



CHALLENGES AND OPPORTUNITIES FOR SUSTAINABILITY IN THE MANAGEMENT OF SUGAR AND ALCOHOL AND REFINING COMPANIES

Desafios e oportunidades para a sustentabilidade na gestão de empresas sucroalcooleiras e refinadoras

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ABSTRACT

The growing demand for management models aligned with sustainability has driven research on business practices in the energy sector. However, most studies focus on competitive and macro-environmental analyses, neglecting the internal dynamics of organizations. This study investigates the relationship between the management models adopted by sugar and ethanol and oil refining companies and the sustainable management guidelines described in the literature. To this end, a methodological approach based on a systematic literature review was adopted, complemented by documentary analysis in selected companies. The results indicate that the sugar and ethanol sector has made significant progress in adopting sustainable practices, with emphasis on regenerative techniques and greater integration of environmental and social criteria in management. In contrast, oil refineries face more complex structural and regulatory challenges, even though they make efforts to incorporate technological innovations to mitigate environmental impacts. The analysis suggests that, while the sugar and alcohol sector is consolidating itself as a reference in sustainability, the refining segment needs to accelerate its transition to management models that promote greater alignment between operational efficiency and socio-environmental responsibility.

Keywords: Sustainability, Sustainable management, Sugar and alcohol, Energy, Oil

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DESAFIOS E OPORTUNIDADES PARA A SUSTENTABILIDADE NA GESTÃO DE EMPRESAS SUCROALCOOLEIRAS E REFINADORAS

Challenges and opportunities for sustainability in the management of sugar and alcohol companies and refiners

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RESUMO

A crescente demanda por modelos de gestão alinhados à sustentabilidade tem impulsionado pesquisas sobre práticas de negócios no setor de energia. No entanto, a maioria dos estudos se concentra em análises competitivas e macroambientais, negligenciando a dinâmica interna das organizações. Este estudo investiga a relação entre os modelos de gestão adotados pelas empresas sucroalcooleiras e refinadoras de petróleo e as diretrizes de gestão sustentável descritas na literatura. Para tanto, adotou-se uma abordagem metodológica baseada em uma revisão sistemática da literatura, complementada pela análise documental nas empresas selecionadas. Os resultados indicam que o setor sucroalcooleiro tem avançado significativamente na adoção de práticas sustentáveis, com destaque para técnicas regenerativas e maior integração de critérios ambientais e sociais na gestão. Em contraste, as refinarias de petróleo enfrentam desafios estruturais e regulatórios mais complexos, embora se esforcem para incorporar inovações tecnológicas para mitigar os impactos ambientais. A análise sugere que, enquanto o setor sucroalcooleiro se consolida como referência em sustentabilidade, o segmento de refino precisa acelerar sua transição para modelos de gestão que promovam maior alinhamento entre eficiência operacional e responsabilidade socioambiental.

Palavras-chave: Sustentabilidade, Gestão sustentável, Açúcar e álcool, Energia, Petróleo

INTRODUCTION

The sugar and alcohol and refining sectors play a strategic role in the Brazilian economy, encompassing activities such as the production of sugar, ethanol and electricity from sugarcane biomass, in addition to oil refining to obtain derivatives essential for the country's economic development. These segments are of great national importance, contributing significantly to job creation and the trade balance. The oil and gas sector, which includes refining, employs more than 330,000 workers, while the sugar and alcohol sector generates more than one million jobs (CNN, 2021; FAESP, 2022).

However, the production of sugar, ethanol and electricity from sugarcane has considerable environmental and social impacts. Sugarcane cultivation currently occupies more than 10 million hectares (UNICA, 2023), which can result in the loss of biodiversity and an increase in greenhouse gas emissions. In addition, sugarcane production can cause soil, water and air pollution, while the use of pesticides poses a risk to the health of workers and local communities.

Oil refining, in turn, also presents significant environmental and social challenges. The stages of production, storage and transportation of petroleum derivatives increase the risk of environmental accidents and adverse impacts on human health (WWF, 2022).

Given this scenario, it is essential that companies in the sugar and alcohol and refining sectors implement sustainable practices to minimize their environmental and social impacts and ensure long-term economic viability. The adoption of environmental, social and sustainable management systems can be a determining factor in improving the sustainable performance of these organizations.

It is important to highlight that bioenergy companies are not automatically sustainable, just as environmental and social responsibility practices in companies in the fossil fuel sector do not guarantee their characterization as sustainable. Therefore, this research seeks to critically evaluate the management adopted by sugar and alcohol and refining companies, analyzing their adherence to the principles of sustainability and sustainable management. This approach will allow for a deeper understanding of the challenges and opportunities for the consolidation of sustainability in the management of these segments.

In this context, the research proposes to answer the following central question: What is the relationship between the management of sugar and ethanol and refining companies and sustainability? To address this question, the study aims to characterize the relationship between the management models adopted in these sectors and the particularities of the sustainable management models described in the literature. To this end, the work had three specific objectives: (i) to review the environmental, social and sustainable management systems applied in the sugar and ethanol sector; (ii) to carry out a similar review for the refining sector; and (iii) to characterize the management models adopted by companies in both sectors, in order to discuss opportunities and challenges for the integration of sustainability in the management of these organizations.

Thus, understanding the relationship between the management models adopted in the sugar and alcohol and refining sectors and the principles of sustainability becomes essential to assess advances, challenges and opportunities in the integration of sustainable practices. To support this analysis, the next chapter presents the theoretical basis of the study, addressing the main concepts of strategic management, corporate sustainability and sustainable management models, establishing the basis for the investigation of the selected companies.

1. THEORETICAL BASIS

1.1 Strategic Management and Competitiveness

The strategic management process is defined by Hitt, Ireland and Hoskisson (2011, p. 6) as “[...] the set of commitments, decisions and actions necessary for the company to obtain competitive advantage and above-average returns.” Ghemawat (2012, p. 2) complements this view by highlighting that strategy is a concept originated from the Greek word *strategos*, used to designate the military commander-in-chief. In ancient Greek, *strategia* refers to the ability and capacity of a general to organize and conduct military campaigns (Serra; Torres; Torres, 2003).

In the business context, strategy can be understood as a set of actions and decisions structured to generate competitive advantage. Strategic competitiveness manifests itself in the implementation of strategies that add value

to the business. Serra, Torres and Torres (2003, p. 5) reinforce this perspective by defining business strategy as “a set of actions executed with the intention of achieving objectives.” In this sense, strategy formulation is an ongoing and essential process for strategic management.

Business-level strategy, in turn, focuses on individual business units. Each strategy allows the company to identify and exploit a competitive advantage within a specific scope, taking into account external factors such as economic trends and technological developments, which directly influence organizational results (Chung et al., 2016; Hitt, Ireland & Hoskisson, 2011).

Strategy formulation can be compared to an organizational flight plan, in which the objectives to be achieved and the actions necessary to achieve them are defined. Questions such as which initiatives should be implemented to strengthen the competitive position and optimize the profitability of business units are crucial for strategic management (Bora, Borah & Chungyalpa, 2017).

Setting strategic objectives is particularly challenging for small businesses, where owners often also serve as managers. In these situations, there is a risk that strategic decisions will be made subjectively, prioritizing individual interests over the sustainable growth of the company. This misalignment can result in internal conflicts and operational difficulties (Costa, 2004).

In an increasingly dynamic and competitive business environment, Ansoff (1993) emphasizes the need for management tools that help strategists, managers and employees to align, monitor and adjust their strategies continuously. In this context, Lobato et al. (2003) highlight the importance of the Balanced Scorecard (BSC) as an essential tool for strategic management. The BSC allows the definition of financial and non-financial performance indicators, facilitating the deployment of organizational strategies and ensuring their effective implementation.

The evaluation of corporate performance and strategic business units must be a continuous process of learning and adaptation. Although it is common to associate strategic management with large companies, its role is equally relevant for smaller businesses. Chiavenato and Sapiro (2009) argue that strategic formulation guides the company in defining a medium and long-term direction, and should always be aligned with its strategic stance.

An essential aspect of strategic formulation is the competitive positioning of the organization. For planned strategies to be effectively implemented, an alignment between processes, organizational competencies, financial resources and operational structure is necessary (Tachizawa and Rezende, 2000; Tavares, 2010). Thus, the adoption of an accurate environmental diagnosis and a detailed analysis of market conditions are decisive for building a sustainable competitive advantage. The effectiveness of the organizational strategy is, therefore, directly related to the company's ability to translate its strategic objectives into concrete and measurable actions (Hitt, Ireland and Hoskisson, 2011).

Every organization seeks strategies and implements them in the hope of achieving returns, that is, profits greater than those the investor expected to earn, considering all risks and uncertainties. Knowing how to exploit competitive advantages, in addition to minimizing risks, helps to obtain satisfactory returns.

It is important to evaluate internal and external processes to choose the appropriate strategy, select resources and skills in order to obtain the best process to achieve the desired results (Hitt, Ireland and Hoskisson, 2011).

1.2 Sustainable Management: Concepts and Practices

Sustainability, therefore, must be integrated into the decision-making process, simultaneously considering economic, environmental and social aspects. In the economic axis, sustainable management seeks to ensure the viability of enterprises, making them attractive to investors. In the environmental sphere, the objective is to minimize impacts on ecosystems and promote operational practices aligned with environmental preservation. In the social pillar, sustainability involves the promotion of fair and balanced relationships with stakeholders, including employees, suppliers, customers and communities affected by business activities (Gassenferth et al., 2015; Oliveira et al., 2012).

In this sense, sustainable management must strengthen the principles of the Tripod Bottom. Line (TBL), which proposes the creation and maintenance of business value in three interdependent dimensions: social, environmental and economic (Laasch; Conaway, 2015). Companies that integrate these pillars in their operations tend to be more resilient in the face of regulatory, reputational and market challenges.

Companies today operate within a global context marked by significant socio-environmental challenges, including climate change, resource depletion, and persistent social inequalities. Given the growing importance of environmental, social and ethical issues in the global business scenario, it is imperative that organizations adapt not only to regulatory requirements, but also to the new demands of consumers, who are increasingly aware of the origin and impacts of the products and services they consume (Machado et al., n.d.; Silva Filho et al., 2021). Therefore, strategic decisions cannot be made without due consideration of socio-environmental aspects.

In this landscape, embracing socio-environmental commitments is no longer merely an option but a strategic imperative. Corporate social responsibility (CSR) encompasses voluntary actions designed to generate positive outcomes for all stakeholders, extending beyond mere profit maximization to include environmental, social, and economic dimensions (Machado et al., n.d.; Silva Filho et al., 2021). By integrating these commitments, businesses can proactively mitigate negative impacts from their operations, build a positive brand image, and foster sustained growth, demonstrating an ethical and transparent approach that benefits both the community and the planet (Machado et al., 2023).

Furthermore, strong socio-environmental commitments are crucial for a company's continued operation and competitive advantage. Gaining and maintaining a "social license to operate" (SLO) means not only complying with formal regulations but also addressing the broader concerns of host communities and society (Silva Filho et al., 2021). Companies that actively share value with their stakeholders and align their practices with global frameworks like the UN's Sustainable Development Goals (SDGs) demonstrate a commitment to collective well-being, which is essential for legitimacy and preventing reputational damage that could lead to operational interruptions or even closure (Silva et al., 2022; Silva Filho et al., 2021). This holistic approach to sustainability, encompassing people, planet, prosperity, peace, and partnerships, allows organizations to adapt to evolving societal expectations and respond effectively to 21st-century challenges (Silva et al., 2022).

To translate these strategic commitments into tangible results, however, internal alignment is paramount. In addition to regulatory and market compliance, employee awareness and engagement are key factors for the success of sustainable management. Environmental awareness within companies must be incorporated into the organizational culture, so that sustainable practices are internalized in the daily lives of employees. Theoretical knowledge about environmental impacts alone is not enough; it is essential that concrete measures are implemented in the workplace.

To enhance this transformation, companies must promote regular discussions on sustainability, identifying practices that can be improved or replaced to reduce environmental impacts. An effective strategy in this regard is environmental literacy, which consists of training employees through specific training on environmental management. This approach not only facilitates sustainable decision-making, but also drives innovation and organizational growth in a responsible manner (Ferronato, 2011).

1.3 Sustainability and Sustainable Development

In recent decades, sustainability has emerged as a central concept in the formulation of business strategies and public policies. The debate on sustainable development is becoming increasingly relevant as companies and governments face complex challenges related to the use of natural resources, social inequality and the need for balanced economic growth. In the corporate context, the adoption of sustainable practices not only contributes to environmental preservation and social justice, but can also generate competitive advantages by strengthening the reputation and resilience of organizations in the face of crises and regulatory pressures (Machado et al., 2023).

For Arruda et al. (2012), sustainable development is based on socio-environmental responsibility and innovative actions that permeate the organizational environment, promoting a balance between the economic, environmental and social dimensions. The classic concept of sustainable development was introduced in the Brundtland Report, which defines it as that which meets the needs of the current generation without compromising the ability of future generations to meet their own needs (Brundtland, 1987).

Sustainability must be understood based on three fundamental pillars: ecological, economic and social. From an economic point of view, productive activities must prioritize initiatives that ensure the creation of sustainable value, balancing financial interests and long-term impacts. From an environmental perspective, it is essential to adopt practices that minimize damage to ecosystems and ensure the preservation of biodiversity (Assis

et al., 2009; Nobre and Amazonas, 2002). In the social pillar, sustainability translates into principles such as inclusion, respect, transparency and quality in relationships with internal and external stakeholders, including employees, shareholders, customers, suppliers, the State and the community in which the company operates (Assis et al., 2009).

Effective implementation of sustainable development requires companies and organizations to reevaluate their management models, promoting corporate governance that integrates innovative and socially responsible practices. The adoption of sustainability metrics and indicators also plays a crucial role in measuring impacts and continuously improving business strategies, consolidating sustainable development as a structuring axis of global competitiveness (Isaac et al., 2017).

1.4 Challenges and Opportunities for Sustainability in the Sugar and Alcohol and Refining Sectors

The adoption of sustainable practices in the sugar and ethanol and oil refining sectors involves distinct challenges, which reflect the operational and structural characteristics of each industry. In the sugar and ethanol sector, one of the main challenges is maintaining sustainability throughout the entire production chain, from the cultivation of sugarcane to the marketing of its derivatives, such as ethanol and sugar. According to Fujihara (2013), this production chain requires the adoption of sustainable agricultural practices, such as regenerative agriculture, crop rotation, and the reduction of the use of chemical fertilizers and pesticides, which can negatively impact soil and water resources. In addition, issues such as the mechanization of planting and harvesting, combined with the need for environmental certifications, represent critical factors for the sustainable competitiveness of the sector.

In the oil refining sector, sustainability is directly linked to technological innovation and energy efficiency. According to Sousa and Gomes (2021), refineries have invested in the development of less polluting processes, such as carbon capture and storage (CCS) and the optimization of waste conversion. However, these technological advances face significant barriers, such as high implementation costs, time to adapt industrial plants, and complexity in the management of petrochemical waste. In addition, the sector faces stricter regulatory challenges, which require greater transparency and adaptation to global requirements for reducing greenhouse gas emissions. The creation of more sustainable supply chains and the search for energy sources with a lower environmental impact, such as advanced biofuels and green hydrogen, are strategic opportunities for this segment, aligning it with stakeholders' demands for greater socio-environmental responsibility.

Integrating sustainability into the management of sugar and ethanol and oil refining companies represents both a challenge and an opportunity. While the sugar and ethanol sector has made significant progress in implementing sustainable practices, driven by the growing demand for biofuels and renewable energy, the oil refining sector faces more structural challenges in transitioning to truly sustainable management. The main opportunities include the development of technological innovations to reduce emissions and optimize processes, as well as the adoption of effective environmental management systems. On the other hand, the main barriers include the need for cultural change within organizations, resistance to adopting new practices, and adapting to increasingly restrictive new environmental regulations.

Given this scenario, understanding the sustainability dynamics in these sectors is essential so that companies can not only improve their environmental and social performance, but also strengthen their competitiveness in global markets. The ability to innovate and adapt to the growing demands for environmental responsibility and corporate governance will be decisive for the strategic positioning of these industries in the coming years.

2 METHODOLOGY

This is an exploratory and qualitative research that investigates how management models adopted by sugar and ethanol plants and oil refineries relate to sustainability practices. The study was structured in four stages: (i) structured literature review, (ii) documentary data collection, (iii) content analysis, and (iv) cross-validation of findings.

2.1 Structured Literature Review

The first stage consisted of a structured literature review inspired by the protocol of Denyer and Tranfield (2009), aiming to identify sustainable management models in the energy sector. Although systematic criteria were adopted to ensure transparency and reproducibility, the review was not conducted as a formal systematic literature review. Searches were conducted in Scopus, Web of Science, and SciELO using terms such as “sustainable management”, “environmental management”, “energy sector”, “bioenergy”, “oil refining” and “business sustainability”. Filters limited results to peer-reviewed articles from the last 15 years. Selected works were thematically grouped according to the main approaches to sustainability in sugar/ethanol and oil refining industries.

2.2 Documentary Data Collection

The second stage involved the selection and analysis of institutional documents from four companies: two oil refineries (Riograndense and Mataripe) and two sugar and ethanol plants (São Francisco and Santo Antônio). Selection criteria included: (i) public availability of sustainability reports, (ii) presence of certifications or programs (e.g., ISO 14001, Bonsucro, Renovabio), and (iii) geographic and operational diversity. Documents analyzed included sustainability reports, corporate policies, and other institutional publications.

2.3 Analytical Framework and Content Analysis

The third stage applied content analysis (Bardin, 1977), based on the dimensions of the Triple Bottom Line: economic, social, and environmental. The data extracted from the companies were coded according to these dimensions, allowing for a thematic comparison within and between sectors. Patterns of convergence and divergence were identified. The content analysis also allowed for cross-referencing of empirical evidence with theoretical models previously identified in the literature review.

2.4 Structuring of Results

The results were structured in two complementary stages. The first consisted of a synthesis of **seven academic studies** selected for their relevance to the topic of sustainable management in the sugar and ethanol and oil refining sectors. These studies were analyzed to identify key theoretical principles, challenges, and good practices related to corporate sustainability in both industries.

In the second stage, the study examined the **sustainability strategies of four companies**—two sugar and ethanol plants and two oil refineries—based on institutional documents. The analysis of these cases was organized according to the **three pillars of sustainability**: economic, social, and environmental. This structure allowed for a critical comparison between sectors and facilitated the identification of convergences and divergences between the theoretical framework and actual corporate practices.

2.5 Data Validation

Finally, the validity and reliability of the analysis were reinforced through methodological triangulation, combining bibliographic data and institutional documents, and through the application of inclusion and exclusion criteria during literature selection and document sampling.

3 RESULTS AND DISCUSSION

The research resulted in the identification and analysis of seven key studies that directly support the understanding of the relationship between management models adopted in the sugar and ethanol and oil refining sectors and sustainability. These studies were selected based on their academic and technical relevance, considering criteria such as thematic scope, methodological quality and adherence to the scope of the study. The main

contributions of these materials to the discussion of the challenges and opportunities in implementing sustainable practices in these sectors are presented below.

Title	Author(s)
1. Corporate social responsibility: a multi-case study with small companies in the sugar and alcohol sector in the Ribeirão Preto region – SP	Borges, F. L. S., Galli, L. C. L., & Tamashiro, H. R. S. (2012). Responsabilidade social corporativa: Um estudo multicase com pequenas empresas do setor sucroalcooleiro da região de Ribeirão Preto – SP.
2. Oil industry and sustainability: scientific mapping	Sousa, R. D. R., & Gomes, E. T. A. (2024). Indústria do petróleo e sustentabilidade: Mapeamento científico.
3. Waste management in the oil and gas industry: an integrated management proposal	Moni, R. C., Quelhas, O. L. G., França, S. L. B., & Merino, M. J. (2011). O gerenciamento de resíduos na indústria de petróleo e gás: Uma proposta de gestão integrada.
4. Business sustainability: Concept and indicators	Araújo, G. C., Bueno, M. P., Sousa, A. A., & Mendonça, P. S. M. (2006). Sustentabilidade empresarial: Conceito e indicadores.
5. The issue of sustainability focused on organizational performance: an exploratory analysis in companies in the sugar and alcohol sector in the state of São Paulo	Pereira, M. A., Crepaldi, M. R., & Calarge, F. A. (2010). A questão da sustentabilidade voltada ao desempenho organizacional: Uma análise exploratória em empresas do setor sucroalcooleiro no estado de São Paulo.
6. Recycling of oily sludge: a contribution to the sustainable management of waste from the oil industry in Sergipe	Alves, M. R. F. V. (2003). Reciclagem de borra oleosa: Uma contribuição para a gestão sustentável dos resíduos da indústria de petróleo em Sergipe.
7. Corporate sustainability in the Brazilian sugar and ethanol sector	Lins, C., & Saavedra, R. (2007). Sustentabilidade corporativa no setor sucroalcooleiro brasileiro.

The selected studies address issues ranging from the implementation of corporate social responsibility to sustainable management practices and technological innovations that minimize environmental impacts. The main findings of each document are presented below, highlighting their contributions to this research.

- a. Borges, Galli e Tamashiro (2012) investigate the implementation of socio-environmental responsibility in small companies in the sugar and alcohol sector in the region of Ribeirão Preto, São Paulo. Based on a multi-case study with three companies participating in the TEAR Program, promoted by the Ethos Institute, the research shows that the adoption of Corporate Social Responsibility (CSR) practices contributes to market differentiation and the promotion of sustainability. Even when facing structural and financial challenges, the companies analyzed perceive the incorporation of CSR as a positive factor for sustainable development and for improving their institutional reputation.
- b. Sousa e Gomes (2024) map scientific publications on sustainability in the oil industry, highlighting the growing emphasis on solutions to mitigate environmental impacts. The results indicate a significant increase in research focused on energy efficiency and carbon emissions reduction, driven by regulatory and social pressures. Although the industry faces substantial challenges in adapting to new environmental requirements, the study highlights that investment in clean technologies and innovation is essential for the long-term viability of the sector.
- c. Moni, Quelhas, França e Merino (2011) analyze the integration between solid waste management and environmental management systems in the oil industry, with a specific focus on offshore facilities. The authors identify challenges, such as the lack of preventive policies for the proper management of waste, which compromises the efficiency of processes. As a solution, the study proposes practical guidelines for sustainable management, emphasizing the use of specific technologies and appropriate regulatory strategies to ensure eco-efficiency and reduce the environmental impacts of oil activity.

- d. Araújo, Bueno, Sousa e Mendonça (2006) present an in-depth discussion on the evolution of the concept of sustainability and propose indicators to assess its application in the Brazilian business context. The research covers the three dimensions of sustainability — environmental, economic and social — and concludes that the integration of these factors is essential for the resilience and viability of organizations in the long term. The study also highlights the need for clear and standardized metrics to monitor and evaluate sustainable performance in companies.
- e. Pereira, Crepaldi e Calarge (2010) examine how companies in the sugar and ethanol sector have responded to demands for greater sustainability. Based on a documentary analysis of 167 mills, the authors found that approximately half of the companies analyzed already adopt sustainable practices. However, cultural and managerial barriers still persist that hinder the consolidation of these practices. The study emphasizes the need for greater organizational engagement, investment in sustainable innovation, and improvement of internal processes to strengthen the sustainable performance of mills.
- f. Alves (2003) proposes an innovative solution for the disposal of one of the most polluting wastes in the oil industry: oily sludge. The study demonstrates the feasibility of using this waste in the production of ceramic blocks, reducing environmental impacts and promoting circular economy practices in the oil sector. The research indicates that this strategy can significantly contribute to reducing the industry's environmental liabilities, in addition to generating new sustainable business models based on the reuse of industrial waste.
- g. Lins e Saavedra (2007) analyze the challenges and practices adopted by large companies in the sugar and alcohol sector in Brazil to incorporate sustainability into their operations. The results show that, although there are still barriers to the implementation of sustainable practices, the sector has already shown significant progress, especially in energy cogeneration and waste management. The study highlights that, in order to achieve global sustainability standards, companies need to intensify technological innovation and improve corporate transparency, ensuring greater alignment with regulatory requirements and stakeholder expectations.

Considering the analysis of the literature and the data from the companies that are the subject of this study, it is possible to identify how theoretical principles of sustainability and corporate responsibility are reflected in real organizational contexts. The strategic positioning of companies in the oil refining sector exemplifies how concepts such as operational excellence, transparency, environmental efficiency, and social commitment, highlighted by authors such as Sousa and Gomes (2024), Moni et al. (2011), and Alves (2003), are translated into practice.

The Riograndense Oil Refinery seeks to establish itself as a leading company in the oil refining sector, basing its operations on sustainability, technological innovation and value creation for its shareholders, employees and the community. Its mission is to operate efficiently in oil refining, providing high-quality products, minimizing environmental impacts and contributing to the socioeconomic development of the region. Its main values include sustainability, ethics, transparency, safety and innovation. Its strategic objectives include expanding refining capacity, technologically improving production processes and reducing environmental impact, in addition to strengthening its role in regional development.

Mataripe Refinery, managed by Acelen, has the vision of becoming a reference in the energy and oil refining sector, both in Brazil and globally, focusing on operational excellence, innovation and sustainability. Its mission is to supply high-quality energy products, operating efficiently and safely, promoting sustainable development and contributing to the country's economic growth. The values that guide its operations include safety, sustainability, innovation, ethics and respect for people. Its main objectives include expanding production and refining capacity, implementing advanced technologies to improve efficiency and reduce emissions, and generating positive socioeconomic impacts in the region where it operates.

The São Francisco Mill, part of the Balbo Group, stands out for its vision of being a global reference in sustainable agriculture, promoting a balance between agro-industrial practices and environmental preservation. Its mission is to produce sugar, ethanol and other agricultural products in a sustainable manner, with a focus on environmental preservation, technological innovation and social well-being, generating value for its employees, customers and the community. Its values include sustainability, innovation, ethics, respect for nature and human appreciation. Its strategic objectives include expanding the production of organic sugar and ethanol, improving

energy efficiency and reducing carbon emissions, in addition to promoting the sustainable development of local communities. The mill seeks to establish itself as a model of sustainability in the agro-industrial sector.

The Santo Antônio Mill, also part of the Balbo Group, aims to establish itself as a global agro-industrial company that is a benchmark in sustainability, promoting the regeneration of ecosystems and the integration of agricultural production with the environment. Its mission is to produce sugar, ethanol and other sugarcane derivatives in a sustainable manner, respecting the environment and generating value for its stakeholders. Its organizational values include sustainability, innovation, ethics, respect for the environment and social responsibility. Its main objectives involve expanding the production of organic sugar and ethanol, implementing regenerative practices to conserve biodiversity, improving energy efficiency and strengthening the positive socioeconomic impact on local communities. The mill seeks to establish itself as a global model of sustainable agro-industrial production.

3.1 Discussion

The evaluation of the selected companies, two oil refineries (Riograndense and Mataripe) and two sugar and ethanol plants (São Francisco and Santo Antônio), was guided by the three pillars of sustainability: economic, social, and environmental. Despite operating in distinct sectors, it is possible to identify points of convergence and divergence in the way these companies integrate sustainability into their management models.

a. Economic Dimension

From an economic standpoint, all companies demonstrate strategies aimed at sustainable growth and competitiveness. The refineries focus on expanding production capacity and increasing operational efficiency. The Mataripe Refinery, under private management since its privatization, prioritizes international market expansion and technological modernization. In contrast, the Riograndense Refinery adopts a more regionally oriented approach, investing in process improvement and sustainable innovation.

These strategies are in line with findings from *Sousa and Gomes (2024)*, which emphasize the oil sector's efforts to increase energy efficiency and reduce environmental impacts—although implementation remains challenging due to regulatory and technological constraints.

In the sugar and ethanol sector, São Francisco and Santo Antônio mills follow a different economic path. Both are focused on producing organic sugar and ethanol, aiming at high value-added markets. Their expansion aligns with the increasing demand for renewable and traceable products, a strategy supported by *Lins and Saavedra (2007)*, who highlight the sector's progress in energy cogeneration and cleaner production. This places the plants in a more advanced position in terms of integrating sustainability into their business models.

b. Social Dimension

Social responsibility is a common value across the four companies, but the scope and depth of their actions vary. Refineries focus on operational safety, transparency, and regional development. For instance, Mataripe has intensified its social investments post-privatization, while Riograndense emphasizes long-standing engagement with local stakeholders.

The sugar and ethanol plants exhibit a more embedded relationship with surrounding communities. Their social strategies encompass education, health, inclusion, and employee well-being. The proximity to rural areas reinforces this dynamic, promoting socially inclusive agro-industrial practices. These findings align with *Borges et al. (2012)*, who identified that even small sugar-alcohol companies adopt practices that link production to community development.

While both sectors recognize the relevance of the social pillar, sugar and ethanol companies demonstrate greater maturity and integration, suggesting a more humanized and territorially committed sustainability agenda.

c. Environmental Dimension

The environmental dimension presents the most striking contrast between the two sectors. The refineries face substantial challenges due to the inherently polluting nature of oil processing. Despite this, both Riograndense and Mataripe report efforts to reduce emissions and invest in clean technologies. Riograndense appears more consolidated in this regard, with structured environmental strategies, while Mataripe is in a transition phase, adjusting to new sustainability targets and regulations.

Studies such as *Moni et al. (2011)* and *Alves (2003)* reinforce this context by pointing to the oil industry's reactive stance in waste management and the slow adoption of preventive environmental practices.

In contrast, the sugar and ethanol plants stand out as models of environmental sustainability. Both employ regenerative agricultural techniques, promote biodiversity conservation, and adopt low-carbon technologies. Their practices align with *Pereira et al. (2010)*, who emphasize the sugar-energy sector's leadership in environmental innovation and integration of sustainability into production systems.

These plants not only minimize negative impacts but also actively contribute to ecosystem regeneration, solidifying their role in the transition to a green economy.

3.1.1 Cross-Sector Comparison

Comparing the two sectors reveals that while both show commitment to sustainability, they operate at different stages of integration and face distinct structural challenges:

- Economically, refineries still rely on fossil-based business models, whereas plants operate in markets driven by renewable products and sustainable consumption.
- Socially, plants present a stronger territorial and human connection, integrating sustainability more directly into their local contexts.
- Environmentally, refineries face legacy and technological hurdles, while plants demonstrate greater alignment with global environmental goals through regenerative and organic practices.

This analysis suggests that while oil refineries are progressing toward sustainability, they require more robust structural shifts to reduce fossil dependency. Meanwhile, the sugar and ethanol plants—especially those of the Balbo Group—are consolidating a position of leadership, leveraging innovation, ecological agriculture, and community engagement to embody a regenerative business model.

CONCLUSION

This study analyzed the relationship between the management models adopted by companies in the sugar and ethanol and oil refining sectors and their respective sustainability approaches. The findings indicate significant differences between the two sectors, both in the degree of implementation of sustainable practices and in the challenges faced in consolidating sustainability in their operations.

In the sugar and ethanol sector, mills such as São Francisco and Santo Antônio stand out for adopting regenerative and organic agricultural practices, reflecting a stronger commitment to environmental sustainability. In addition, these companies integrate the economic and social pillars more effectively, promoting positive impacts on local communities and actively contributing to sustainable development.

On the other hand, oil refineries, although committed to innovation and operational efficiency, still face more complex structural challenges to align their activities with sustainability requirements, especially with regard to environmental impact. The Riograndense and Mataripe refineries, for example, have invested in reducing emissions and in clean technologies, but the transition to a fully sustainable model is still a gradual process, conditioned by the very nature of the oil industry and the difficulties in replacing fossil fuels.

From an economic perspective, both sectors are seeking to increase production efficiency and market competitiveness. However, while sugar and ethanol plants are benefiting from the growing demand for renewable products, such as organic sugar and sustainable ethanol, refineries continue to depend on fossil fuels, which poses a challenge for them to adapt to new global sustainability guidelines.

From a social perspective, both plants and refineries demonstrate a significant commitment to the safety and development of local communities. However, plants maintain a more direct connection with the social development of the regions where they operate, mainly because they are closer to the agricultural chains and small rural producers.

Given this scenario, it can be concluded that sugar and ethanol plants have management models that are more aligned with the principles of sustainability, with more advanced practices in environmental and social aspects. Refineries, in turn, face more significant challenges in adapting their operations, especially with regard to environmental sustainability. However, it can be observed that both sectors recognize the importance of sustainability and are advancing, albeit at different rates, in their transition strategies to more sustainable models.

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