STRATEGIC ENVIRONMENTAL ASSESSMENT FOR PLANNING SUGARCANE EXPANSION: A FRAMEWORK PROPOSAL[1]

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1 Introduction

Sugarcane ranks as the second most important source of energy in Brazil, considering ethanol and cogeneration of electricity (EPE, 2014). In addition, the versatile sugarcane Brazilian industry covers a wide range of hydrocarbons, including plastics, other biofuels and non-energy products, such as sugar and inputs for the pharmaceutical industry (SUGARCANE.ORG, 2015). This sector, according to Furtado, Scandiffio and Cortez (2011), is characterized by the dynamism of the sugarcane industry, in which the vast majority of mills has the option to switch between the production of ethanol and sugar in accordance with expansion opportunities provided by these two markets.

The share of biofuels is increasing in the world energy matrix and the prospect is that this trend will continue. According to projections of the Decennial Energy Plan 2020 to meet the demand for ethanol in the next decade, without damaging the sugar production, it is necessary to expand about 4.6 million hectares of sugarcane crops (BRASIL, 2011), amounting to 12.6 million hectares. According to Goldemberg *et al.* (2014), renewable energy policies adopted by 27 countries in 2013 will demand greater involvement of biofuels, predicting a rise in the production of ethanol from corn and sugarcane from 80 to 200 billion liters in 2021.

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Ethanol, which stands as a source to partially offset the consumption of fossil fuels in climate change mitigation by greenhouse gases emission (COELHO; LUCON; GUARDABASSI, 2005; GOLDEMBERG, 2007), is undoubtedly the main product of sugarcane to demand the expansion of this crop in Brazil.

In terms of sugarcane production distribution, in January 2015, 383 ethanol mills were operational in Brazil, 165 only in the state of São Paulo, and 29 more requests for starting operation were under analysis (ANP, 2015). As for the areas predicted to address the expansion (BRASIL, 2011), there are studies that indicate this vector to the South-Central region of the country, which doubled their areas occupied by sugarcane between 2000 and 2008, and North and Northeast region (BRASIL, 2011; GONÇALVES, 2009). Furthermore, the Brazilian foreign policy, allied to private companies, is stimulating the adoption of the national model of ethanol production in other countries in Latin America and Africa (BRIANEZI, 2009), as well as in Cuba (ALONSO-PIPPO *et al.*, 2008).

The debate on the potential impacts that the expansion of the sugarcane ethanol production can cause is subject to much controversy, highlighting the impacts of land use change (SCHARLERMANN; LAURANCE, 2008; ROSILLO-CALLE, 2010; CAMELINI, 2011; GALLARDO; BOND, 2011a; 2011b; DUARTE, 2013), with the consequent interference in socioeconomic and environmental dynamics in regions where sugarcane crops have expanded.

These potential impacts are only partially evaluated in the current energy planning model which provides for the sugarcane expansion (DUARTE, 2013). The zoning effectively applied to sugarcane regulates the suitability of areas for planting sugarcane; however, this instrument would depend on others for a proper assessment of impacts on land use change (CLEMENTE, 2013). The environmental licensing, based on the Environmental Impact Assessment (EIA), addresses the environmental impacts of power plants individually, and does not allow assessing regional and cumulative effects (GALLARDO, BOND, 2011b; DIBO, 2013).

Thus, integrated assessments covering the social and environmental consequences of the expansion of sugarcane on a regional scale are not performed requiring the adoption of another instrument with a more comprehensive and integrated approach to identify more sustainable development alternatives to this decision context.

The Strategic Environmental Assessment (SEA) has been considered an appropriate tool for including environmental and social issues proactively in planning initiatives (THERIVEL, 2004; DALAL-CLAYTON; SADLER, 2005; FISCHER, 2007; PARTIDÁRIO, 2007). This instrument has been discussed by professionals in the Impact Assessment area since the 1990s, currently being adopted in more than 60 countries in order to contribute to the preparation of a wide range of plans and programs, which were not formerly properly evaluated in a comprehensive and integrated way regarding their social and environmental consequences (TETLOW; HANUSCH, 2012). International experience in SEA allows assuming that the instrument application can minimize adverse impacts and maximize the benefits to the environment and society associated with the expansion of the sugarcane industry.

Thus, this paper proposes a Strategic Environmental Assessment roadmap for supporting sugarcane expansion planning as presented in the Decennial Energy Plan. The roadmap was based on the international best practice of SEA so that it can be applied to river basins where a sharp sugarcane expansion is predicted in the coming years. In order to demonstrate their potential viability with regard to data availability for evaluating sustainability indicators, the roadmap is also tested for a basin (Turvo/Grande), in the state of São Paulo, located in the region aimed at expanding sugarcane, according to the forecasts of the Decennial Energy Plan.

2 Strategic Environmental Assessment and its role in planning

A classic definition, from Sadler and Verheem (1996), describes SEA as a systematic process to evaluate and to ensure that the environmental consequences of policies, plans and programs are properly considered at the early stages of decision-making. Partidário (2007) affirms SEA is an instrument of great potential and can be adapted to all planning arrangements in different decision-making contexts.

SEA originates from and has a close relationship with EIA. Both are tools to support decision-making, but while EIA is intended to assess the environmental impacts of projects, SEA refers to planning in earlier decision-making stages of the project, at the level of policies, plans and programs (PPPs). However, EIA has established practice whilst SEA, despite its systematic use in some countries, is not yet fully disseminated. Lobos and Partidário (2014, p. 34) consider that "evidence available suggests that SEA is still largely practised according to a projects' EIA philosophy". Unlike EIA, whose methods and process steps are generally similar in the countries that use it (MORGAN, 2012), SEA includes a wide range of design possibilities, as noted by Fischer (2004), since the planning steps contours are more diffuse and less accurate than the steps of engineering projects. Brown and Therivel (2000, p. 188) argue that "different methods of SEA will be required for different strategic tasks and the different contexts in which the SEA is prepared."

SEA is an instrument that began to spread in the early 1990s. The major international regulatory framework came with the European Directive on SEA (Directive 2001/42/EC), being mandatory for countries in the European Union for sectoral and regional plans and programs, and thus expanding SEA application after its enactment in 2004. Therivel (2004) identified 20 countries that used SEA systematically and formally by 2003, and Dalal-Clayton and Sadler (2005), in 25 countries in 2005. Tetlow and Hanusch (2012), in a poll held in 2011 in the most recent conference on SEA of the International Association for Impact Assessment (IAIA), observed that the instrument is present in over 60 countries with formal or informal application.

In Brazil, the first attempt to institutionalize the SEA was in São Paulo, in 1994, by Resolution SMA 44/94, but without continuity. At the federal level, the Bill of Law nº. 2072/2003 stands out, which would introduce a requirement for SEA for PPPs, whose current situation is archived. Until March 2015, another bill was awaiting the opinion of the Committee on Constitution and Justice and Citizenship, Federal Bill

of Law nº. 261/2011, aiming to amend Law 6938/81 (the National Environmental Policy Act) in order to provide for SEA of PPPs. In São Paulo, there are provisions for applying SEA in different contexts, including Decree nº. 55947/10 which provides for the State Policy on Climate Change, and Decree nº. 6074/10, establishing the State Program on Oil & Gas.

As for application cases, there is a record of some SEA experience in the country: ten cases are described by Teixeira (2008); two SEAs applied to the tourism sector were studied by Lemos (2011); Malvestio and Montaño (2013) identified 35 SEAs in the energy sector; Margato and Sánchez (2014) raised 24 SEAs; Oberling, La Rovere and Silva (2013), studied 21 SEAs; da Silva, Selig and Van Bellen (2014), raised 32 SEAs; and finally Montaño *et al.* (2014), gathered knowledge of about 40 EIAs. Despite these cases, the lack of a Brazilian regulatory framework on SEA and the gap in the defining the implementation and analysis role result in the inexistence of an official repository of SEA reports developed in Brazil.

The study of procedural effectiveness of SEA practice in Brazil driven by Montaño *et al.* (2014) showed that, although more than half of the cases have adopted procedures used in the literature and in international guidelines, the instrument has to be improved in Brazil, even regarding its procedural aspects. Previous research highlighted the lack of consistency in the Brazilian SEA procedures and the need to improve the current system emphasizing the urgency of the discussion of methodologies, approaches and ways for implementing and improving instrument practice (SÁNCHEZ; SILVA-SÁNCHEZ, 2008; PELLIN *et al.*, 2011; MALVESTIO; MONTAÑO, 2013). Sánchez and Croal (2012) considered relevant to promote the expansion of SEA in the jurisdictions in which their contribution has not been fully appreciated, as is the case in Brazil.

Margato and Sánchez (2014), from a critical review of the practice of Brazilian SEA, expose a paradox about the procedures and methods for their effectiveness. Although different methodological approaches can be used in jurisdictions where there is no requirement to perform SEA, the lack of a clear framework for decision-making, which requires a certain standardization of methods, reveals a mismatch between technical aspects and the degree of influence of SEA in decision-making.

When SEA is applied to a specific context, priorities can be determined in order to provide more effective strategies for reaching specific sectoral development objectives with the inclusion of the environmental variable in planning (ANDRÉ, DELISLE; REVERÉT, 2004). McGimpsey and Morgan (2013) discuss the application of SEA in a non-mandatory context and recommend the development of a conceptual model that can be incorporated into existing guidelines and regulation framework.

For the Brazilian case, therefore, the present situation of lack of mandatory SEA allows shaping a process that meets the specific needs of existing plans. In the case of energy planning, SEA could subsidize the proposed expansion to the different sources of energy, and in the case of ethanol, the sugarcane expansion, besides contributing to the alignment of sectoral policies.

3 Instruments for planning sugarcane expansion

The Brazilian planning for sugarcane expansion relates mainly to two initiatives: the energy plans, which also consider non-energy uses of sugarcane to outline future scenarios, and sugarcane zonings, that guide the environmental licensing of plants in the São Paulo case.

The sugarcane expansion in Brazil derives largely from investments of the private sector, occasionally with government incentives. In the current configuration, long-term projections of the sector are presented in the National Energy Plan and the medium and short term in Decennial Energy Plans (PDE), in order to provide to the market with a reference for the sector expansion, allowing minimizing uncertainties in the preparation of strategic planning by the agents (BRASIL, 2011).

The PDE 2020 presents trends in the supply of ethanol that would represent a significant expansion of the sector, favoring ethanol over other liquid fuels, estimated as necessary for increasing the sugarcane crop area from 8 million to 12.6 million hectares in the country (BRASIL, 2011). However, according to Duarte (2013), the PDE 2020 forecast is closer to a study of potential than a plan that sets goals to be achieved by the government and by the private sector.

The projected expansion of the sector would imply effects of land use change and consequent interference in socioeconomic and environmental dynamics of regions that will receive the new sugarcane plantations. In Brazil, as in many other countries, there is no specific planning with set goals for the growth of one or other crop. The land use regulation is mainly by zoning, which present rules prescribing how the various territorial sub-units (zones) should or should not be used (OLIVEIRA, 2004). There are also indicative zoning, as opposed to normative zoning, which are only suggestive of the potential use and occupation in their subregions.

In the sugarcane industry, two zonings guide the expansion of this crop. The Agro-Environmental Zoning, covering the state of São Paulo, was developed in 2007 in a partnership between the Department of Environment (SMA), the Department of Agriculture and Supply (SAA) and the Sugarcane Industry Union (UNICA). This zoning defines four categories of areas to set up new plants or existing expansions based on criteria related to climate, air quality, relief, soil, availability and quality of water, protected areas and fragments for maintaining connectivity. Subsidized by this zoning, State Resolution SMA nº 88/08 sets standards for environmental licensing of plants in each of these four categories (SÃO PAULO, 2009).

The Agro-Ecological Zoning, nationwide, was developed by the Brazilian Agricultural Research Corporation (EMBRAPA) meeting the request by the Ministry of Agriculture, Livestock and Supply (MAPA) (MANZATTO *et al.*, 2009). Published in Federal Decree nº. 6.961/2009, it was used to define the provision of funding to the sector by means of Resolution nº. 3.813/09 of the National Monetary Council. Unlike the São Paulo case, the guidelines of the federal zoning were not included in environmental licensing, despite the efforts made in this direction as the Federal Bill of Law nº. 6.077/2009.

Zonings are a fundamental part in the planning of land use change brought by the expansion of sugarcane. However, the complex dynamics of social and environmental variables resulting from land use change is not adequately captured only with the use of this instrument, requiring another more suitable one to be integrated into this decision-making context.

Gallardo and Bond (2011a) demonstrated that the EIA applied to projects in the São Paulo sugarcane industry, even supported by Agro-Environmental Zoning, proves to be insufficient to identify the cumulative impacts of sugarcane expansion. Oberling (2008) and Clement2 (2013) propose the use of the SEA, respectively, applied to energy planning for expanding ethanol in Brazil and the Green Ethanol Project in the state of São Paulo.

4 Method

The research applied is characterized as exploratory qualitative with methodological design based on the literature review, document study and focus group. For constructing a roadmap, the research was largely based on literature review, discussion and interpretation about (i) the themes addressed in sugarcane expansion planning; and (ii) the good practice and SEA procedures that could be adopted for the Brazilian case.

The documental study aimed to identify the main guidelines about the expansion of sugarcane, contained in the energy planning documents of the country. To this end, PDE 2020 (in force at the time of the research development)was selected as the main document analysis. This choice is justified due to PDE 2020 showing expansion projection, considering the non-energy uses of sugarcane, including demand projections for other products, in addition to ethanol.

The technical focus group, according to Martins and Theóphilo (2009), is a dynamic for the purpose of discussing a specific topic from a predefined script. The moderator can record the opinions synthesizing discussions with richness and flexibility that extrapolates the results from individual interviews. This strategy was employed with researchers and professionals affiliated to universities, research institutes and environmental agencies, who participated in two thematic workshops in São Paulo city, to support the confirmation of the main issues related to the environmental impacts of the sugarcane expansion and the definition of strategic objectives and critical decision factors in the context of SEA. The first workshop was held in 2011, during the III Interdisciplinary Workshop for Research on Sustainability Indicators, attended by about 20 professionals from different institutions; and the second workshop, held in 2012 at the Institute for Technological Research, counted on the presence of about 10 researchers from different backgrounds belonging to this institution.

Considering the diversity of approaches to the SEA application and the non-specialists difficulty in understanding, mainly politicians and others directly related to decision making (VERHEEM; TONK, 2000), the preparation of the roadmap was based on the most tested model or the most discussed for promoting environmental governance in the planning, the European SEA Directive (Directive 2001/42 / EC) (PARTIDÁRIO; SHEATE, 2013; PISCHKE; CASHMORE, 2006), subsidized by detailing established by

Partidário (2007, 2012) and Therivel (2004). These proposals offer differences for designing some steps, so that those references, jointly or separately, guided the preparation of the steps established in the roadmap for the case study. It is worth noting that the three main blocks established in the roadmap following the proposal supported by Partidário (2012) (SEA Context and Strategic Focus; Analysis and Evaluation; and Follow-up). It is notable, however, that other proposals found in the literature correspond to the same logical sequence of technical activities, as in McGimpsey and Morgan (2013), whose denominations are employed: Scoping for the SEA Context and Strategic Focus; Implementation for Analysis and Evaluation; and Monitoring for Follow-up.

In addition, discussions about the impact assessment of renewable energy were also considered, in particular the recommendations proposed by Mulvihill, Winfield and Etcheverry (2013), Oldreive (2013) and White and Noble (2013). Public participation, recognized as one of the fundamental procedures for the success of the SEA (FITZPATRICK; SINCLAIR, 2003; COSTA; BURSZTYN; NASCIMENTO, 2009; REGA; BALDIZZONE, 2015), is included in this roadpmap.

SEA is usually applied as a process that occurs in parallel or at the end of a planning process, wherein the first situation is more desirable (THERIVEL, 2004; PARTIDÁRIO, 2007). The proposed roadmap would be applied as a parallel SEA process to a planning which would enable sugarcane expansion, making the interconnnection of relevant topics related to the sustainability of its expansion strategically in both processes**.**

Thus, we intend to demonstrate that the planned expansion for the sugarcane sector, as in the case of PDE 2020, may occur in line with the principles of sustainability, by using SEA. Moreover, it is emphasized that this roadmap, with adjustments, could be applied to other sugarcane expansion plans and its by-products.

The proposition of SEA includes analysis of the PDE 2020 projections per river basin, as shown in step 4. This choice is justified since this approach provides an appropriate scale for understanding the regional context of the sector expansion. Also, the planning and management of water resources in Brazil presents a strong environmental governance framework (PORTO; TUCCI, 2009) and there is periodic publication of consolidated data.

The elaboration of the roadmap was guided by the adoption of the criteria proposed by IAIA (2002), which ensure compliance with the SEA good practices highlighted in the international literature, which are presented and discussed in Table 1.

Table 1 – Performance criteria of IAIA (2002) discussed for the proposed SEA roadmap

Performance criteria	Comments on the proposed SEA roadmap
Integrated	The roadmap covers sustainability issues related to the sugarcane expansion for defining and for performing a comprehensive analysis of the critical decision factors that were discussed in thematic workshops with experts for integrating themes.
Sustainability-led	The roadmap provides the consideration of various development alternatives related to the projections of scenarios of the sugarcane sector expansion and monitoring by using sustainability indicators.
Focused	The roadmap enables the definition of strategic objectives which are directed to the main relevant issues regarding the sustainable expansion of sugarcane, which in turn can be integrated into the analysis of the proposed sustainability indicators.
Accountable	The roadmap as proposed can be carried out in a transparent and participatory manner, allowing detailed consultation by the public about the decisions taken and their justifications.
Participative	The roadmap is proposed to accommodate broad public participation in several stages, as well as that of the specialized technical and scientific community.
Iterative	The roadmap is presented to only one of the planning cycles, wherein in the next cycles review and suggestions for modifications and adjustments may occur, based on continuous improvement.

Source: Prepared by the authors.

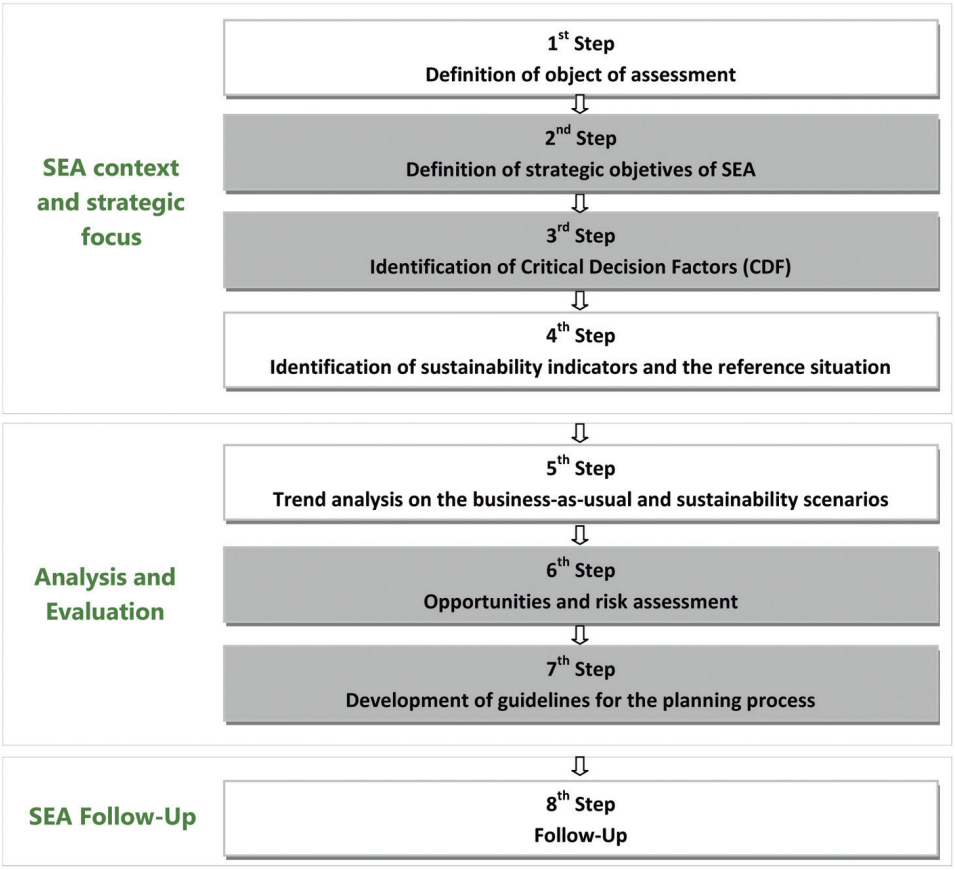
5 Sugarcane expansion: roadmap subsidized by the Strategic Environmental Assessment

The roadmap presented herein, as shown in Figure 1, seeks to outline a minimum conceptual framework of each step involved for its use. The preparation of these steps was based on a sequence of technical activities established for developing Strategic Environmental Assessment studies, taking as a reference the proposals supported by Partidário (2007, 2012) and Therivel (2004), and operationalized to the context of sugarcane expansion, in search of regional particularities and systematic perspective of the social-environmental impacts associated with the sector.

In order to demonstrate the roadmap application feasibility, the sustainability indicators are evaluated for availability of data in existing documents in the country, especially the data on watershed plans.

The roadmap proposal includes opportunities for public participation throughout the planning cycle, indicating the steps at which it is important to have meetings or public consultations relying on authorities, environmental consultants, organizations and the general public, for appropriate consideration and adoption of multiple perspectives by different stakeholders before the decision making (THERIVEL, 2004; PARTIDÁRIO, 2012). Thus, the inclusion of participatory processes for the PDE through SEA must ensure that the stakeholders' views influence this process during (i) the definition of strategic objectives; (ii) the identification of Critical Decision Factors; (iii) the assessment of opportunities and risks; and (iv) the development of guidelines for the planning.

Figure 1 – SEA roadmap for the sugarcane expansion planning



Source: Prepared by the authors.

5.1 SEA Context and Strategic Focus

The purpose of this stage is to ensure that the SEA will focus only on what is important, from an analysis of the natural, social, cultural, political and economic context of the object under evaluation (PARTIDÁRIO, 2012).

This stage comprises four steps that correspond to understanding the context and scope of the environmental planning in focus and the establishment of the key elements of analysis for the baseline construction, in other words, what is expected from a scoping phase (THERIVEL, 2004).

1st Step: Definition of object of assessment

The object of assessment consists in the plan or in development strategies to which the SEA will direct their contributions. Thus, what we intend to discuss and develop is

not the design of the planning for the sector, but the inclusion of environmental, social and economic variables, based on the principles of sustainability in existing planning.

Thus, in the case of sugarcane expansion planning, the object of SEA is the PDE 2020, which addresses the sugarcane crop expansion in the country, with the main contributions aimed at evaluating the consequences of different scenarios from a strategic dimension to the region where it is expected to expand, in order to identify the best in the light of the sector sustainability discussions.

2nd Step: Definition of SEA strategic objectives

The strategic objectives should translate or represent the aspirations and inherent needs in a planning process, in order to highlight agendas and competing interests entailing balance and possibility of integration in the analysis. It must thus address the relevant issues to the planning context. In Therivel's approach (2004), some topics should be selected for a brief baseline that can help to identify problems, and hence SEA can define objectives able to also influence the planning objectives.

In the case of PDE, as it is a heterogeneous area in terms of existing social and environmental problems, the proposal is that the analysis are developed for the spatial area of watersheds in which the sugarcane expansion is expected, interacting with the River Basin Plans for each region.

The definition of objectives should take into account existing plans and interaction with stakeholders related to the implementation of these plans. Some strategic objectives that could be adopted are:

a) Promotion of sustainable territorial expansion.

b) Promotion of sustainable management of natural resources.

c) Positive energy balance and reduction of greenhouse gases.

d) Maintenance of small and medium farmers in the local/regional economy.

e) Guaranteeing social rights of industrial workers in the agricultural and industrial phases.

f) Good governance and inter-relationship with the sector planning with control instruments.

g) Valuation of local socio-environmental benefits.

h) Mitigation of indirect, cumulative and synergistic environmental impacts associated with the production chain and the supply chain of ethanol from sugarcane.

i) Acomplishment of renewable energy production targets set out in national energy planning.

These strategic objectives were discussed in the focus group workshops from the subsidies of the sustainability criteria established by Gibson *et al.* (2005). In designing these objectives, there was an attempt to overcome some of the limitations identified in Gallardo and Bond (2011a; 2011b) as the current model of the decision making of sugarcane expansion.

3rd Step: Identification of Critical Decision Factors (CDF)

The broad literature on the environmental, social and economic impacts of sugarcane ethanol contributed to the initial technical support for synthesizing these impacts on CDF during the workshops. The definition of CDF aims to simplify the categories of analysis in integrative themes, aligning them to what is proposed by Partidário (2007; 2012).

The Critical Decision Factors (CDF), proposed by Partidário (2007; 2012), summarize the main themes proposed in an approach that integrates these themes, with the same weight for all the variables aimed at sustainability, which should guide the implementation of the SEA. The CDF will structure the technical studies and, consequently, assessing opportunities and risks to gather the necessary information for the decision making. These CDF must be the object of public participation and, at least, of consultation with the authorities with environmental responsibilities set out in the legislation.

As an illustration, Table 2 presents a selection of CDF made from extensive literature review (GALLARDO, BOND, 2011a; DUARTE, 2013; DIBO, 2013) and corroborated by the focus group. The complementation of this list should occur from the results of the public participation stage, essential to ensure the pluralism aspects of sustainability (FITZPATRICK; SINCLAIR, 2003; REGA; BALDIZZONE, 2015), as well as from important issues related to the particularities of the river basins where there sugarcane expansion will occur.

Table 2 – Description of the Critical Decision Factors for planning the sugarcane expansion

CDF	Description
Land use change and food security	Corresponds to understanding the current land use change process, aiming to capture the relationship between the sugarcane plantations expansion, with the remaining areas of agricultural, pastoral and ecological protection. The objective is to identify whether and how the trends of planned sugarcane expansion are occurring. The food security issue is also a theme present in this context.
Land ownership and control instruments	Considers the assessment of issues related to land ownership and the legal relationship of the sugarcane-producing areas . The relevant aspects are inserted to demonstrate the suitability of areas for sugarcane expansion, by specific devices such as the Agro-Environmental and Agro-Ecological Zoning and other planning instruments related to River Basins Plans, Management Plans and Master Plans that interfere with the sugarcane expansion.
Ecosystem services	As regards natural resources, from the perspective of ecosystem services, which should be used based on the assumptions of sustainable development. For natural resources affected by the SEA object, surface and underground water resources, biodiversity and soil resources are considered. Waste and inputs compose this balance in order to reduce the consumption of natural resources.
Local community well-being	Aims to understand how the sugarcane expansion may affect the socioeconomic and environmental dynamics of the area under review. Considers the implications of generating employment, remuneration and income distribution, in addition to issues related to the working conditions of employees in the sugarcane industry, particularly of the crop, cases of slave labor, among others. Infrastructure and access to sanitation, as well as working conditions issues are also considered.
Air quality and greenhouse gases	Considers aspects relative to air quality and respiratory health, especially related to the implications of sugarcane burning in practice. Issues such as energy efficiency by cogeneration and reducing greenhouse gas emissions underlie the aspects highlighted here.

Source: Prepared by the authors.

4th Step: Identification of sustainability indicators and the reference situation

This step firstly assumes the identification of qualitative or quantitative indicators, representative for the CDF and that meet the strategic objectives set by the SEA. The indicators are intended to provide information to help to assess potential impacts (direct, cumulative, synergistic and indirect) of the sector expansion.

The importance of this step in SEA is also weighted by Silva, Selig and Morales *et al.* (2012) which emphasize that deviations in the choice and use of sustainability indicators can lead to wrong or insufficient conclusions, with the possibility of damaging the effectiveness of the evaluation system.

According to Dibo (2013), there are weaknesses in the consideration of cumulative impacts in the individual expansion of sugarcane mills. The analysis of cumulative impacts at the strategic level through SEA provides proactive planning allowing to effectively assist the decision making process of a strategic action (COOPER; SHEATE, 2004; THERIVEL; ROSS, 2007).

Table 3 presents a basket of 44 sustainability indicators that can be adopted to measure CDF in the established context. There is also information about the availability of data for the composition of each indicator, which was seen as an illustration for one of the basins in which the sugarcane expansion is intended in the PDE 2020 - Basin Turvo/Grande (SP) to data presented in the Basin Plan Report Turvo/Grande (CBH-TG, 2013). It is understood that the data on this river basin, which is the fourth largest São Paulo basin covering an area of 15,975 km^2 and 64 cities, inserted in São Paulo - the largest sugarcane producer in Brazil - can illustrate how feasible data acquiring is for conducting a SEA guided by the established roadmap. Observe that in the same table, 31 (70%) of the 44 proposed sustainability indicators have data readily available in existing documents.

Table 3 – Sustainability indicators for CDF evaluation and availability of data on existing information systems for the Turvo/Grande (SP) watershed

CDF	Sustainability indicators (Greatness/Parameter and unit of measurement)	Data availability
Land use change and food security	1. Relation between crop area and total area - %	X
	2. Relation between sugarcane crop area and total area - %	X
	3. Relation between area with vegetation and total area - %	X
	4. Relation between silviculture area and total area - %	X
	5. Relation between cattle area and total area - %	X
	6. Relation between urbanized area and total area - %	X
	7. Areas occupied by permanent and temporary crops (per crop types) - ha	X
	8. Amount of production of permanent and temporary crops (per crop types) - t	X
	9. Number of head of cattle per pasture area - nº/ha	X

Land ownership and control instruments	10. Relation between areas considered with high and medium ability for sugarcane cropping in the agroenvironmental zoning and total area - %	–
	11. Relation between the area considered available for cropping sugarcane and total area - %	–
	12. Relation between the whole area and area cropped by sugarcane - %	–
	13. Number of properties registered in the same location of another property - nº	–
Ecosystem services	14. Number of monitored points with Trophic State Index, classified as mesotrophic, oligotrophic and ultraoligotrophic, regarding the total number of monitored points - %	X
	15. Number of monitored points with the Water Quality Index classified as Good and Optimum regarding the total number of points monitored - %	X
	16. Number of monitored wells whose water is classified as potable water relative to the total number of wells monitored - %	X
	17. Total volume of granted water - m^3/year	X
	18. Relation between the volume of granted water for irrigation and the total volume of granted water - %	X
	19. Conflicts due to the extraction or use of surface water and groundwater, per type - nº	–
	20. Annual amount of soil loss by erosion - t/ha.year	X
	21. Annual amount of agrochemicals used - kg/ha.year	–
	22. Amount of agribusiness waste (vinasse and filter cake) used - kg/ha.year	–
	23. Relation between the area occupied by forest fragments and total area - %	X
	24. Relation between the area occupied by the Conservation Units of integral protection and total area - %	X
	25. Relation between the area occupied by the Conservation Units of sustainable use and total area - %	X
	26. Relation between Permanent Preservation Areas with vegetation cover and total Permanent Preservation Areas - %	X
	27. Relation between the endorsed Legal Reserve Area and total area - %	–
	28. Number of penalties for violations of environmental regulations relating to flora and fauna - nº	–

Local community and well-being	29. Geometric rate of annual growth - % a.a.	X
	30. Urbanization rate - %	X
	31. Number of formal employment relationships of men and women, according to educational level (agriculture, livestock, industry, civil construction, trade and services in total) - nº	X
	32. Relation between the number of jobs in agricultural activity and total employment - %	X
	33. Relation between the average wage paid to employees in the sugarcane crop and the minimum wage - %	–
	34. Annual number of people in slave labor - nº	X
	35. Relation between the number of households connected to the sewage system and total households - %	X
	36. Volume of treated sewage in relation to the total sewage collected - %	X
	37. Relation between the number of households provided with solid waste collection and total households - %	X
	38. Quality index of number of the landfills - nº	X
	39. Annual number of records of accidents associated with sugarcane farming - nº	–
	40. Annual number of records of deaths resulting from work associated with sugarcane farming - nº	–
Air quality and greenhouse gases	41. Rate of hospitalization for acute respiratory infection in children under 5 years of age - nº/1.000 hab.year	X
	42. Relation between the number of days and total days in the year, in which the air quality standard exceeds the parameters: total suspended particulates, inhalable particulate matter (PM 10) and Nitrogen Dioxide - %	X
	43. Number of days per year in which sugarcane burning occured - %	–
	44. Relation between the number of establishments which comply with the goals of phasing out sugarcane burning and total establishments which still operate with sugarcane burning - %	X

Legend: **(X)** available data; **(-)** no data available.
Source: Prepared by the authors.

From the identification of indicators, it is possible to analyze the current situation of river basins, thus creating a reference scenario for a trend analysis to be performed in the next step.

The identification of the reference situation is focused on pre-selected issues, directed at defined goals (Therivel, 2004).

A description of the dynamics of the basin focusing on issues selected as CDF is the product of this step. This product can also be presented as a watershed map which defines the potential area to conciliate sugarcane agricultural expansion and possible conflicts with other land uses.

5.2 Analysis and Evaluation

This phase aims at promoting strategic paths to achieving sustainability and proposing guidelines to support this framework (PARTIDÁRIO, 2012). This phase is divided into five steps.

5th Step: Trend analysis of the business-as-usual and sustainability scenarios

The Decennial Energy Plans (DEP) present only a single expansion scenario in its final report. This scenario, named business-as-usual scenario, is developed from a series of mathematical models based on macroeconomic projections.

Ideally, this 5th step of the SEA framework should be performed at the same time as the business-as-usual scenario of the DPE is developed in order to include the options being evaluated in the context of energy planning. Thus, the SEA results are more capable to influence decision-making, highlighting aspects that can assist to integrate social and environmental issues within planning (PARTIDÁRIO, 2012; THERIVEL, 2004).

Always focusing on CDF, SEA assesses the business-as-usual scenario of DEP and at least proposes one new scenario – the sustainability scenario. This sustainability scenario is capable of overcoming potential problems identified in the business-as-usual scenario. By the end of this step, SEA will provide at least two scenarios gathering evidence on trends of each CDF. Table 4 illustrates a possible result of this step.

Table 4 – Critical Decision Factor evaluation under the business-as-usual scenario and sustainability scenario

CDF	Scenarios
Land use change and food security	*Business-as-usual scenario:* food production levels are significantly reduced in the watershed, with the replacement of mainly maize crops, are the most affected by this replacement.
	Sustainability scenario: areas of underutilized pasture would be sufficient to meet the land demand for cropping sugarcane in a moderate sugarcane expansion. Eventual replacement of crops would have no significant impact on food production levels in the watershed.
Land ownership and control instruments	*Business-as-usual scenario:* the expansion of sugarcane would be directed to areas defined by the integrated analysis of the current land use map and the Agro-Ecological Zoning sugarcane map .
	Sustainability scenario: for identifying suitable areas for accommodating sugarcane expansion, an integrated analysis of current land use, the Agro-ecological sugarcane zoning, Watershed plans, Management Plans and Municipal Master Plans and the contents of applicable control instruments is undertaken.
Ecossystem Services	*Business-as-usual scenario:* replacing food production areas can reduce the supply of cultural and regulation ecosystem services and cultural adjustment.
	Sustainability scenario: sugarcane crops preferably replace underutilized pasture areas while still respecting ecological corridors helping to increase ecosystem services supply.

Welfare of the local community	*Business-as-usual scenario:* sugarcane expansion will not necessarily be coupled to socioeconomic improvements in the municipalities and workers affected.
	Sustainability scenario: sugarcane expansion should reflect an improvement in the employees´ working conditions and also in the socioeconomic conditions of the municipalities affected.
Air quality and greenhouse gases	*Business-as-usual scenario:* the increase in the areas of sugarcane expansion for supplying biofuels targets contributes to the partial substitution of fossil fuels and consequently reduces the emission of greenhouse gases and improves air quality in general.
	Sustainability scenario: a moderate expansion in sugarcane crops tends to encourage the development of alternative sources of energy and consequently to reduce the emission of greenhouse gases within the limits imposed by the other CFDs. Good practice in sugarcane handling and harvest should be used for keeping good health and safety conditions at work and air quality.

6th Step: Opportunities and risk assessment

According to Partidário (2012), SEA can help find better directions or paths to assess the opportunities and risks of each scenario. This author suggests that a SWOT analysis for each CDF must be performed in order to highlight strengths, weaknesses, opportunities and threats to scenarios.

This analysis also makes possible to prioritize a set of impacts not commonly addressed in individual projects analysis, such as cumulative and synergistic impacts. This analysis will help to build the integrated assessment of how each CDF may behave in the expansion of trends within each scenario.

Showing the extent of scenarios that achieve the strategic goals of SEA defined in Step 2 is also a task of this step.

7th Step: Development of guidelines for the planning process

Guidelines should be developed to be incorporated within energy planning for managing opportunities and threats.

According to Partidário (2012), the guidelines should include a set of actions to deal with the CDF within the plan. The guidelines may include recommendations on new regulations and institutional changes and measures to be incorporated into the Environmental Impact Assessment process when planned new plant projects are undertaken. The guidelines should also indicate the contents for monitoring the plan.

For preventively planning, the guidelines should particularly cover the CDF that shows trends of reduction in the quality of scenarios, enabling the effective integration of sustainability into planning process.

5.3 SEA Follow-up

After the planning process is concluded, guidance is introduced in this stage for following-up the SEA process (MORRISON-SAUNDERS, ARTS, 2004).

8th Step: SEA follow-up

According to Gachechiladze-Bozhesku and Fischer (2012, p. 22), "if the SEA is directed to facilitate strategic changes, the instrument needs to focus on ways in which strategic alternatives are implemented, not only formulated". The main objective of SEA follow-up is to effectively complete the proposed planning, correcting any deviations. Moreover, this step allows evaluating the effectiveness of the roadmap proposed and providing feedback for other similar planning processes.

SEA follow-up is a crucial step for ensuring the implementation of the guidelines established for the planning. The features for accomplishing SEA follow-up are similar to EIA follow-up by employing management and monitoring tools (CHERP; PARTIDÁRIO; ARTS, 2011). These tools must focus on proposed sustainability indicators for obtaining sustainability aspects in planning and also ensuring adequate governance to the SEA process. Nilsson *et al.* (2009) advised understanding the integration of organizations and knowledge and requirements and issues for planners in this step of SEA.

6. Final Considerations and Recommendations

The Strategic Environmental Assessment framework was presented embracing the main international best practices and for demonstrating its applicability from watershed analysis. The existence of the vast majority of data for analysis of the sustainability indicators reinforces its application to the projected expansion of sugarcane crops predicted in the Decennial Energy Plan 2020 (DEP 2020).

The SEA framework is able to interact with current projections of the business-as-usual scenario for the expansion of sugarcane allowing its immediate application. At the same time, the framework was built to encompass the analysis of planning aimed at sustainability.

Thus, comparing the framework to the current planning adopted by the DEP, it results are: sustainability in strategic approach to decision-making sugarcane expansion; provided strategic focus and sustainability within decision making by integrating environmental, social and economic issues; sustainability indicators to evaluate impacts of planning; data availability for fostering sustainability indicators in planning; and a comparison between business-as-usual scenario and sustainability scenario.

This framework also contributes to establishing basic steps of SEA beyond the minimum technical reference, which can be inserted in planning the sugarcane expansion driven by DEP in order to integrate strategically relevant issues of sustainability. This proposal also identifies and assesses the feasibility of using a preliminary list of sustainability indicators for watershed.

Although the instruments currently used in planning for the sugarcane expansion such as zoning and environmental impact assessment are relevant, they do not provide the integrated analysis reached by using the SEA framework. We recommend the use of SEA as an addition and prior to these instruments of public environmental governance, providing advances in a comprehensive and integrated vision for planning sugarcane expansion.

The effectiveness of the SEA framework has been achieved by other applications supported by broad society participation during the SEA process since the definition of strategic objectives, which imply outlining priorities for medium and long terms from different visions of a desirable future.

Future researches for improving the SEA framework should be directed to better discussing its aspects: defining the critical decision factors from broad participatory processes; obtaining data for sustainability indicators not rated or their replacement; proposing methods and techniques that support detailing a sustainability scenario covering social, environmental and economic demands in the planning of sugarcane expansion.

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STRATEGIC ENVIRONMENTAL ASSESSMENT FOR PLANNING SUGARCANE EXPANSION: A FRAMEWORK PROPOSAL

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***Abstract*:** The Brazilian sugarcane industry has experienced a rapid expansion during the 2000s. The prediction of the sugarcane crop expansion in the coming decades raises controversy about social and environmental impacts, which are partially evaluated in the current energy planning. In order to integrate these discussions to the decision-making, this article aims at presenting a Strategic Environmental Assessment framework to support the sugarcane expansion planning as presented in the national Decennial Energy Plan. The main positive aspects of this framework include: the integration of environmental, social and economic issues providing strategic focus and sustainability to the decision-making; the proposition of sustainability indicators whose data are available for watershed scale; and guidelines for analyzing alternative scenarios established in the energy planning. The authors believe this framework allows integrating sustainability into the decision-making of the sugarcane expansion planning supported by the Strategic Environmental Assessment.

***Keywords*:** Strategic Environmental Assessment; sugarcane; sugarcane ethanol; sustainability; energy planning.

***Resumo*:** A indústria brasileira da cana-de-açúcar vem se ampliando desde os anos 2000. A continuidade da expansão desse cultivo agrícola nas próximas décadas suscita controvérsias acerca dos impactos sociais e ambientais associados, os quais são parcialmente avaliados no planejamento de energia. Visando integrar essas discussões à tomada de decisão, esse artigo objetiva apresentar um roteiro de Avaliação Ambiental Estratégica para subsidiar o planejamento da expansão da cana-de-açúcar apresentado no Plano Decenal de Expansão de Energia. Os principais aspectos positivos desse roteiro incluem: integração dos temas ambientais, sociais e econômicos proporcionando foco estratégico e de sustentabilidade à tomada de decisão; proposição de indicadores de sustentabilidade com disponibilidade de dados para o recorte de bacias hidrográficas; e orientações para avaliação de cenários alternativos ao estabelecido no planejamento energético. Considera-se que esse roteiro possibilita integrar a sustentabilidade na tomada de decisão do planejamento da expansão de cana-de-açúcar suportada pela Avaliação Ambiental Estratégica.

Palavras-chave: Avaliação Ambiental Estratégica; cana-de-açúcar; etanol; sustentabilidade; planejamento energético.

Resumen: La industria brasileña de la caña de azúcar viene se ampliando desde el año 2000. Ha previsiones de que los cultivos de la caña de azúcar seguirán creciendo por las próximas décadas, lo que genera controversias acerca de los impactos sociales y ambientales asociados, los cuales son apenas parcialmente evaluados en el planeamiento de energía. Este artículo tiene como objetivo presentar una guía de Evaluación Ambiental Estratégica para subsidiar el planeamiento de la expansión de la caña de azúcar presentada en el Plano Decenal de la Expansión de Energía Brasileña. Los principales aspectos positivos de esta guía son: integración de los temas ambientales, sociales y económicos ofreciendo orientación estratégica y de sostenibilidad para la toma de decisiones; propuesta de indicadores de sostenibilidad con disponibilidad de datos en las cuencas; y las directrices para la evaluación de escenarios alternativos a los establecidos en el planeamiento de energía. Se considera que este guía permite la integración de la sostenibilidad en la expansión de la caña de azúcar con el apoyo de la Evaluación Ambiental Estratégica.

Palabras clave: Evaluación Ambiental Estratégica; caña de azúcar; etanol de caña de azúcar; sostenibilidad; planificación de energía.