

# Is There a Bitter Flavor in Sustainability for the Sugar-Alcohol Industry?

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**ABSTRACT:** Biofuel has been pointed out as one “green” option for traditional fossil fuels like petroleum. Brazil is one the leading countries within this proposal competing globally with its sugar ethanol.. Nevertheless, there is a debate between corn ethanol and sugar ethanol .regarding the appropriateness to produce fuel instead of food in highly fertile regions. This industry is also severely criticized regarding its socio-environmental practices. We analyzed three cases identified as featuring best practices in this industry in Brazil. Two of the companies are located in the state of São Paulo, Southeastern Brazil, the most important region in sugar-ethanol production. The third is situated in the Brazilian Midwest, a region with fast growth in this industry. In this region, cattle, soy and corn have been substitute by sugarcane plantation. The results suggest that, when a company in this industry pursues a sustainable approach to its operations, it is possible to mitigate environmental impacts and to improve local social conditions. Such practices are potential sources of competitive advantage. However, clear gaps are still present regarding integration and collaboration along the supply chain. Nevertheless, sustainable business policies have also created new business opportunities. The continuous challenge is to develop synergetic operational capabilities that are able to mitigate environmental impacts, to decrease operational costs and to add value to the products.

**Keywords:** *green supply chain, sustainability, integration, ethanol, biofuel.*

## 1. INTRODUCTION

One of the current challenges in the sugar-ethanol industry is to deal with the question of sustainability, while taking into account the characteristics of this economic activity. It is known that this sector has sought to achieve new levels of operational performance in the last few years (Krajnc et al., 2007). At the same time, there is a need for improving its competitiveness, as much in the domestic market as in the international (Farinelli et al., 2009). Nevertheless, the present policies of this sector in Brazil have constantly been criticized internationally in the business press (Kozloff, 2010). Brazilian companies that focus on large scale production treat social issues as a secondary concern (see for example, Hall et al., 2009), and not as a sustained process in the long term (Pereira and Ortega, 2010).

Generally the industry has sustainability at the extend people involved want to. In the case of sugar-ethanol a lot of effort has been made in different ways around all the countries that produce sugar cane, sugar and ethanol. Sugar-ethanol industry is particularly challenging due to interdependencies of climate uncertain and political-economic decisions, what directly impacts its value chain (Everingham et al, 2002) .

This study focuses on the Brazilian sugarcane production in order to observe its challenges toward sustainability, based on triple-bottom line (economic, social and environmental perspectives). Brazil is the world's largest sugar producer and second largest ethanol producer, behind the United States. In 2010, the total sugar cane production of 620 million tons led to 38 million tons of sugar and 27.4 billion liters of ethanol. Sugarcane is grown primarily in the South-Central and Northeastern regions with different harvesting periods: in South-Central Brazil, the harvest runs from April to December, and, in the Northeast, from September to March. The South-Central region produces over 85% of Brazil's sugarcane, São Paulo State alone accounting for 60% of it.

Brazilian sugarcane cultivation today occupies 7.8 million hectares, or 2.3% of the country's total arable land. The annual revenue of the sector is around US\$ 36 billion, the foreign revenue (export) component accounting for US\$ 16 billion. It ranks second in Brazilian agribusiness exports, just after soya production. The industry employs 1.15 million direct workers, distributed nationwide among more than 400 mills.

## 2. LITERATURE REVIEW

### 2.1 *Linking operations strategy to sustainability*

The concept of the triple bottom line developed by Elkington (1997) confers broad responsibility on a company in relation to its activities.. In order to achieve a long term sustainability, a company has to manage not only its economic capital, but also those that are natural and social (Dyllick and Hockerts, 2002). It is important to stress that the concept of capital differs from the traditional vision of the economists, indeed gaining new meanings. In this case, it covers natural capital, as it is related to natural resources.

Environmental responsibility is linked to concerns, such as conservation and sustainable use of natural resources. This means adaptation of processes and development of products that utilize less material and energy, as well as limiting damage to the environment caused by the industrial activities (Kleindorfer et al., 2005).

Ecologically sustainable companies are those that only utilize natural resources that are consumed at a rate below that of natural reproduction or at a rate in accordance with the development of new resources. These do not cause emissions that accumulate in the environment beyond the capacity of the natural system to absorb and assimilate them. Finally, they are not involved in activities that degrade the social ecosystem (Dyllick and Hockerts, 2002).

It is considered that socio-environmental aspects are necessary for economic development. Such combination increases prosperity by more efficient utilization of the resources and less emissions of environmentally adverse substances. When there is integration among the partners in the Supply Chain Management (SCM), the materials are utilized more efficiently and the natural resources better conserved, providing economic advantages for the companies (Zhu and Cote, 2004, Linton et al.,2007). Thus, from an initially reactive posture, companies are gradually shifting to a more proactive one in relation to the sustainability aspects.

Social responsibility contemplates the responsibility of companies in the development of society. Ideally, companies would assume a commitment to the development of society, executing actions to boost social development, social inclusion and the improvement of the living conditions of neighboring populations (Pedroso and Zwicker, 2007, Van Der

Hejden et al., 2010). Socially sustainable companies are those that add value to the communities in which they operate, increasing the human capital of the individual partners, as well as promoting the social capital of these communities (Dyllick and Hockerts, 2002). Hutchins and Shuterland (2008) measure the social performance of a supply chain from four perspectives. They are related to labor equity, health-care, safety and actions related to philanthropy.

## 2.2 Linking operations strategy and sustainability

Since Skinner seminal article of 1969, Operations strategy has discussed the strategic role of operational processes for business units. Further different authors have treated operations strategy as a business strategy deployment (for example, Wheelwright, 1984) or a capability grounded in the resource-based approach (see, for example, Schroeder et al., 2002). Wheelwright (1984) argued that operations strategy is related to the unit's business strategy, and it is operationalized through a set of decision categories: capacity, technology, facilities, vertical integration, workforce, quality and organization. The main consensus is related to the competitive criteria that include cost, delivery, flexibility and quality (Wheelwright, 1984, Miller and Roth, 1994).

Currently, new approaches, like sustainable operations, have been integrated to the operations management debate (Angell and Klassen, 1999, De Burgos and Lorente, 2001). It is possible to adapt the four stages of Wheelwright and Bowen (1996) and Hayes and Wheelwright (1984) to sustainable operations (Kleindorfer et al., 2005). According to them, a company, in the first stages, only sees the internal aspects of its operations. A company in the third stage combines their operational decisions to the business strategy. A company in the most advanced stage is able to create new capabilities from their operations, has operational issues embedded in its strategy, and creates new patterns of performance related to operations.

## 3. METHOD

The research method adopted was multiple case studies. Quality and depth were sought within this methodological orientation (Yin, 2009; Collis and Hussey, 2005). In order to assure internal validity, we followed the patterns indicated by the theory (Eisenhardt, 1989; Stuart et al., 2002; George and Bennett, 2004). More precisely, we selected the cases by their representativeness, as Brazil is one of the biggest

players in the sugar-ethanol industry and based on the fact that all 3 organizations chosen are known as best-practice entities. The companies studied present some singularities, such as leadership in the sugar-ethanol market and management concerned with sustainability. Their location in a traditional sugar cane region and in a more recent area for the sugar-ethanol industry in Brazil presents singular aspects when compared with each other.

For data collection, the techniques utilized were semi-structured interviews, non-participant observation and secondary data (we addressed an extensive documentary analysis through annual reports, memos and relevant documents in each organization, as well as in associations and unions). We recorded every interview for subsequent transcription. Respondents were selected based on their involvement in sustainability strategy and practices. The executives who joined the respondent group were: the Director President, the Commercial Director and Management staff from the Administrative, Operations, Purchasing, Commercial, Sustainability and Environmental Departments. On average, each interview lasted 60 minutes. Representatives of the ethanol distribution companies, Premium and Petrobras, were also interviewed. In order to improve data quality for phenomenon analysis, we sought to increase the quantity of observable information available as much as possible. In order to do so, at least two authors jointly visited, interviewed and collected data in the field. Interviews were also evaluated in real time, combining non-participant observations and field notes. Furthermore, we built a database that was shared among the authors in order to offer deeper insights and re-enact events. This strategy aimed to minimize bias and supported the robustness of the study (Eisenhardt, 1989; George and Bennett, 2004).

## 4. CASE STUDIES

### 4.1 Institutional environment influence - Sugarcane expansion in Brazil

The sugar and ethanol industries suffered significant price and volume fluctuations, as presented in Table 1. Consequently, some firms have invested in alternative product lines. The main ones have been using the bagasse for cattle feed and leavening (fermentation), and the sale of excess energy generation. Some mills have also invested on producing neutral alcohol for beverages and cosmetics products.

The main obstacle to massive investment in energy sales by the São Paulo sugar mills is lack of planning and regulation by the Federal Government, which, in turn, increases investor uncertainty. In 1993, espe-

cially for the foreign market, the Group developed VHP (very high polarization) sugar, an innovation in the industry. Granulated refined, crystal and organic sugar are also traded.

**Table 1: Brazilian Sugarcane Harvest**

	06/07	07/08	08/09	09/10	10/11	11/12
Sugarcane crushing (tons)	425,416	492,382	569,063	602,193	620,409	559,215
Sugar production (tons)	29,798	30,719	31,047	32,956	38,006	35,925
Ethanol production (million liters)	17,710	22,422	27,513	25,694	27,376	22,681
Anhydrous ethanol (million liters)	8,292	8,363	9,336	7,065	8,323	8,593
Hydrous ethanol (million liters)	9,418	14,059	18,177	18,629	19,053	14,088
<b>Exports</b>						
Sugar (thousand tons)	19,597	18,603	20,795	24,088	27,514	24,342
Ethanol (million liters)	3,692	3,625	4,722	3,166	1,906	3,098
<b>Imports</b>						
Sugar (thousand tons)	0.044	0.031	0.08	0.018	0.017	
Ethanol (million Liters)	3.808	0.568	2.441	22.971	78.076	

Source: Adapted from Unica, Mapa & Secex

At the same time, sugarcane expansion is not considered a threat to the Amazon rain forest (Unica, 2008). Firstly, sugarcane expansion in the last 25 years has occurred primarily in South-Central Brazil, in areas that are significantly distant from the rain forest and other important ecological areas, such as the Pantanal wetlands and the Cerrado. In fact, most of this expansion (currently 60% of the national output) has occurred in the populous São Paulo State on traditional agricultural lands, close to established sugar and ethanol processing plants.

Second, the Amazon rain forest does not offer favorable economic and agronomic conditions conducive to sugarcane production, alternating dry and wet seasons, what are not suited to grow the plant and build up sucrose levels in the cane. Moreover, the absence of a reliable transportation infrastructure to transport the final product (either sugar or ethanol, since the cane itself cannot be transported for long distances) out of the processing areas is a major limiting factor that precludes sugarcane production in the region.

Third, future expansion is anticipated to continue in South-Central Brazil, particularly in degrade pastures. The most promising areas for expansion are in

Western of the São Paulo state, Western of the Minas Gerais state and the Southern regions of the states of Mato Grosso do Sul and Goiás, in the Cerrado biome. From 1992 to 2003,, the sugar cane areas have grown in the Center- South around 94% of the existing production units. Moreover, the expansion of the sugarcane sector has not yet attracted other agricultural activities, such as cattle and soybean, into the rain forest (IBGE, 2008, UNICA, 2008). The dynamics of the cattle industry, which has been present in the Amazon region for the past 30 years, are unrelated to the sugarcane production. Cattle raising activities in the greater Amazon are linked to the logging industry, which has been the “cash crop” of the rain forest. Sugarcane for ethanol production in Brazil occupies around of 1/4 of that dedicated to corn, 1/8 of the area planted with soybeans and 1/60 of the land used for cattle farming. As a result, while sugarcane production has increased steadily in recent years, food production in Brazil has also grown dramatically without any material price increases for a while.

#### 4.2 Cases: An overview

Company A is the second largest producer of ethanol in Goiás State, Midwest region of Brazil. The

company has received prizes related to socio-environmental practices in the last few years. Its single plant has ISO90000 and ISO14001 certifications. It was a pioneer in Brazil in sugar-ethanol regarding socio-environmental practices. It produces organic sugar as well as traditional sugar and ethanol. Upon being enquired if the market would accept to pay a premium for a product made according to the standards of care entailed in environmental preservation, all the interviewees manifested that the Brazilian market, despite prioritizing the purchase of such a product, would still not be willing to pay more.

Company's financial data indicates that there were some losses in previous years. In 2007, the company's result was positive, totaling US\$ 12.51 million. In the following years the results were negative, presenting losses of US\$ 1.55 million in 2008 and US\$ 24.02 million in 2009. The company explains that such results are related to the interaction of several factors: investment in new machinery and equipment for the plant, acquisition of crop machinery, hiring qualified personnel to operate them, the rising price of fertilizer used on crops and the dry weather.

Company B is the result of a joint venture between a big Brazilian sugar and ethanol exporter, and one of the biggest global players in the fuel market. This organization possesses 23 mills and is the 5th largest Brazilian corporation, based on yearly turnover.

Company B has focused on increasing sugarcane and plant productivity like other large companies in this industry. Some plants have made significant investments in industrial automation, agricultural mechanization and outsourcing, transportation logistics and sugarcane development and farming. These investments have reduced costs, increased productivity and produced residues and by-products, such as bagasse, which are used for energy co-generation, animal feed and fertilizer.

Company C is one of the largest Brazilian sugar-ethanol trader with an integrated production process based on a network configuration. Its business model concentrates 22% of the Brazilian market and plays a significant role in the global sugarcane market. The organization has a unique business model that consolidates all sugar and ethanol supply chain actors, from follow-up of the harvest in the field to the end markets, including storage, transport and trading phases.

The group now participates in the European Bonsucro standard (EU Renewable Energy Directive

Production Standard), which includes fundamental requirements for the sale of biofuels in the European Union. The company also has an agreement with Eco-Energy for sales to the U.S. market. Even so, the environmental initiatives are still in their early stages. The main challenge of the Group is to engage in a sustainable approach to all the mills and partners in the network.

Even so, there is progress in this process, but the actions are still incipient. Currently they are beginning to deploy measurements procedures, sharing information and seeking mill owners' motivation to adopt best practices. Initial results already show a quick drive in this sense, but there are no significant environmental and financial results yet. While realizing the importance, a considerable part of the network members is characteristically conservative and aims to develop a sustainable culture effectively. There is an increasing pressure regarding socio-environmental impacts, and, clearly, companies in this industry are trying to respond to these pressures.

#### 4.3 Technologies and Process

Alternative use of pesticide is one the main actions present in the cases. Company A utilizes the monitoring of termites and rationalization in the application of insecticides in infested areas have allowed an economy of US\$ 500,000/year in the last few years. In the Company B the biological control of certain sugarcane pests is present. They produce spores of the *Metarhizium anisopliae* fungus, replacing the use of pesticides in the control of spittlebugs (*Mahanarva fimbriolata*). A common pest in cane fields is the sugarcane borer (*Diatraea saccharalis*), which the Group controls with the *Cotesia flavipes* wasp, which is bred in their own laboratories. Both controls contribute to environmental preservation.

Another common action is the rationalization of the fertilization application or alternative one as well. Company A deployed several actions aimed at reducing production costs based on the utilization of the vinasse to substitute the chemical fertilizer applied to the fields. At present, the company is managing to fertilize-irrigate 20% of its plantation. The company's use of fertilizers can be observed in relation to the national average. The cost reductions have reached around US\$ 1 million in the last few years. Its use of agricultural pesticides is 51.85% less than the national average. This represented a cost reduction of over US\$ 2.5 million/year. The company also utilizes natural fertilizers. One example is compost, a byproduct that acts as a substitute for chemical fertilizer. Around 5%

of the residues generated in the manufacturing process are transformed into compost.

Improving industrial processes and rational use of water are two concerns in all the companies. Company B creates a program that enhances the quality of the raw material, from soil preparation through to harvesting, by reducing mineral and vegetable impurities. As a result, the sugarcane now arrives at the mill with a lower impurity content, which improves crushing efficiency and, more importantly, reduces cane washing, in turn reducing water consumption and environmental interference. Moreover, water utilization is, in general, a key factor in assessing sustainability and GSCM. Water use reduction during the industrial production process of ethanol remains a challenge for mainly mills (Schaffel and La Rovere, 2010). However, Company B has installed blower cleaning equipment in 11 mills, eliminating the use of water in their operation, and two plants have installed diffusers instead of conventional milling. This innovation improves plant crushing capacity by 0.5%.

In the company A, there are also standardized routines for all the functional areas of the plant. Periodically, an internal team audits those areas. The company explains that, for the whole process, an analysis of the environmental risk is made. With regard to seeking efficiency in the use of packaging, as suggested by Sarkis (2003), it was explained that the company utilizes plastic in its products due to its lower cost. Moreover, there is no reverse logistical flow of packaging. The company has taken actions over the years aimed at decreasing the environmental impacts caused by the residues from its industrial processes.

On the other hand, Company B adopted geo-processing technologies with utilization of satellite images to monitor plantation. The information obtained enables the company to direct actions necessary to improve its productivity rapidly and efficiently. Another geo-processing technology implemented was the SIG (Geo-Referenced Information System), which facilitates exploring the databank based on thematic maps.

Thus, Company B also decreased its water consumption by 16% from 2008-2009 to 2009-2010. There are also investments in place to obtain more concentrated vinasse, thereby reducing water. This residual water should be used to recover evaporation losses in the process, allow water consumption rationaliza-

tion and improve efficiency on the shop floor.

The first improvement mentioned by the company C is mechanized harvesting, which also leads to minimization of emissions (CO<sub>2</sub>). To assess what would be best for nearby communities, they developed a series of joint forums and realized that the priority was to mechanize. Sugarcane burning significantly disturbed local communities directly.

Since 2011, Company C has implemented an advanced system for monitoring social, environmental and economic KPIs aligned to GRI methodology. Using EDI, all mills report, in real time, the current performance and outcomes to the entire network. The company makes significant efforts to train employees and to convince mills to adopt these methodologies, partly due to the need for competitiveness. One of the key efforts is to allocate to each mill a sustainability representative engaged in the practices, following the daily routines. Besides, Company C has also approved 40 of the 48 mills on the RFS-2. Even considering the autonomy of each member, they motivates the members of the network to share knowledge and their best practices. It highlights evidence of collaboration within the network, combining efforts on problem solving, increasing productivity and seeking better uses of natural resources like water.

#### 4.4 Facilities

Company A has a single plant located in the Midwest of Brazil, one of the region's main producers of grains and other agricultural products. The company possesses 38,000 hectares under sugar cane cultivation, and 2,400 direct employees and 10,000 indirect. On average, the company harvests 2,800,000 tons of sugar cane, and, in the last few years, it has produced an average of 4,200,000 sacks of common sugar, 12,000 tons of which are organic. It produces around 100,000 m<sup>3</sup> of ethanol. Besides this, it possesses the capacity to generate 40 MW of electricity from the bagasse.

All the residues generated undergo a weighing and control process, and then accounted for. For every residue, there is an annual reduction goal of 5%. The company has also had a contract since 2001 for carbon credit trading with the Dutch government. In the period 2001 to 2007, the company contributed a reduction of 130,597 tons of CO<sub>2</sub>, which represented revenue of € 587,686.50. The commercialization of carbon credit is possible because around 90% of the

irrigation pumps used in the sugar cane fields are run on electricity produced from bagasse instead of fossil fuels like diesel.

Company B, however, is twenty times bigger than Company A in number of employees, 43,000 being direct, has a cultivated area of 605 thousand hectares, grinds 44 million tons of sugarcane, producing 4 billion tons of sugar and 2.2 billion liters of ethanol (data from 2010-2011). Their plans include expansion of its market share, and to reach a production level of 5 billion liters of ethanol by 2015.

In other hand, Company C entity is composed by 47 mills that belong to the sugar consortium by an exclusive sales regimen. These mills are located in the Southeast region of Brazil. Additionally, another 50 non-partners have occasional participation in this process too, allowed to sell non-exclusively to Company C. The main benefit of being part of this business model is to increase the competitiveness of small-size mills. Each member has the possibility of a long-term contract for the amount produced, which minimizes risks and allows investments, training and participating in projects. In the 2011-2012 harvest, Company C members were able to reach total sugar sales of 6.9 million tons. Sales in the Latin American market, including Brazil, amounted to 1.83 million tons, while global exports reached 5.12 million tons. Meanwhile, ethanol sales reached 3.7 billion liters, of which 3 billion liters represented domestic sales and the balance exports. The occasional members' mills (non-exclusive partners) represented 2.7 million tons of sugar and 400 million liters of ethanol. All these activities consolidated a net income of US\$ 6 billion. For the company, exports enjoyed a premium price, but it needs to achieve socio-environmental international standards and obtain certifications.

#### 4.5 Supply Chain

Unlike other companies in this sector in Brazil, Company A is verticalized and its activities span from the cultivation of the sugar cane to its processing. It includes bearing all the inherent costs incurred in seeding and harvesting, assuming the financial and environmental risks, providing all the equipment and labor, among other aspects. In this manner, the company aims to ensure a stable supply of the raw material.

Upon investigating if the buyers' market presents any requirement regarding productive practices

that respect the environment throughout the company's supply chain, it was detected that this occurs only in the case of organic sugar. All the production of this product is sold to foreign buyers, who seek to find out about the sustainable practices adopted by the company and the supply chain.

Company B crushed more than 39 million tons of cane in the fiscal year, 2008-2009. Its pace of growth over the past five years has forced the Group to increase its cane purchases from suppliers, which have jumped from 5.2 million tons in 2001 to more than 17 million tons in 2008-09. The company takes action to monitor and mitigate socio-environmental impacts related to the entire value chain, including suppliers and buyers. A group of 28 suppliers and 9 buyers joined in a training and development program with the objective of implementing a management approach based on the Global Reporting Initiative (GRI) model. All the participants have been involved in the search for standardized information and in the definition of needs for a software implementation.

Company B has also embarked on a joint project with several sugarcane players in order to reduce transport costs by 20%. The Group is investing around US\$ 3.5 billion in building an ethanol pipeline (length 880 miles) with a capacity of 21 billion ethanol liters annually. As a result, all players will not only optimize costs, but also mitigate environmental impacts and carbon emissions.

Large buyers, like Coca-Cola, pressure the market as a whole for more advanced environmental practices because they are concerned with their whole supply chains. Next requests followed by upstream supply chain pressure indicate aspects like water consumption and re-use practices. Therefore, there is a pursuit of sustainable activities throughout the whole supply chain, from the sugarcane producer to the final client.

#### 4.6 People

Company A moves forward through actions that contemplate concerns with society and employees which possess importance in obtaining certifications and awards, and, consequently, access to more demanding markets, such as North America and Europe. At the same time that mechanization of the reaping of the raw material, which, today, extends to 88% of the total plantation, responding to one of the main criticisms of sugar cane growing in Brazil – labor ex-

ploitation, it is viewed by the company as a potential source of social disequilibrium in the region.

Among the actions of the company to ease the loss of jobs in manual harvesting, we highlight a project that consolidates the production seedlings and provides incentives for planting rubber trees in the region. This activity needs labor for the latex collection. Currently, there are 2,700 million trees, and around 1,000 workers are employed directly. Additionally, there are actions related to community education development. Since 1994, the company has implemented a series of activities in the area of education. It provides primary and intermediate level education. Currently, more than 300 students, children of employees, are benefited.

The company invests in the qualification of its employees, providing study scholarships. The company informs that, in the last two years, it has benefited around of 380 employees with subsidization of 50% of the monthly fee at graduate and post-graduate level. The investments in education of employees reached US\$ 375,000 in the last years.

Company B adopted a similar strategy who grasps its attention on training and qualification of the cane cutters and increases their remuneration, since mineral impurity content is a factor in the Profit Sharing Program. In 2007, Company B created a Program, designed to ensure that all Group employees are fully equipped to carry out the Group's agricultural activities. The partnership with HR – People and Agricultural Development resulted not only in the technical training of their workers, but also in the preparation of team leaders. The advantage is that teams are trained in technical matters by their immediate superiors and, with the help of HR, in be-

havioral aspects. Program results are carefully monitored in order to ensure quality, safety, and respect for the environment.

It is possible to identify a significant increase in social investments. In 2007, they invested around US\$ 2 billion, followed by US\$ 2.2 billion in 2008 and US\$ 2.8 billion in 2009/2010. Additionally they implement a sustainable business strategy in its supply chain. It is not a simple task, because the company's database includes 33,000 suppliers, and 15,000 of them have engaged in active business with Company B in the last few years.

Specific social actions drive Company C efforts in the social dimension. Partnerships with NGOs educate more than 5,000 teenagers, aiming at improved life quality and a better future through reading, logical reasoning, problem solving, performance in learning. Other social projects take care of child health through sports initiatives, like swimming sponsorship for a group of 250 children from low-income families. Internally, there are also policies related to the improvement of job health conditions, accident reduction and workers' health.

## 5. Final remarks

The cases suggest that sustainability is still a challenge for the "green" biofuel even for the largest companies in Brazil. All three companies' present actions are related to sustainable practices in their operations, albeit situated in different stages.

Table 2 summarizes the decisions related to sustainability using an operations strategy perspective, and each of them are discussed in detail.

**Table 2: Categories of decision and existing policies in the cases analyzed**

Decision Categories	Company A	Company B	Company C
Technology and Process	Mechanization in harvesting.  Rationalization in use of inputs.  Re-use of byproducts (sugarcane bagasse).	Mechanization in harvesting.  Advanced tools for harvesting and monitoring.  Rationalization in water use.  “SóPuraCana” quality system.	Mechanization in harvesting.  Advanced tools for harvesting and monitoring.
Facilities	One plant.  Low scale.	Multiple plants.  High scale.	Network of plants.  High scale.
People	Social programs for income generation.  Training and development.	Training and development.	Social programs.  Training and development.
Supply Chain	Low upstream integration.  Increasing downstream integration.  Vertical integration from plantation to processing.	Increasing upstream and downstream integration.	Increasing upstream integration.

Nevertheless, Company A is in the most advanced stage of sustainable practices, featuring simultaneous goals of cost reduction and increasing value added to its products. Apparently, this is a trade-off but a combination of quality certifications and other sustainability - related practices may create a capability in this case. For this company, sustainability is embedded in the business strategy, which influences all the decisions. Company A is characteristically in the third stage of competitiveness with a clear integration of its sustainable decisions in operations with the company's business strategy

Company B still presents actions favoring mitigation of environmental impacts in conjunction with gains in productivity and (re-)use of byproducts. The company's organic products seek to compete in higher added value markets. Similarly Compa-

ny C, is in the same second stage of sustainability still following the traditional industry pattern. The mills that comprise Company C production network present initial actions related to technology and processes, but mainly for mechanized harvesting, thereby following the practices of the industry. Its products are certified commodities with potential sales in more sophisticated markets like the EU. We may state that, for these two companies, sustainability is still advancing towards higher integration with their business strategies.

We also identified that all the companies also seek to implement actions to reduce operational costs that accomplish socio-environmental standards. Thus, it is expected that companies in commodity industries, like sugar-ethanol, will develop environmental capabilities in operations that may simultaneously

increase added value and decrease operational costs. In an advanced stage, we expect that is possible to create synergetic capabilities: even in a commodity market. Therefore, we may consider that companies in the sugar-ethanol industry seek to develop environmental capability in operations that enable synergy between added value and operational costs.

From the economic aspect, even though Company A presented the most advanced practices, the company has undergone a period of consolidation of its investments aimed at sustainable practices, which may explain some unsatisfactory financial results over the last few years. At the same time, Companies B and C have expanded their operations leveraged by their positive results in the last years. In the environmental dimension, several actions of the three companies have sought the reduction of residues and their reutilization, mainly for sugarcane cultivation, which demonstrates that these companies pursue improvement in their socio-environmental practices. Finally, in the social dimension, the actions are directed towards substitution of direct labor in the harvest, investments in education and training, and social actions in the society.

One of the main challenges for this industry is to add value to their commoditized products, and simultaneously decrease operational costs. Based on the cases studied, the following actions are associated to the sustainability and operations strategy approach in the sugar-ethanol sector: (i) Seeking environmental certifications and advanced technologies, (ii) Mechanization of sugarcane harvesting, (iii) Training and development for sustainable practices, (iv) Actions for input consumption reduction and reutilization, and (v) Need for supply chain integration upstream and downstream.

All these actions may decrease some trade barriers related, for example, to job safety in sugarcane harvesting and water use. At the same time, the current low risk of expansion of new cultivation areas into the Amazon rain forest region is a positive aspect for the image of this industry.

These manuscript findings were based on case studies of three Brazilian sugar-ethanol organizations. The results can be valid within this specific context. Due to the interdependencies of uncertainty, political and economic decision process, future studies may advance by comparing organizations located in different contexts.

Derived from the conclusions of this study, this paper open an opportunity of future research exploration of challenges for the trade-off of adding value and increasing pressure for cost reduction. Also the influence of scale and organizational design in the sustainability policies deserves deeper analyses.

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