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A method for strategic planning of food and bioenergy chains (CHAINPLAN) applied to the sugarcane chain in Brazil

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Abstract

Global competition and environmental factors make it increasingly necessary in many countries to establish a strategic plan for various national food and bioenergy chains. Neves (2007) developed a simple method (CHAINPLAN) to help in the process of developing a strategic plan for a food chain, which has been applied to chains in various countries. The objective of this paper is to report the results of a new application of (part of) this method: to the sugarcane chain in Brazil. As this chain has an important trade association (UNICA – Brazilian Sugarcane Industry Association) for coordination of collective actions, the paper focuses on two specific steps: the mapping and quantification of the chain; and the elaboration of the strategic plan. The chain mapping and quantification procedure, which is the second step of the method, quantifies an industry's contribution to the country's GDP, as well as to job creation, tax generation, and the distribution of economic activities. In relation to the sugarcane chain in Brazil, it was found that the sugar-energy sector GDP in 2008 was US$ 28.15 billion, equivalent to 2% of the total Brazilian GDP. The estimated total value of sales of the various links that comprise the sugarcane chain reached US$ 86.8 billion. Completion of step 2 of the CHAINPLAN method allows the chain's agents to conduct a macro-environmental and internal analysis of the chain to identify strategic projects (collective actions) to improve the chain's competitiveness. This step was also carried out on the Brazilian sugarcane chain.

Keywords: chain mapping, chain quantification, chain planning and management, sugarcane chain

1. Introduction and research problem

The sugarcane sector is one of the oldest chains of the Brazilian economy. Since the introduction of the first plants (seeds) in 1532, sugar has been one of the most important Brazilian products. Although sugar is still important, the sector has undergone a deep transformation in the last 50 years. Besides sugar, the sugarcane mills and ethanol plants now also focus on ethanol production, and most recently attention has turned to bioelectricity, bioplastics, alcohol chemistry, diesel and carbon credits marketing. All of this is in addition to the possibility of using advanced technologies that increase productivity and reduce costs. This is a new level of business, in which competitiveness is keen.

Progress in the sugarcane chain is not only related to technology. There is a growing commitment to social and environmental issues, like improving the workers' quality of life, promoting rational use of land and water, mitigating the effects of mechanized harvesting, and preserving ecosystems. Although advances in these areas have also been substantial, there is still much work ahead for this industry. Externally, Brazil must convince critics that the increase in Brazilian sugarcane production does not negatively impact forest and food production areas, and it must also demonstrate the regularity of the ethanol supply and the sustainability of production (social, environmental, and economic).

Internally, Brazil must show that using ethanol in vehicles has a number of benefits in addition to financial savings. This would justify further support from the federal government; for example, the level of ethanol in gasoline could be increased from the current 25% to 30%, and the Brazilian Development Bank (BNDES) could provide long-term financing to improve the competitiveness of the sector and increase investments in co-generation of electricity.

To create a global market for sugar and bio-ethanol, the players need to be more demand-driven and they need to develop a strategic plan for the sugarcane chain that will make it more transnational and sustainable. The elaboration of a process for strategic planning and management of food and bioenergy chains could make this task easier.

For this purpose, Neves (2007) developed the CHAINPLAN method for strategic planning and management of food and bioenergy chains, which has been applied to agribusiness systems in Brazil, Uruguay, South Africa and Argentina, among other countries. It consists of five stages: a review of initiatives introduced by the chains' leaders, mapping and quantification of the chain, formation of a vertical organization for contractual coordination, development of

a plan of strategic projects, and implementation of the plan. A recent new application of this method is presented below.

2. Objectives and methodological procedures

This paper aims to contribute to academic (and corporate) efforts to design a planning process for food and bioenergy chains, considering various future possibilities in the formulation of objectives, guidelines and strategies to ensure the sustainable growth of the chains.

The paper's specific objectives are to:

- Present a method for strategic planning and management of food and bioenergy chains (CHAINPLAN).
- Present the results of applying step 2 of this method, i.e. mapping and quantifying the sugarcane chain in Brazil, showing the financial transactions generated in every link of the productive chain, the jobs generated, the taxes paid, and the GDP.
- Present the results of a macro-environment analysis (STEP analysis) and an internal-environment analysis conducted in order to propose a strategic plan for the sugarcane chain in Brazil.

The methodological procedures involved (1) a review of the CHAINPLAN method (Neves, 2007), (2) a literature review related to the sugarcane agribusiness system, and (3) in-depth interviews with experts from the industry, government, and trade associations.

In accordance with the first step of the CHAINPLAN method, we reviewed the contributions made by many Brazilian agribusiness organizations to sugarcane chain and these were helpful in elaborating section 4.2. below. To save space, we have not reproduced many of the different strategic agendas here.

At the same time, it was not necessary to carry out the third step of the CHAINPLAN method, which is to create a vertical organization for coordination of collective actions. This paper is part of broader efforts by the Brazilian Sugarcane Industry Association (UNICA), the largest association in Brazil representing sugar, ethanol, and bioelectricity producers, to increase public knowledge about the sugar and ethanol industry in the country. In particular, the association wants to effectively convey to the public the benefits of producing and using clean energy from renewable and sustainable agricultural systems.

Finally, the fifth step was considered dispensable because implementation of the suggested strategic plan for Brazilian sugarcane chain has not been done in a centralized way. Some strategic projects have been put into practice by different Brazilian agribusiness organizations, while others have not been initiated yet.

3. Theoretical background

This article does not use a network approach, since the unit of analysis is not a network, but rather a food chain. A food chain is considered here to be limited by the boundaries of a particular country. Its actors are input suppliers, farmers, industry, distributors, and service providers. Examples of such country chains are the Dutch flower chain and the Danish pork chain.

Two traditional approaches to studying chains can be found in the literature. The commodity system approach (CSA) was developed by Goldberg (1968) in the USA in studies of citrus, wheat, and soybean production systems. The CSA methodology emphasizes the sequence of product transformations in the system. Goldberg's research had its merit in changing the focus of analysis from the farm to the whole system, which prevented researchers from considering the agricultural sector in isolation from the overall economy.

The second approach, proposed by Morvan (1985), considers a chain ('filière') as linked operations for the transformation of a good. The chains are influenced by technology and have complementary interdependences, according to Batalha (2001). According to Morvan (1985), the filière analysis is an important instrument to describe systems, to define the technology role in the framing of productive systems, to organize integration studies, and to analyze industrial polices, firms, and collective strategies.

Although not used here, there are important additional contributive theories. The supply chain is viewed as a system that integrates raw material suppliers, factories, distribution services, and consumers (Stevens cited in Omta *et al*., 2001). Furthermore, there is the network concept in which organizations are directly involved in different processes that add value in the elaboration of goods and services until the final consumer (Christopher cited in Omta *et al*., 2001). Lazzarini *et al*. (2001) integrate chain and network concepts in a study on net chains. According to these authors, the integration of these approaches allows the consideration of existing organizational interdependences in a network, as well as the different mechanisms of coordination (managerial plans, process standardization, and adjustments), and sources of value (production and operations optimization, transaction cost reduction, diversity, and 'co-specialization' of knowledge).

Hardman *et al*. (2002) demonstrated the possibility of increasing the competitiveness of South African apple chain exportations through cooperation among producers, packers, and exporters. From the ideas of CSA and the filière, it is possible to develop tools and managerial activities to improve the chains' efficiency. Thus, the concepts of Supply Chain Management (SCM) and the set of networks and net chain ideas are important theoretical concepts and empirical

notions for the development of food and bioenergy chains (Batalha and Silva, 2001).

Based on a chain literature review and empirical research, Neves (2007) proposed, as a methodological contribution, a five-step process for implementation of strategic planning and management in food and bioenergy production chains (the CHAINPLAN method). This method can be used by an industry association, an institute, or even government, to produce a strategic plan for a particular country chain. The Dutch Tomato Association, for example, could use it to produce a strategic plan for the whole chain. The method is summarized in Figure 1.

The focus of this paper is on two specific steps: the mapping and quantification of the chain; and the elaboration of the strategic plan.

The mapping and quantification process, step 2 of the CHAINPLAN method, was applied by Rossi and Neves (2004), Neves and Lopes (2005), and Consoli and Neves (2006) in research on the Brazilian wheat, orange, and milk chains, respectively. It was also applied by researchers of the University of Buenos Aires in the soybean chain. This process can be summarized in six stages (see Figure 2).

Table 1 shows the guidelines and procedures for carrying out the various stages of the mapping and quantification process.

This process was applied in the sugarcane chain in Brazil by 10 researchers, who collected secondary and mostly primary data over a 5–month period. This information was consolidated in a one-page description of the food chain, showing all of the participants and the revenues of the different links of the productive chain in a year of analysis. This method can be used not only to produce this type of financial overview, but also a quantification of jobs and taxes generated by the chain on a yearly basis.

Elaboration of the chain´s strategic plan, step 4 of the CHAINPLAN method, was applied in the sugarcane chain in Brazil with a view to the following 5 to 10 years of development. This process can be summarized in twelve stages (see Figure 3).

Table 2 shows the guidelines and procedures for carrying out the various stages of the strategic plan elaboration process.

The application of this process in the Brazilian sugarcane chain demanded a review of literature related to the chain, in-depth interviews with experts from the industry, government, and trade associations, as well as workshops for the chain agents on collective actions that could be taken.

Both processes described above are part of the CHAINPLAN method, but they can be carried out separately if so desired by research leaders and sponsors.

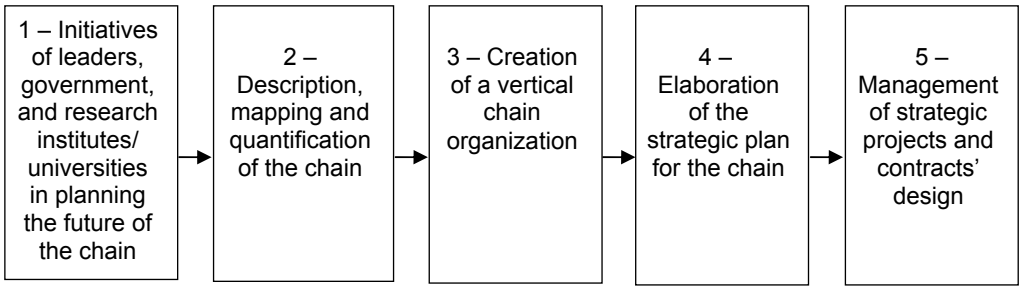

Figure 1. The CHAINPLAN method for strategic planning and management of food and bioenergy chains (Neves, 2007).

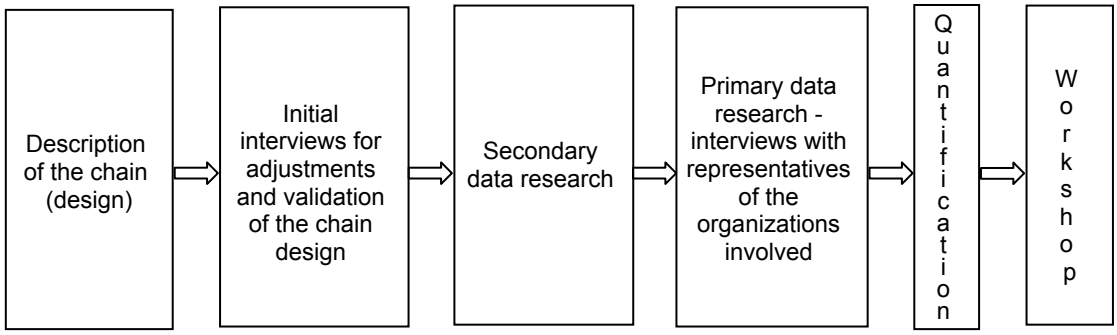

Figure 2. Process for mapping and quantification of the chain (Neves *et al.*, 2004).

Table 1. Guidelines for mapping and quantification of the chain (Neves *et al.*, 2004).

Stages	What has to be done
1. Agribusiness chain description (in focus)	The first stage consists of making a preliminary description of the chain participants, represented in small boxes, based on theory and the researchers' experience. It is also necessary to scope which segments will be studied, keeping the focus on the central axle of the chain.
2. Presentation for private-sector professionals and other experts to make adjustments to the structure	The second stage involves submitting the analysis to chain and industry specialists and interviewing them with the purpose of making possible adjustments in order to arrive at a description that reflects the current reality of the chain. It is very common to forget participants and agents, and this second stage helps to map all possibilities.
3. Research in associations, institutions, and publications for secondary data	The third stage consists of searching for secondary data from sources that have academic and statistical credibility, a good reputation, and demonstrated integrity.
4. Interview with professionals for primary data	After collection of the available secondary data, which in some countries and environments may be very limited, primary data are collected. In this empirical research stage, in-depth interviews are conducted with representatives of several organizations in the chain to obtain information about the sales of a particular segment of the chain, employment statistics, and amount of taxes paid.
5. Quantification and strategic proposals	Quantification involves determining the turnover of each sector in the chain, through the companies' revenues, and estimating several sub-sectors of the chain. To guarantee reliability of the data , some secondary and primary data are compared to find any incongruities In this process, at least two different data sources are used to check the results, and additional interviews are conducted with similar agents as needed.
6. Workshop to verify data	Finally, the data are validated in a workshop. Information is sent to participants prior to the event, and then the numbers are discussed at the workshop. Alternatively, materials are sent to relevant agents of all links in the chain for verification. The research is then presented to the press and other institutional organizations.

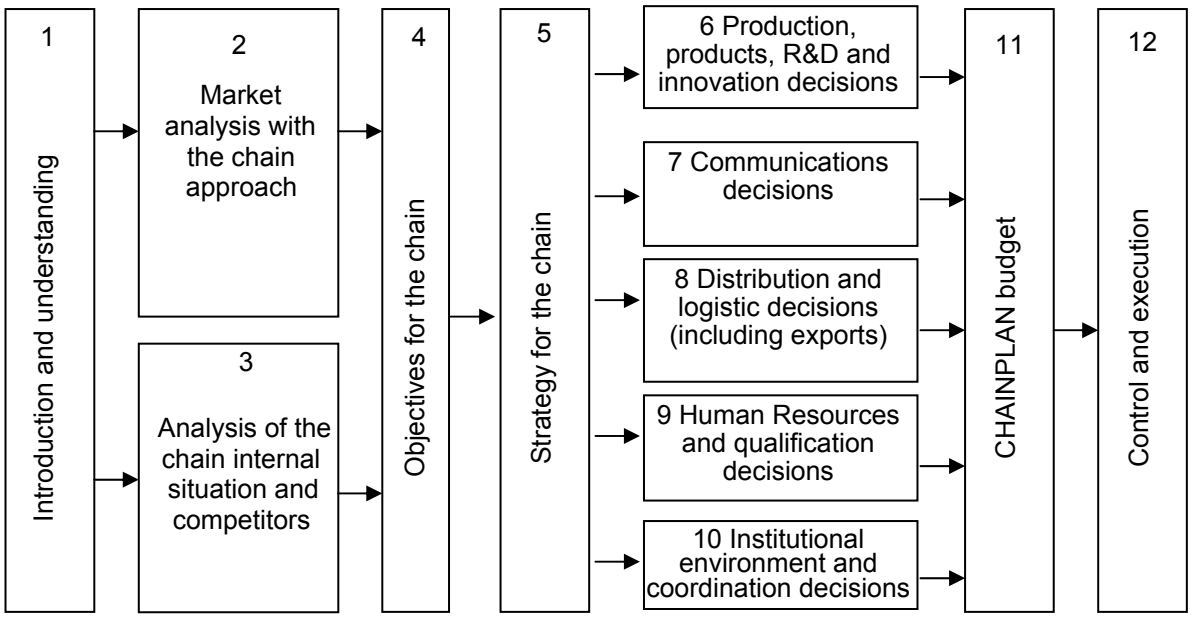

Figure 3. Process for elaboration of the chain´s strategic plan (Neves, 2007).

Table 2. Guidelines for elaboration of the strategic plan of the chain (Neves, 2007).

Stages	What has to be done
Phase 1 – Introductory steps	
1. Introduction and understanding	• Verify whether the chain has plans in place and study them. • Verify which teams will take part in the process. • Study plans made for production chains in other countries, for benchmarking.
2. International market and consumer analysis with chain approach	• Address threats and identify opportunities created by the so-called uncontrollable variables (possible changes in the legal/political, economic and natural, socio-cultural, and technological environments) in the domestic as well as the international market. • Understand existing barriers (tariff and non-tariff) on the international market and identify collective actions to reduce them. • Analyze the final and intermediate (dealers') consumer behavior and purchase decision processes. • Describe the main national and international competitors.
3. Internal situation analysis and global benchmarks	• Identify all the strong and weak points of the chain. • Describe the existing governance structures and the transactions´ characteristics. • Analyze the value creation, resources, and abilities of the chain. • Analyze the critical success factors of the chain. • Select, among the chains (which may or may not be competitors), the benchmarks (sources of good ideas).
4. Objectives for the chain	• Define and quantify the major chain objectives in terms of production, exports, sales to achieve sustainable growth and to develop solutions for the weak points.
5. Strategies to reach proposed objectives	• List the major strategies (actions) that will be used to reach the considered objectives in item 4 in terms of positioning and value capture.
Phase 2 – Plans for Production, Communication, Distribution, Human Resources, and Coordination	
6. Production, products, R&D and innovation projects	• Analyze productive potentials and production capacities. • Analyze products and product lines, as well as complementary product lines for expansion decisions. • Develop innovation opportunities in the chain, and in the launch of new products. • Foster partnerships with universities and research centers. • Make decisions related to the joint construction of brands, and labels for the system use. • Analyze and implement the certification process for the chain´s sustainability.
7. Communication projects	• Identify the target public for communication (messages from the production chain). • Develop goals for this communication (product knowledge, product reminders, persuasion, etc.) and try to define the unique positioning and message that will be generated by the chain. • Define the communication tools to be used; i.e. advertising or public relations strategies to boost sales, among other things. • Review communication actions and results.
8. Logistics and distribution projects	• Analyze the product distribution channels and search for new ones. • Analyze the possibilities of value capture in the distribution channels. • Define new ways to penetrate the markets (through franchising, joint ventures, and other contractual forms, or through vertical integration).
9. Human resources and training projects	• Conduct management training for chain participants. • Conduct technical training in food and bioenergy production. • Transmit information from technological and research centers.

10. Coordination and institutional environment projects	• Develop projects to finance the chain. • Develop basic infrastructure-improvement projects. • Develop projects to increase consumption in government programs. • Push for tax incentives in the production chain. • Strengthen export activity through export promotion agencies. • Promote a product standardization project. • Develop proposals for chain conflict solutions. • Ensure coordination in the development of contracts and proposals.
11 Strategic projects consolidation	• Consolidate all projects generated in steps 6 to 10 and establish priorities.
12 CHAINPLAN budget	• Calculate the budget of every project according to the total budget available.

4. Results

The Brazilian sugarcane chain mapped and quantified

Brazil is the world's largest sugarcane producer, accounting for over 30% of global production. Sugarcane is also one of the leading crops in terms of income generation in the Brazilian agribusiness industry. The sugarcane chain's GDP was US$ 28.1 billion in 2008, representing 2% of the national GDP; an amount that is almost equivalent to the overall economic output produced in a country like Uruguay (US$ 32 billion). The chain GDP calculation was estimated by adding the sales of all final goods and services offered in the economy. Subtracting sales taxes, the amount is US$ 24.3 billion (Table 3).

The agricultural inputs sold to the sugar-energy sector amounted to about US$ 9.2 billion in 2008. From this total, the pesticide industry earned revenues of US$ 768.4 million from this chain, 9.5% of total pesticides sales in the country. The agricultural fertilizer industry earned US$ 2.2 billion from the sugarcane chain, 14% of total fertilizer sales in Brazil.

The auto parts sector together with machinery maintenance services earned revenues of about US$ 2.8 billion from the sugarcane chain, including parts and labor to maintain nearly 144,000 machines. The chain acquired 981 harvesters, 22% of the total sold in 2008, accounting for a turnover of US$ 426.5 million.

The 2008/09 sugarcane harvest reached a record production of 568.96 million tons and a planted area of about 8.5

Table 3. Estimates of the sector's gross domestic product based on the end products (Neves *et al.*, 2010).

Product		Domestic market US$ (million)		Exportation US$ (million)	Total US$ (million)	
		With tax	Excluding tax	Tax exempt	With tax	Excluding tax
Ethanol	Hydrated	11,114.50[a]	9,105.10	23,78	11,138.28	9128.88
	Anhydrous	2,972.89[b]	2,250.88	2,366.33	5,339.22	4617.21
	Non-energetic uses	438.78[c]	351.57	n.d.	438.78	351.57
Sugar		5,297.14[d]	4,455.83	5,482.96	10,780.10	9938.79
Bioelectricity		389.63[e]	242.87	n.d.	389.63	242.87
Yeast		21.41	19.43	42.20	63.61	61.63
Carbon credits		n.d	n.d	3.48	3.48	3.48
Total		20,234.35	16,425.68	7,918.75	28,153.10	24,344.43

[a] Sales by gas stations, considering the formal and informal markets.
[b] Sales by ethanol plants to ethanol wholesale distributors, considering the formal and informal markets.
[c] Sales by ethanol plants to the beverage and cosmetics industries.
[d] Sales by sugar mills to the food industry added to sales by retailers to final consumers.
[e] Sales by the sugarcane mills and ethanol plants in energy auctions.

million hectares. The São Paulo State accounted for 68.6% of the sugarcane crushing in the south-central region. The sugarcane chain was responsible for revenues of US$ 11.5 billion shared among independent suppliers (44.5% of the industry demand) and the farms owned by the mills - the so-called vertical integration (55.5%).

The industry was responsible for the purchase of US$ 6.4 billion in industrial inputs. The industrial equipment and assembly services sales were estimated by considering the investments made in the 29 ethanol plants and sugar mills that started operation in 2008. In addition to investments related to the new units' installation, the sales of equipment and services for the maintenance of industrial units, which is performed between crushing seasons, was also considered. Sales of hydrated ethanol have grown considerably in recent years (compared with 2006, the increase was 87% in 2008). The main reason for this growth is introduction of flex-fueled-engine cars (in 2003), which in 2008 accounted for 90% of the light commercial vehicle sales in Brazil. Anhydrous ethanol is sold in Brazil primarily in a gasoline blend, which currently contains 25% ethanol. The largest share of sugar production is destined for foreign markets. Sugar production grew at rates much higher than the growth of Brazilian consumption, which has remained stable over the last six years at an average of 3% per year.

The bioelectricity generated from sugarcane bagasse and sold to electricity markets increasingly stands out as an important product of the industry. At the same time, about 10% of the yeasts used in ethanol production, specifically in the fermentation of sugarcane, are recovered and dried to be used in the composition of animal feed. For carbon credits, in terms of trading volume, Brazil ranks third among the selling countries, but it still accounts for only 3% of the market. Finally, bioplastic is one of the most promising innovations. If planned investments are executed, in a short time this product will be a very important item in the sugar mills' and ethanol plants' portfolios.

Figure 4 shows the major output of step 2 of the CHAINPLAN method as applied in the sugarcane chain. The values below each link indicate its gross sales in this productive chain in 2008. Total gross revenue (financial movement of a chain in a year) of the sugarcane chain was about US$ 86.8 billion. This value represents the sum of

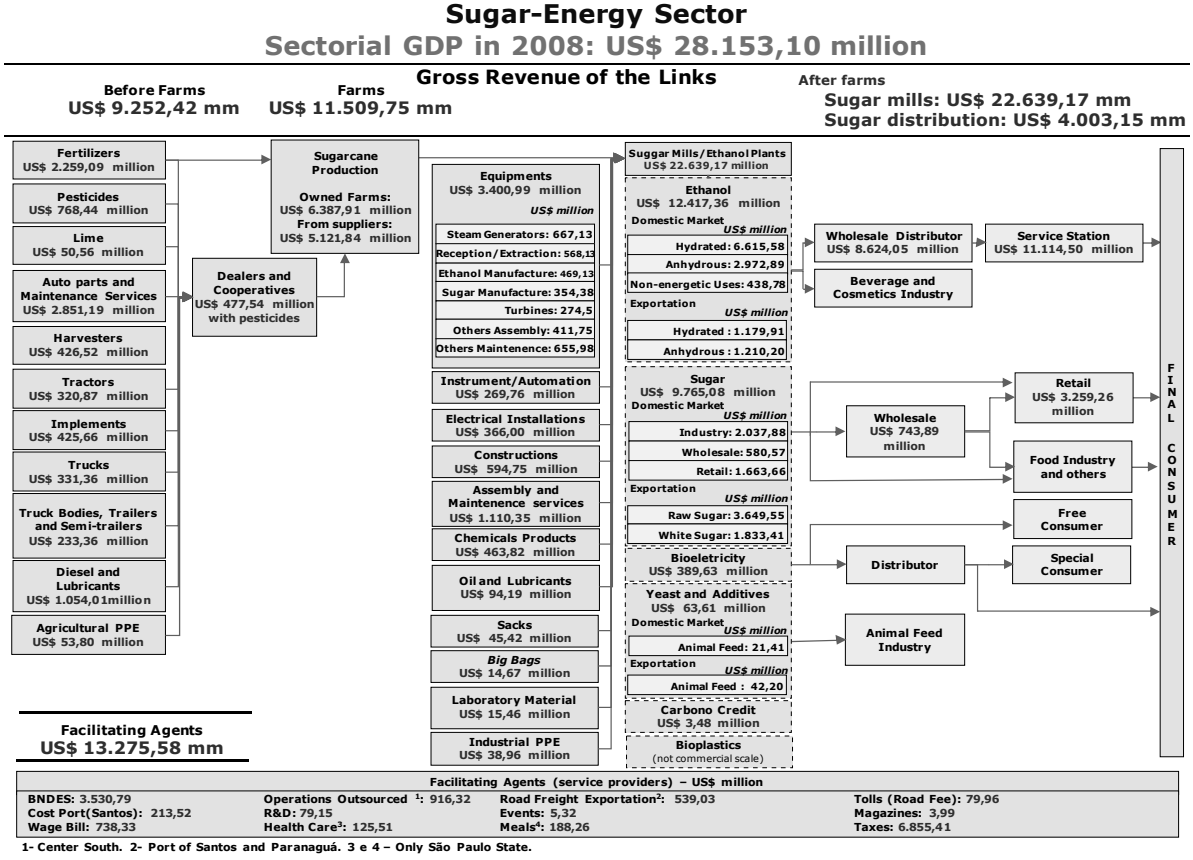

Figure 4. Sugarcane chain mapped and quantified (gross revenue) (Neves *et al.*, 2010).

all estimated sales made by every link of the chain and the financial transactions of the facilitating agents described.
According to the Brazilian Ministry of Labor, the sugarcane industry in 2008 accounted for 1.28 million formal jobs, with 481,662 allocated in the field of sugarcane cultivation; 561,292 in sugar mills for raw sugar production; 13,791 in sugar refining and milling; and 226,513 in ethanol production. This represents 2.15% of all Brazilian jobs, highlighting the importance of the sugar-energy sector. If informal employment is also taken into account, the number of jobs in the sector increases to 1.43 million. Considering also that every direct job generates two indirect jobs, a figure of 4.29 million people placed in jobs related to sugarcane is reached. The aggregate tax generated in the sugar-energy sector was estimated at US$ 6.8 billion.

A strategic plan for the sugarcane chain in Brazil

In preparing this plan, it was helpful to consult agendas already established by many important Brazilian agribusiness organizations, such as UNICA (Sugarcane Industry Association), UDOP (Union of Bioenergy Producers), ORPLANA (Sugarcane Growers Association), CANAOESTE (Sugarcane Growers Association of Sao Paulo State), ABAG Ribeirao Preto (Brazilian Agribusiness Association in Ribeirao Preto City), CTC (Sugarcane Technological Center), IEA (Agricultural Economics Institute), and IAC (Campinas Agronomic Institute).
A macro-environmental analysis of the chain was done using the 'PEST or STEP analysis' tool, which is well enshrined in the literature of strategic planning. It considers the main uncontrollable factors in a production system which can create opportunities and threats. Such an analysis covers the political-legal, economic, natural, socio-cultural, and technological dimensions of the chain (Jain, 2000; Johnson and Scholes, 1997). Table 4 categorizes the environmental changes as either opportunities or threats to the sugarcane chain.
This micro-environmental analysis was followed by a comparative analysis of the world's main producers and exporters (Australia, India, and Thailand primarily related to sugar; USA and EU related to ethanol) to understand the competitive benchmarks. An internal analysis was then completed to determine the Brazilian chain's strong and weak points. The idea is to reinforce strong points, while directing projects to improve weak points in the forthcoming years.
The dimensions of analysis were divided into five categories, in accordance with the CHAINPLAN method (see Table 5). The goals in the chain's strategic plan must be clear and consistent and, whenever possible, quantitative. Thus, for the sugarcane chain, size-related goals could be established, such as a target for production and exportation volumes. The goals must also contribute to economic sustainability (income to the main links in the productive chain), the environment (to maintain the production bases for future generations), and people, aiming to promote jobs and income. Table 6 provides some suggestions.
Brazil must pursue a cost-leading strategy based on economic, environmental, and social sustainability in order to supply the most broad market lines of sugar buyers. Brazil's sugarcane industry should also position itself as one of the cleanest industries in the world, taking solar energy and transforming it into biomass energy to be used by human beings.
To cope with new opportunities and threats, the chain needs to think strategically and change. Examples of strategic projects that could be implemented in the sugarcane chain are provided below for each of the following areas: coordination and institutional environment, production and innovation, communication, distribution and logistics, and human resources and training. These projects could be split between the public and the private sectors or be implemented jointly in some cases. They represent suggestions for strategic action that could ensure continuation of favorable conditions for the sugar-ethanol-energy sector.

Examples of projects related to production, products, R&D, and innovation

- Encourage programs for vertical growth of sugarcane production (higher yield in the same area), through increased productivity, especially in genetic modification of sugarcane.
- Promote research and development (R&D) through the formation of public-private partnerships (PPPs) and technological parks made up of agronomic institutes, intelligence centers in universities, private companies, technological centers and associations, with tax incentives and funds for the development of joint research in the sector.
- Integrate and diversify farming and processing activities for food and energy production. The integration of sugar mill and ethanol distilleries with biodiesel plants will add additional products to the production mix of mills.
- Strictly control the expansion of sugarcane plantations. Expansion should take place mainly in regions where there are degraded or underused pastures, and in accordance with the agro-environmental zoning of sugarcane production by the Brazilian Ministry of Agriculture (MAPA).
- Adapt large diesel engines for ethanol, aiming at the truck market for sugarcane suppliers and mills, as well as the market for tractors and urban buses.

Table 4. Summary of the opportunities and threats to the sugarcane chain.

	Political-legal	Economic-natural	Social-cultural	Technological
Opportunities	• New emission-reduction targets and growth of the carbon-credit markets • General tax incentives for biofuels production • Development and internalization of biofuels market in developing countries, with the advancement of new projects (biofuels and feedstock production) on degraded areas • Addition of ethanol in different countries, replacement of MTBE used in gasoline to meet environmental agenda • Brazilian ethanol qualified as advanced biofuel in US • Prohibition of burning sugarcane in Brazil, which benefits crush and ethanol facilities • New institutional framework for electricity in Brazil • Agro-environmental zoning in Brazil	• Growth in the consumption of sugar (products / food that use sugar) • Instable prices of oil • Growth in flex-fuel vehicle fleets • Export of technologies and biofuels facilities from actual producers' countries to new ones • New and high flows of foreign direct investments in biofuel industries • Good agricultural practices like rotation of crops (food and energy), causing an increase of food production in the areas of renewable energy crops • Positive energy and carbon balances for all biofuels sources	• More awareness of global warming • Migration of people to cities (e.g. China) • Image of renewable and clean fuel • Acceptance of GMOs • Social movements related to organic production/fair trade/nutraceutics/ cosmetics • Inclusion of small producers • Generation of green jobs and income	• New technologies enhancing vehicle efficiency (flex-fuel, hybrids) • New machines for cane harvesting • Generation or expansion of cellulosic ethanol use (biobutanol, hydrolysis) • Genetic modification of energy crops for resistance to dry weather and diseases • Use of biofertilizers from by-products • Integration of biodiesel and ethanol facilities • Privatization/public-private partnerships in infrastructure facilities and R&D initiatives
Threats	• Social-environmental barriers to biofuel imports • Lack of international standards for biofuels • Lobbying of oil companies and local producers against imported ethanol • Lack of regulatory stocks of biofuels in countries (which facilitates fluctuation of commodity prices) • Tax inequality through value chain and states of Brazil • Conflict of 'pre-salt' petroleum investments vs. bioenergy economy in Brazil • Gasoline price control in Brazil and Petrobras monopoly	• Growth in the hybrid vehicle fleets (gasoline and electricity) • Lack of machines and equipment for expansion of industrial capacities High fluctuation of agricultural commodity (feedstock) prices • More powerful diseases and pests • Climate change bringing reduction in the available land • Lack of agricultural inputs (fertilizers mainly) • Lack of credit/funding lines with easy access	• Image of jobs related to the harvest (sugarcane, palm) • Image of land occupation generating competition with food • Image of the 'monoculture' • Mechanization vs. unemployment in agriculture • NGOs against the growth of biofuels • Strict requirements for social-environmental certification	• Sweeteners and other energy sources • New technologies generating more competitive energy (hydrogen) • Deficient infrastructure for distribution of agricultural production from new frontiers (internal logistics) • Low investments in R&D in developing countries

- Develop new products from ethanol and sugar in addition to those that have already been developed, such as biodegradable plastic and diesel.
- Strengthen electric power production, to seize existing potential in the sector, giving priority to this form of renewable energy through financing.

Table 5. Summary of the strengths and weaknesses in the sugarcane chain.

	Innovation / R&D / production	Communication	Distribution and logistics	Human resources and training	Coordination and institutional environment
Strengths	• Sugarcane has lower biofuel cost (than corn, beet, rapeseed) • Capacity of the mature and large industry in Brazil • Strong metal-mechanical industry dedicated to ethanol facilities • Capacity of expansion to new land in Brazil • Sugarcane varieties more resistant to climate change • Strong agronomic and biotechnological intelligence centers in Brazil • Total use of by-products and residues in the field • Flex-fuel technology	• Image of green fuel, jobs generator, environmentally correct, exporter, regional development promoter, and renewable fuel • 'Free' advertising • UNICA (Sugarcane Industry Association) communication actions in Brazil, USA and EU	• Vertical integration of ethanol facilities to distribution of fuels • Trading and oil companies' control of the sector • Bioelectricity's facilities concentration close to high demand of electricity and complementary to hydroelectricity sources	• Good training capacity (universities and research institutes) in Brazil • UDOP (Union of Bionergy Producers) corporative university for executives and technical workforce	• Consecana model (sugarcane payment formula) • Agricultural partnerships for sugarcane production • Associations and cooperatives • Voluntary agreement to eliminate the practice of burning sugarcane
Weaknesses	• Low profitability of the sugarcane independent suppliers • High investments in cellulosic ethanol research by the developed countries • High investments in hybrid car technology by the developed countries • High investments in improved ethanol (biobutanol) by the developed countries	• Image of labor conditions during the harvest in developing countries • Concentration of land and farmers • Poor corporate governance practices by the sugar mill sector	• Bad export logistics in developing countries • Delay of ethanol pipeline infrastructure • Ethanol internal price fluctuation • Lack of fuel stock capacity in Brazil • Difficulty of connection to electrical grid by sugar mills	• Low coordination between organizations that offer training (research institutes and universities) • Lack of executive and technical workforce • Reallocation of former sugarcane cutters	• 80 to 90% of the production cost of ethanol comes from sugarcane • High vertical integration of biofuel facilities for agricultural production • Non-payment of sugarcane by fiber content • Lack of long-term contracts for distribution • Lack of pattern contracts for ethanol exports

- Strengthen the capability of the sugar and ethanol mills to include small producers through sustainable remuneration and long-term contracts.
- Facilitate innovations related to other products (second- and third-generation ethanol) that could be processed at the mills.

Examples of projects related to communication

- Strengthen the work of UNICA (Sugarcane Industry Association) and APEX (Governmental Agency for Brazilian Exports' Promotion) with the 'Agora' project to promote the image of Brazilian ethanol as a sustainable fuel that reduces countries' dependence on imported and scarce oil; encourages the adoption of clean technologies (flex fuel, gasohol, local production in a sustainable manner, expansion of distribution net);

Table 6. Examples of strategic objectives (goals) for 2020.

Type of Goal	Description
Sugarcane production	Produce X tons on a target cost of R$ x and on a target price of R$ y.
Ethanol production	Produce X billions of liters, being responsible for 80% of Brazil's fuel consumption on a target cost of R$ x on a target price of R$ y.
Energy production	Produce X MGW, being responsible for 15% of Brazil's needs on a target cost of R$ x on a target price of R$ y.
Sugar export	Export X tons to Y countries, being responsible for 60% of world exports, on a target price of R$ x.
Ethanol export	Export X tons to Y countries, being responsible for 60% of world exports, on a target price of R$ x.
Volumes of production units	Operating units.
Profit margins in different links	Expected margins.
Job volume	Expected jobs.
Production of other products from sugarcane	Produce X liters of diesel and Y tons of plastic, among other products.
Indirect GHG emissions (land use change)	80% of sugarcane plantation expansion should be on degraded or underused pastures. Average agricultural yield should be increased to 100 tons/ hectare through GMO varieties.
Energy balance	Energy balance of sugarcane chain should be increased to 10:1 through more efficient boilers, B2B biofuel consumption and multi-modal logistics.

ensures a sustainable production system, with a high energy balance (reduces emissions of greenhouse gases); allows the co-generation of clean energy (with the use of sugarcane bagasse); and generates carbon credits.

- In partnership with municipalities and businesses, test the use of ethanol by city buses on a much larger scale. These buses could be painted and decorated with pictures about the chain, and through them people could gain knowledge and information.
- Petrobras could export gasoline ready for use, with anhydrous ethanol added to it, to neighboring countries. There is a clear possibility for Petrobras to become the first green oil company in the world. Petrobras has a very important role to play in promoting the image of ethanol, and ethanol (as well as biodiesel) has a very important role in establishing Petrobras' image.
- Work on the development of African countries to jointly build an image of ethanol as a renewable, peaceful fuel.
- Use gas stations as a communication tool for ethanol: 'green' stations offer an opportunity for the supply chain to communicate with the final consumer. The sector has neglected this opportunity for decades.
- Make use of knowledge portals for sugarcane (the UNICA web site or other sources), which offer everything that researchers and consumers need to know about sugarcane, with databases of theses and dissertations, articles, books, and videos. One must remember that this is the 'new media' generation, and therefore information should be offered to people in new ways.

Examples of projects related to distribution and logistics

- Implement mechanisms to encourage the compilation of strategic stocks of ethanol. This will avoid ethanol price fluctuations, which harm the image of the product in the eyes of the consumer. Ensuring the safety of supply in domestic and international markets by maintaining regulator stocks in Brazil and the main consumer markets for Brazilian ethanol can improve the sector's image in Brazil and around the world.
- The mills in associative organizational forms, like franchising or joint-ventures, could have their own gas stations in cities. These concept stations ('factory outlets' called 'green' or 'eco' stations) would serve two basic functions: to establish retail prices of ethanol (hindered by the action of urban cartels or the power of oil distributors), and image communication to the final consumer, as stated above.
- Speed up already-announced investments in ethanol pipelines, as well as in port facilities for ethanol export at the lowest possible cost.

- Streamline the public-private partnerships (PPPs) and strengthen a broad privatization program of highways, railways, and ports.
- Ensure general adoption of the standard contract for ethanol developed by IETHA (Association for International Trade of Ethanol). Technicians from Brazil, the EU and USA should first work to standardize the fuel and transform it into a commodity.
- Companies should consider collective actions to strengthen the logistics of transportation, port storage, and distribution of sugar and ethanol, aiming to have very competitive costs.
- Ensure easy access for mills to transmission lines (electrical power grids) of the SIN (National Interconnected System), to enable them to strengthen the energy supply.

Examples of projects related to human resources and training

- Map specific needs and coordinate the efforts of existing organizations in the training of technicians and executives for the sugarcane production chain. The Union of Bioenergy Producers (UDOP) has done excellent work in this area.
- Map the essential technical and undergraduate courses for the sugarcane agribusiness and its spatial distribution. Plan, along with many different organizations and the Ministry of Education, the granting of scholarships and incentives for research.
- Implement training programs for workers who have lost their jobs after mechanization of harvesting (former sugarcane cutters). UNICA has been doing this through the 'Renovacao' project.
- Promote training of public employees related to agribusiness, in order to improve performance in the management of food quality, sustainability, certification, and traceability.
- Provide sustainability training for mill and farm employees.
- Establish a digital platform for training, aimed at popularizing existing knowledge.
- Create a 'Sustainable Regional Development' program to stimulate sugar and ethanol mills to start thinking about the inclusion of local communities. Propose corporate social-responsibility projects to add local companies and/or small producers to the sugar/ethanol mill supply chain. SEBRAE (Brazilian Service of Support for Micro and Small Companies) could coordinate this kind of activity.

Examples of projects related to coordination and institutional environment

- Federal and state governments need to focus on tax equality. The ethanol VAT rate could be reduced to 12% in all of the Brazilian states and federal taxes could be slightly reduced This reduction in revenues would be offset in part by increases in demand and production. This does not consider the environmental benefits and internalization development.
- Governments should also give greater tax benefits to 'flex-fuel' vehicles as opposed to gasoline-fueled ones. American, French, and Japanese manufacturers have proven that these flex engines are fully feasible. Brazilian manufactures could, like the French manufacturers, export these cars and engines, spawning this technology and consumption to other markets.
- Study whether the addition of anhydrous ethanol to gasoline could be expanded from the current 20–25% to nearly 30%. Many people with gasoline-fueled cars have already made this transition on their own.
- In the Consecana (sugarcane payment formula by sugar content) review, which is usually performed every five years, greater importance could be given to sugarcane bagasse (payment per fiber content in the sugarcane).
- Adjust the certification process of Brazilian ethanol from sugarcane, coordinated by UNICA, to fit the industry standards for quality demanded by developed countries, mainly on the issue of sustainability.
- Utilize the sector's idle capacity to provide electricity by establishing a clear institutional framework and purchasing warrants, and by giving preferential treatment to this type of energy.
- Create a list of priority countries for trade agreements (FTAs and tariff reductions) related to sugar and ethanol, and strengthen work in these countries. For example, Brazil has conditions to export not only sugar and ethanol, but also plant technology (facilities) for Africa and Latin America.

These are only some ideas generated through the authors' work in more than 10 projects in the sugarcane chain. These ideas have been proposed in various contexts, and some have already been implemented, either by existing organizations or by governments. The authors recommend that coordination of this planning effort in Brazil be centralized and aimed at making the sector more sustainable, thereby increasingly Brazil's competitive advantage as a supplier of energy to the world. In a period with water, food, and energy crises, sugarcane is, without a doubt, Brazil's best resource to help meet these needs.

5. Conclusions: the future

Several factors have motivated governments to establish mandatory blending targets for biofuels, including increasing oil prices, energy dependence and global warming. The basic idea behind biofuels is that when they are added to fossil fuels in in cars' engines, part of the money flow moves from the oil business towards the agro-business. If someone in New York fills up his or her car tank with fuel consisting of 10% ethanol (E10), around 10% of the money spent by the car owner will not go to the oil business chain, but to the corn business chain. And this revolution is happening in several parts of the world, empowering agriculture and land owners. The future opportunities are great, since biofuels today account for only around 2-3% of total fuel consumption globally and there are plenty of areas available on the planet to support this development.

This article demonstrates how Brazil has been successful in adopting *sugarcane* policies – the Proalcool program in the 1970s and 1980s, deregulation and free trade in the 1990s , the consolidation of mandatory blending targets (E25) and the launch of FFVs (Flex Fuel Vehicles) in the last decade – taking advantage of this plant's unparalleled capacity to transform solar energy into economic benefits.

In 2010, the sugarcane chain in Brazil was responsible for a GDP of US$ 30 billion, a financial movement of US$ 90 billion, and the generation of almost 4.5 million (direct and indirect) jobs. The chain was also responsible for US$ 7 billion in tax generation for federal and state governments; and its major products, sugar and ethanol, were responsible for US$ 12 billion in exports.

Brazil is self sufficient in the supply of sugar to internal markets and it holds a 53% share of world sugar exports. Sugarcane generates not only sugar, but ethanol and bioelectricity. Of the total fuel consumed in the country, ethanol already accounts for 52%, and gasoline accounts for the remaining 48%.

Since more that 3 million new cars are sold per year in Brazil, and of these, 90% are flex fuel vehicles (which can use either gasoline or ethanol), it is expected that the ratio of fuel consumption will be 80% ethanol and 20% gasoline by 2015. Sugarcane production takes up only 9 million hectares (i.e. less than 3%) of the 350 million hectares available for agricultural development in Brazil.

After crushing the sugar cane, about 1/3 of its weight is bagasse. This bagasse is burned in boilers inside the industrial units, cogenerating electricity, which is partially used to run the mill, and partly sold to the consumers' network, representing an additional source of income. Brazil estimates that by 2020, 15% of its electricity supply will come from sugarcane (a substantial increase from 3% in 2010).

The efficiency of ethanol makes it economically beneficial for consumers. Most mills produce ethanol at a cost of about US$ 0.40/liter, and the average retail price is US$ 0.80/liter (55-60% of the price of gasoline). At gas stations in Brazil, consumers can choose between E100 (100% hydrated ethanol) and normal gasoline, which for more than 10 years has contained 25% anhydrous ethanol, without causing any damage to gasoline engines.

Companies have started extracting several other products from sugarcane, the most promising of which are probably bio-plastic and diesel. Coca Cola recently launched its 'plant-based plastic bottle', 30% of whose plastic comes from cane. Diesel derived directly from sugar is already in production in Brazil, using an engineered yeast-based technology developed by a company called Amyris in the USA. This cane diesel has been approved by Mercedes Benz for use in normal diesel engines. Important new developments related to sugarcane are expected in the near future. The first GMOs are expected by 2014, and could increase the sugar content by 40%. Hydrolysis has the potential to allow production to go from 8,000 liters of ethanol per hectare to 12-15,000.

Maintenance of the sugarcane chain's competitiveness will depend on the operationalization of important strategic projects, in which responsible agents, deadlines, and budgets are clearly defined. More than ever, planning is necessary in this sector in order to take advantage of all the opportunities and to resolve weaknesses as the industry looks for equilibrium and sustainability. Because of this, we offer our proposal for this chain.

A suggestion for future research would be to apply the CHAINPLAN method to other sugarcane chains in other countries. This would allow researchers, policy makers and practitioners to compare results, support each other in strategic planning, and look for benchmarks for improvements.

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