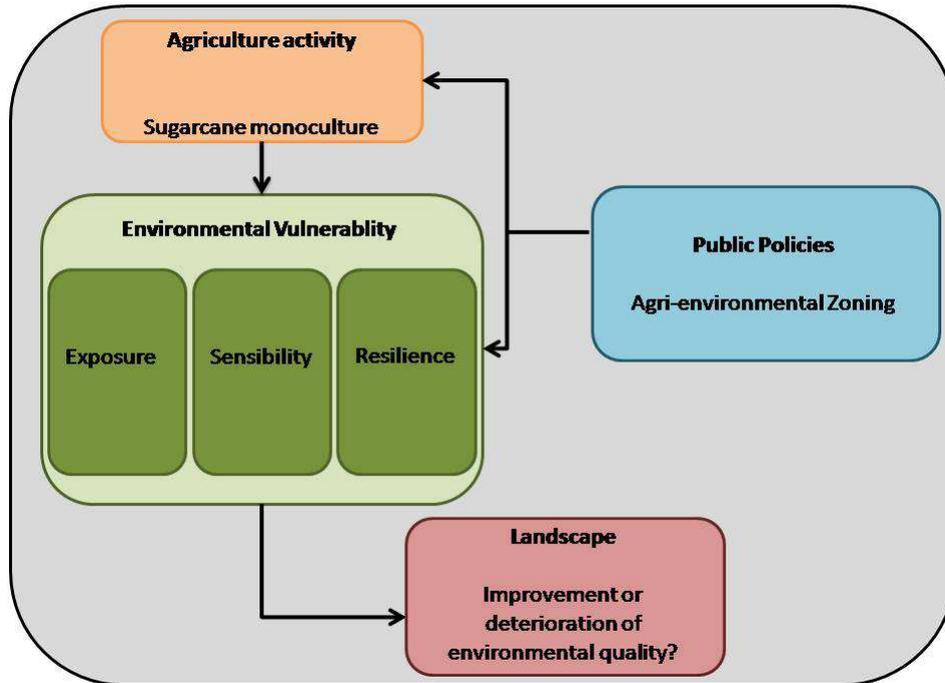


Figure 1 – Conceptual framework of environmental vulnerability assessment in the sugarcane monoculture context.

## 6. Environmental vulnerability in the sugarcane agri-environmental zoning

The agri-environmental zoning of the State of Sao Paulo's sugarcane sector (AEZ) is considered an environmental planning instrument, with the main objective of disciplining the expansion and occupation of this sector. In addition, can support the creation of public policies and contribute to the planning of entrepreneurs (business plans and projects expansion) (Sao Paulo, 2009a).

The justifications for the EAZ creation were three: the expansion of planting area; the large international demand for ethanol, and the need to protect natural resources (wildlife, vegetation, soil, surface and underground water resources) through planning and management areas protected and subsidies for the definition of different actions to be used for areas with environmental sensitivity.

Therefore, the expected consequences are that the sugarcane enterprises, such as mills and plantations, are located mainly in the areas indicated as appropriate, but also in areas with appropriate with limitations and restrictions, provided that the application of appropriate technical measures to minimize impacts identified in the context of the environmental licensing.

This zoning, being agri-environmental, should address in theory the potentialities (agri) and constraints (environmental) in territorial planning of sugarcane cultivation. In this sense, to verify if environmental constraints are being properly treated, there were used the perspective of environmental vulnerability, which brings an approach to the limits of the territory for the activity.

Thus, it was sought to understand if the EAZ is driving the territory towards an increase or a decrease in vulnerability, from checking whether the criteria for sensitivity are internalized in zoning. For analysis, it was used the final AEZ map and thematic maps of each component.

Table 1 presents an analysis on how the EAZ internalize some themes that compose a territory's environmental vulnerability.

**Table 1 – Assessment of the internalization of sensibility’s components from environmental vulnerability in the sugarcane agri-environmental zoning.**

Sensibility components		Consideration	Detailing
Natural resources	Soil Quality	Partially considered	In relation to the soils were considered three parameters of land suitability: Natural Fertility, depth and stoniness. Therefore, it wasn't included issues more related to the condition of soil quality, such as susceptibility to erosion and contamination.
	Air Quality	Satisfactory considered	It was considered from the air quality standards (Decree No. 52.469/07) that considers the following parameters: particulate matter, respirable particles, total suspended particles, smoke and sulfur dioxide.
	Water Quality	Partially considered	In relation to groundwater was considered a vulnerability mapping of aquifers being contaminated. Regarding surface water was considered the classification of basins and waterways with critical situation. But it was not considered the potential of these have their quality affected by the sugarcane expansion.
	Flow of watercourses	Partially considered	It was considered watersheds defined as critical in relation to the amount of water available and granted. However, it wasn't considered the basin's capacity to support the sugarcane expansion.
Landscape	Natural vegetation cover	Partially considered	It wasn't considered the amount of vegetation existing outside protected areas. But they are considered some priority areas for increased connectivity between green areas for the implementation of the Legal Reserve, Private Reserve of Natural Heritage (PRNP) and restoration of ecological corridors.
	Others agriculture activities	Not considered	It was not considered in any way the existence or potential of other crops that compete spatially with sugarcane.
Biodiversity	Legal Reserve	Partially considered	There are considered priority areas for increased in connectivity between green areas, with the implementation of, for example, Legal Reserve.
	Permanent preservation areas	Not considered	There aren't considered the delimitation of permanent preservation areas of watercourses and hilltops.
	Diversity of species	Partially considered	Despite the consideration of areas of importance to the protection of biodiversity, aren't considered specifically the species that are most affected by the sugarcane cultivation.
	Protected areas	Partially considered	There are considered some types of protected areas, but not all.
	Proximity of sugarcane cultivation and	Partially considered	There are defined the surrounding areas of environmental conservation unit, but these is only a limiting factor to sugarcane activity, aren't defined as inadequate.

Most of the components (9 of 11) were partially considered. Two components were not considered in AEZ and only the component "Air Quality" was satisfactory considered.

In terms of the Natural Resources components, the EAZ addressed issues of soil, water and air through specific mappings that were included in the final composition. The subject of soils in relation to agricultural suitability was well treated, was used a study with analyzes of different soil types and characteristics (natural fertility, depth and stoniness) related to the conditions for sugarcane production. However, weren't included issues of soil quality (contamination, compaction and erosion) that are affected by sugarcane cultivation. So it could, for example, address the susceptibility of soils to compaction and erosion.

Regarding water resources, there are many details that have been mapped by agencies and government institutions such as the Geological Institute (IG), Society of Environmental Sanitation Technology (CETESB) and Department of Water and Power (DAEE). Were considered important data on surface and groundwater, but there was no proper linkage between the situation of these resources quality and sugarcane agriculture. The river basin's carrying capacity to receive large areas of sugarcane was missed, whereas this activity has significant water consumption and generates products with a potential contaminant.

In terms of air quality, this component was the only one that was properly addressed, this is probably due to the fact that there are specific standards of air quality laws that are applicable to various human activities, including sugarcane cultivation, facilitating the inclusion of this component.

In the case of landscape components, the amount of existing vegetation was not considered. This it is of great importance in Sao Paulo state, as no longer has large areas of primary vegetation. However, the EAZ has the positive aspect of having considered the work of the project called BIOTA/FAPESP, this defined priority areas for connectivity between vegetation fragments with the creation of ecological corridors.

Also, the EAZ didn't consider in any of the mappings the other existing agricultural activities in Sao Paulo that spatially compete with sugarcane, like maize and orange. It could also have considered the potential of pasture to become more efficient and release areas for the sugarcane expansion.

The biodiversity components were included through the work of BIOTA/FAPESP Project and the delimitation of two protected areas types (fully protected and areas with some environmental protection), including their buffer areas<sup>1</sup> where the sugarcane activity is not considered inappropriate, so it remained unclear what are the restrictions to the activity in

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<sup>1</sup> Range in the vicinity of protected areas, where human activities are subject to specific rules and restrictions, in order to minimize negative impacts on the protected areas.

these areas. Other types of protected areas with sustainable use and the protected areas at the municipal level were not included. This would be of great importance for this type of zoning, so it does not consider these areas as possibilities for the sugarcane expansion.

All these protected areas, buffer zone and priority areas for connectivity are considered to be of importance for biodiversity. This is indeed true because of the relationship between the protection of forest fragments and the protection of existing flora and fauna species. However, the EAZ didn't consider that there is a commitment of biodiversity with the existence of large areas with sugarcane monoculture, since the ecosystem's dynamics is affected by that.

The subject of the legal reserve was considered in the matter of location these areas in the priority areas for connectivity, but failed to treat the low percentage of legal reserve in relation to municipality's rural territory. For example, it could have included data from legal reserve deficits by basin, indicating those in which there is a priority environmental regularization.

And the permanent preservation areas were not addressed in the EAZ mappings, it is important to consider the range of the river's surrounding and hilltops that are protected by law. Similar to the case of the legal reserve, data on the situation of these areas by basin could have been included, showing where there is a priority to recompose them.

In addition to all these analyzes, it is noteworthy that looking to the agriculture suitability map and the EAZ final map, one can see that most of area considered unsuitable for sugarcane expansion are, actually, areas with no edaphoclimatic aptitude. The remaining are the protected areas where farming is prohibited. Therefore, even considering in some way the sensitivity's components of an territory environmental vulnerability, the strongest criteria is the edaphoclimatic aptitude, i.e, the potentialities for sugarcane production is better considered than the territorial vulnerabilities.

Elements that compose the environmental sensitivity can't be neglected in such important public policy, in which seeks the spatial planning of agricultural activities, with has significant impacts in the environment as the sugarcane culture.

The disregard of other agricultural activities and permanent preservation areas can generate significant negative effects with consequences to the ecological system, but also to the economic system, since these two are integrated. The State of Sao Paulo, especially the Midwest and Northwest, can't become the only areas with sugarcane monoculture, there are

other crops that are important to the regional economies revitalization and to the landscape heterogeneity.

The permanent preservation areas have an essential role in the regulation and stability of ecological system due to their capacity of preserve the water resources, landscape, geological stability, biodiversity and gene flow of wildlife fauna and flora, and also protect the soil from degradation and ensure human populations well-being (Brasil, 1965).

These, as well, generates benefits for agricultural activities by the ecosystem services, for example, maintaining the quantity and quality of water from sources and rivers and pest control. Thus, should be considered in the EAZ, mainly to reverse the degradation situation of these areas in Sao Paulo, and prevent further degradation to occur, ensuring the Forest Code respect.

Regarding the legal reserve, the State of Sao Paulo presents a problematic situation in relation to disrespect of the 20% of rural property that must be maintained with native vegetation. The legal reserve is necessary for the sustainable use of natural resources, conservation and rehabilitation of ecological processes, biodiversity conservation and shelter and protection of native flora and fauna (Brasil, 1965).

In addition, other issues related to forest areas and biodiversity could be better treated in the EAZ. The maintenance of the landscape with natural vegetation is essential for the ecological balance and resilience performance in the systems, so that there is a reduction of vulnerabilities. As well as the maintenance of ecosystem services that are important for agricultural activities in general, because they generate benefits such as pest control, nutrient recycling, carbon sequestration, biodiversity conservation, regulation of water flow, soil stability, detoxification of pollutants, break-winds for crops, rainwater shock and maintenance of water quality (Skorupa, 2003).

Other topics that deserved to be covered in the EAZ are the water and soil quality that are affected by sugarcane cultivation, especially at the local level. The environmental sensitivity to receive impacts which significantly change the quality of natural resources, for example in the level basin, was not considered. One possibility would be to do as in the case of air quality and consider the quality standards established by regulations.

These issues demonstrate the weakness of using the EAZ instrument alone, mainly because they ignore several sensitivity's components from territories with sugarcane. But this does not invalidate the EAZ as public policy, since this instrument has a set of mappings with many relevant information that can be used in the construction and implementation of other

policies aimed at the sector in question. Besides, this zoning can assist the performance of other government agencies such as Environment Department and the Agriculture and Supply Department of Sao Paulo.

## **7. Final considerations**

In dealing with environmental issues, and more generally sustainability, it is essential a systemic approach that allows a comprehensive understanding of the effects of human activity on ecosystems. Since the human being is part of the environment and their economic decisions affect the ecosystem, causing negative consequences, even for the very man who depends on various services provided by nature.

This approach is essential to understand the functions and connections between ecological and economic systems, and therefore find ways of solving the problem of man-nature relationship. Thus, need to be incorporated into management and environmental planning, in which environmental problems should be treated as complex, they can't be understood and solved only by the sum of pieces, requiring the understanding of emergent properties between the parties – support provided the systemic approach.

In Brazil, there is still a major bottleneck in the environmental management process, it is the lack of incorporation of systemic perspectives through, for example, comprehensive analysis of landscape that contribute to the incorporation of the environmental dimension in the process of creating and application of policies public, as is the case of environmental policy instruments.

To change this condition, frameworks to assess environmental vulnerability can have important contributions to the systemic approach related to the impacts in the ecological system suffers due to human activities in the economic system.

The conception of a framework that is able to identify the internalization of environmental vulnerability in agri-environmental policies is relevant, primarily because of the extension of impacts of tropical agriculture and its expansion in Savana and Amazon biomes.

Therefore, the framework used in this study showed that the agri-environmental zoning from the sugarcane sector of Sao Paulo doesn't internalize the sensibility components

in a proper way. The issue of vulnerability is treated from the standpoint of the sugarcane sector concerns with the obedience of environmental legislation that establishes minimum standards, but does not guarantee that the environmental sensitivity is respected with the territorial maintenance and expansion of this activity.

The EAZ as a tool for environmental management should go beyond just the internalization of negative externalities of sugarcane activities, providing for society a holistic analysis of the relationship between ecological and economic system that is expressed in landscape changes. To do so, it would require a comprehensive understanding of the potentialities and vulnerabilities of the territory against the sugarcane culture, considering the environment carrying capacity.

Additionally, the EAZ policy should be within a context of reflection on the great sugarcane expansion in São Paulo. Thus, it would be possible to make a suitable planning for the sector, since the expansion can't be unlimited, even in areas indicated as appropriate in the zoning. Since the existence of large areas of monoculture has important consequences on the environmental vulnerability of the territories, affecting ecosystem services essential to society.

In conclusion, the current policy for the Brazilian ethanol and sugar industry (focused on the case of São Paulo) induces a decrease in local resilience, due to the non-consideration of vulnerability factors, on behalf of regional and national economy growth. Therefore the EAZ doesn't induce the Sao Paulo territory towards the reduction of environmental vulnerability, and can't be considered as a means of inducing sustainability, or at least strong sustainability. It can even generate increased vulnerability if there isn't a set of other policies and actions to ensure that the sugarcane expansion in a planned way, with minimization of the range of environmental impacts.

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