

Sustainable Development And Socio-Environmental And Corporate Responsibility As A Competitive Advantage In The Energy Transition In The State Of Ceará

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Abstract:

Background: The concert of nations has become aware of the importance of sustainable development as a means of mitigating the effects of environmental degradation and social impacts. To achieve ecosystem balance, the three pillars of sustainability—economic, social, and environmental—must operate in harmony.

Materials and Methods: This study employed a qualitative approach. The research was conducted through bibliographic and documentary analysis.

Results: The study identified the adherence of companies and industries in the state of Ceará to sustainable development practices within their business models. This commitment has the potential to position Ceará with a competitive advantage in the global energy transition.

Conclusion: The research demonstrated a range of economic and socio-environmental benefits associated with the energy transition in Ceará, suggesting that sustainable development and socio-environmental and corporate responsibility can strategically favor the region in the global energy landscape.

Keywords: Sustainable development; socio-environmental responsibility; energy transition; competitive advantage.

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I. Introduction

Global warming and the resulting climate change are phenomena that characterize the contemporary world. Nature, as a result of intense economic activities, has demonstrated that the use of fossil fuels for energy generation—anchored in a model of unlimited consumption—has led to severe climate changes with disastrous consequences for the environment.

It was only in the second half of the 20th century that international organizations began to recognize that the ecosystem was under intense pressure from greenhouse gas emissions, bringing serious socioeconomic consequences across all continents. At that time, the first initiatives emerged to raise awareness that decarbonizing the economy and advancing the energy transition would be essential steps in mitigating the damage caused by the economic model based on high consumption of natural resources.

New concepts then emerged to reconcile economic development with socio-environmental development. The alignment of these principles would contribute significantly to an effective energy transition. The state of Ceará could not remain outside this race toward economic, social, and environmental sustainability in favor of the energy transition, as it presents favorable indicators and a proven commitment to this issue.

The methodology adopted in this study is distinguished by its qualitative approach, which is fundamental for a deep and critical understanding of the influence of sustainable development principles and socio-environmental and corporate responsibility in the energy transition process in Ceará. Two research procedures were employed: bibliographic research, supported by scientific works, including articles and theses that guided the study's development, and documentary research, based on the analysis of both national and international documents that present and support the interconnection between sustainable development and energy transition.

Accordingly, the general objective of this study is to characterize the extent to which the principles of sustainable development and socio-environmental and corporate responsibility—implemented by companies and economic organizations—could competitively favor Ceará in the context of the global energy transition.

The specific objectives established are as follows: to provide a brief historical overview of the implementation of sustainable development by the international community since the 20th century; to present concepts, definitions, importance, and benefits of socio-environmental and corporate responsibility in the contemporary world; and to analyze sustainable development and socio-environmental and corporate responsibility in Ceará as a competitive advantage in the global energy transition.

This article is organized into four sections. The first section presents the introduction, outlining the research context, the methodology adopted, and the objectives of the study. The second section discusses the methodological aspects in detail, focusing on the qualitative approach and the research procedures used. The third section comprises the theoretical framework, addressing sustainable development, socio-environmental and corporate responsibility, and their influence on the global energy transition as driven by the state of Ceará. Finally, the fourth section presents the final considerations, which summarize the main findings and suggest directions for future research.

II. Material And Methods

The methodology adopted for the development of this research is characterized by its qualitative nature, whose significance within the scientific domain lies in its capacity to provide an in-depth and contextualized understanding of economic, social, and environmental phenomena.

As emphasized by Lakatos and Marconi (2019), qualitative research goes beyond mere quantification and seeks to interpret meanings, interrelationships, and the underlying structures of data, thereby proving particularly effective in investigations aimed at exploring the direct relationship between sustainable development and energy transition. The methods employed consisted of bibliographic and documentary research. The former was based on the analysis of national and international publications, reports, scientific articles, and websites, thus providing a solid theoretical foundation.

According to Pereira et al. (2018), this type of approach is essential to global science, as it enables the organization of existing knowledge and offers guidance for future research. Documentary research, in turn, relied on the analysis of national and international publications pertinent to the topic, including reports from the Intergovernmental Panel on Climate Change (IPCC), the International Energy Agency (IEA), the United Nations (UN), the Global Reporting Initiative (GRI), McKinsey & Company, the Office of the President of Brazil, the Ministry of Science, Technology and Innovation (MCTIC), the Ministry of Mines and Energy (MME), the Ministry of Foreign Affairs (MRE), the Federation of Industries of the State of Ceará (FIEC), as well as sustainability reports from Qair Brasil, Casa dos Ventos, and the Pecém Industrial and Port Complex (CIPP).

These documents facilitated the understanding of the interface among sustainable development, socio-environmental and corporate responsibility, and the energy transition, offering the State of Ceará the potential for a competitive advantage in the ongoing energy transition process.

According to Grazziotin, Klaus, and Pereira (2022), the combination of documentary and bibliographic research constitutes powerful methodological tools for scientific progress, as it enabled not only the organization of consolidated knowledge but also the establishment of interrelations between sustainable development and energy transition. In this context, the articulation between bibliographic and documentary sources enhanced the analytical depth of the study, allowing for an integrated interpretation of the economic, social, and socio-environmental aspects related to Ceará's competitive advantage in the energy transition process.

III. Literature Review

This theoretical framework was structured into three subsections. The first provides a brief historical overview of the implementation, foundations, origins, and justifications of sustainable development as promoted by the international community since the 20th century. The second aims to present the concepts, definitions, significance, and benefits of socio-environmental and corporate responsibility in the contemporary world, highlighting their relevance for both current and future generations. The third offers an analysis of the current context of sustainable development and corporate socio-environmental responsibility in the State of Ceará, emphasizing their role as a competitive advantage for the region within the ongoing global energy transition.

Brief Historical Overview of the Implementation of Sustainable Development by the International Community Since the 20th Century

Climate change, primarily driven by economic activities centered on the production and consumption of fossil fuels, has led to significant environmental degradation. These impacts are particularly concerning given the sensitivity of ecosystems within the biosphere to anthropogenic disturbances. Environmental pollution and the depletion of natural resources have become critical areas of study, as the accelerated pace of environmental degradation threatens the regenerative and restorative capacities of ecological systems (Barbosa & Gomes, 2024b).

Historically, the adoption of an economic production system reliant on non-renewable energy sources, characterized by substantial emissions of greenhouse gases and pollutants, has culminated in concurrent energy and environmental crises. Addressing these challenges necessitates collaborative efforts between private sectors and governmental entities on an international scale (Costa et al., 2024).

Recognizing these pressing issues, the international community and various global organizations-initiated dialogues in the latter half of the 20th century to emphasize the importance of harmonizing economic development with socio-environmental considerations. This collective foresight aimed to mitigate the adverse impacts of environmental degradation resulting from unsustainable economic practices.

The Club of Rome and *The Limits to Growth* Report

In 1968, a consortium of politicians, physicists, industrialists, and scientists convened in Italy to deliberate on the planet's sustainable development. This assembly, known as the Club of Rome, was the first international association to critically examine sustainability and environmental concerns, focusing on the limitations of economic growth in the context of escalating natural resource consumption (Ferreira, 2014).

By 1972, in collaboration with the Massachusetts Institute of Technology (MIT), American scientists Dennis Meadows and Donella Meadows, along with Norwegian academic Jørgen Randers, employed advanced mathematical models to simulate the interactions between human activities and the environment. Their findings were published in the seminal report *The Limits to Growth*, which projected that if prevailing trends in population growth, industrialization, environmental contamination, food production, and resource depletion continued unabated, the planet would reach its growth limits within the next century, potentially leading to a sudden and uncontrollable decline in both population and industrial capacity (Meadows et al., 1972).

The profound impact of *The Limits to Growth* report extended to national policies, inspiring legislative measures such as Brazil's Law No. 6.938/81, which established the National Environmental Policy and the National Environment System (SISNAMA) (Mariani, 2017). This report is widely regarded as a pivotal moment in raising global awareness about the interdependence of economic development and environmental sustainability.

United Nations Conference on the Human Environment (Stockholm, 1972)

In response to the insights from *The Limits to Growth*, the United Nations convened the Conference on the Human Environment in Stockholm, Sweden, in 1972. This landmark event marked the first global conference to place environmental issues at the forefront of international discourse, with participation from 113 countries, 250 non-governmental organizations, and various UN agencies (United Nations, 1972).

The conference underscored that economic development and environmental conservation are not mutually exclusive objectives. Instead, it catalyzed a growing movement to reconcile economic, social, and environmental interests for the benefit of future generations (Chaves & Castello, 2013). The resulting Stockholm Declaration articulated 26 principles that significantly influenced environmental legislation worldwide, including the environmental chapter of Brazil's 1988 Federal Constitution (Silva, 2009, as cited in Mariani, 2017).

Additionally, the conference led to the establishment of the United Nations Environment Programme (UNEP) and the formulation of the Declaration on the Human Environment, which outlined 23 guiding principles for environmental stewardship (Juski & Ribeiro, 2015).

The Brundtland Commission and *Our Common Future*

The concept of sustainable development was further refined during the 1980s through the work of the World Commission on Environment and Development, commonly known as the Brundtland Commission. In its 1987 report, *Our Common Future*, the commission defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development [WCED], 1987).

The commission emphasized that the unchecked consumption of natural resources jeopardized their regenerative capacities, thereby threatening the well-being of future generations. It advocated for an international environmental policy framework that would ensure the availability of essential resources for the survival and prosperity of coming generations (Chaves & Castello, 2013).

United Nations Conference on Environment and Development (Rio de Janeiro, 1992)

In 1992, the United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit or Rio-92, was held in Rio de Janeiro, Brazil. This conference brought together heads of state and representatives from 179 countries to deliberate on sustainable development, building upon the foundations laid by the Brundtland Report (Chaves & Castello, 2013).

The Rio-92 conference highlighted the increasing awareness of the systemic issues inherent in the prevailing economic model and facilitated discussions on the interlinkages between socioeconomic development and ecological transformations (Estender & Pitta, 2008). A significant outcome of the conference was the adoption of Agenda 21, a comprehensive action plan designed to be implemented globally, nationally, and locally by organizations within the United Nations system, governments, and civil society in areas where human activities impact the environment (United Nations, 1992).

Agenda 21 established a framework for international cooperation aimed at promoting sustainable development throughout the 21st century. It emphasized the need for environmental awareness, institutional strengthening, and the harmonization of economic efficiency, social equity, and environmental protection (Chaves & Castello, 2013). The plan delineated three core areas of sustainable development: economic, social, and environmental (Estender & Pitta, 2008).

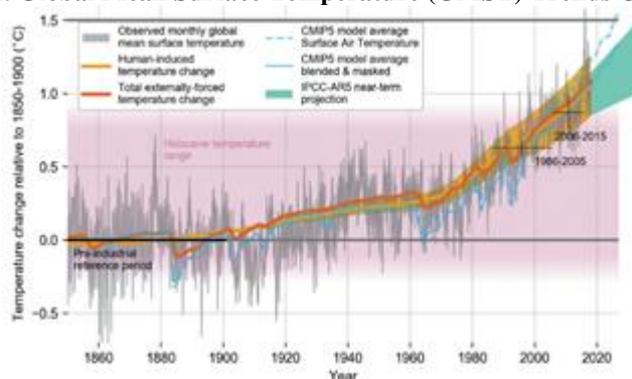
The 2030 Agenda for Sustainable Development

In 2015, during the 70th session of the United Nations General Assembly, world leaders adopted the 2030 Agenda for Sustainable Development, which introduced 17 Sustainable Development Goals (SDGs). These goals address a broad spectrum of global challenges, including poverty, inequality, climate change, environmental degradation, peace, and justice (United Nations, 2015). Among these, SDG 7 aims to ensure access to affordable, reliable, sustainable, and modern energy for all by 2030. It emphasizes the substantial increase in the share of renewable energy in the global energy mix and the enhancement of international cooperation to facilitate access to clean energy research and technology. SDG 13 focuses on taking urgent action to combat climate change and its impacts by integrating climate change measures into national policies, strategies, and planning, and by improving education and awareness-raising on climate change mitigation and adaptation (United Nations, 2015).

The Paris Agreement (2015)

The Paris Agreement, adopted in 2015 during the 21st Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC), represents a landmark international treaty aimed at strengthening the global response to climate change. The agreement's central objective is to limit the increase in global average temperature to well below 2°C above pre-industrial levels, with efforts to limit the temperature increase to 1.5°C (UNFCCC, 2015). Recognizing climate change as a common concern of humankind, the Paris Agreement underscores the necessity of balancing climate action with sustainable development and poverty eradication efforts. It mandates that all parties put forward nationally determined contributions (NDCs) and pursue domestic measures to achieve them, thereby fostering a collective commitment to mitigating climate change impacts (UNFCCC, 2015).

Figure 1. Global Mean Surface Temperature (GMST) Trends Over Time



Source: Intergovernmental Panel on Climate Change (2023, p. 57).

According to the targets set, it would be necessary to reduce CO₂ emissions by 60% by 2050 (McKinsey, 2021). Therefore, in order to achieve the goals of this agreement, it would be imperative to decarbonize a significant portion of the global energy system, which still heavily relies on polluting fossil fuels (Oliveira, 2022).

The primary objective of the agreement is to encourage actions against climate change by strengthening the capacities of countries to cope with the impacts generated by such changes. In the case of Brazil, the country is expected to reduce its emissions by 48% by 2025 and by 53% by 2030, compared to 2005 levels. Additionally, a reduction between 59% and 67% is targeted by 2035, also based on 2005 levels, which

corresponds to approximately 850 million to 1.05 billion tonnes of CO₂ equivalent in absolute terms (Ministério das Relações Exteriores [MRE], 2025).

Following the Paris Agreement, global awareness of the need to seek renewable energy alternatives—ones that are environmentally cleaner and ecologically sustainable—in opposition to petroleum-based fuels has intensified (World Economic Forum [WEF], 2024, as cited in Barbosa & Gomes, 2024b). The summit reinforced the urgency of the energy transition, including in its objectives the strengthening of the global response to climate-related threats, grounded in sustainable development (Gomes et al., 2024).

The Intergovernmental Panel on Climate Change (IPCC, 2023) released a report acknowledging the interdependence between climate, ecosystems, biodiversity, human societies, and sustainable development. The report associated the Paris Agreement with broader goals of poverty eradication and sustainable development, emphasizing that effective responses to climate change would require a collective effort guided by the United Nations Sustainable Development Goals established in 2015.

As a partial conclusion, it is evident that since the second half of the 20th century, the international community has undertaken a range of initiatives, engaging numerous countries on the issue of sustainable development. One of the most significant realizations of contemporary society is the awareness that natural resources are finite in the face of unlimited consumption.

It is, therefore, urgent to adopt a set of measures across economic, social, and environmental domains to meet and reconcile the needs and aspirations of current generations without compromising those of future generations. Part of these measures, as a solution for economic, social, and environmental sustainability, lies in the diversification of global energy generation through a comprehensive energy transition.

Concepts, Definitions, Importance, and Benefits of Socio-environmental and Corporate Responsibility in the Contemporary World

According to the *Dictionary of Environmental and Sustainable Development*, sustainable development provides long-term economic, social, and environmental benefits by considering the needs of both current and future generations. This definition not only emphasizes the conservation of natural resources but also highlights the importance of social equity (Gilpin, 1996).

According to the Brundtland Report, issued by the World Commission on Environment and Development, sustainable development should be understood as a process of transformation in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all harmonized and reinforce both present and future potential, with the aim of meeting human needs and aspirations (Ipiranga et al., 2011).

As can be observed, sustainable development is founded on three main pillars: economic development (wealth generation), environmental protection (impact on natural systems), and the social dimension. In other words, it involves the proper use of natural resources and the pursuit of social well-being, seeking a balance among these pillars (Ferreira, 2014).

From the integration of these three pillars emerged the concept of the “Sustainability Triple Bottom Line,” proposed by American entrepreneur John Elkington. This framework, also known in the context of corporate responsibility as *People–Planet–Profit*, suggests that for a company to be sustainable, it must be financially viable, socially equitable, and environmentally responsible, always aiming to maintain a balance among these three dimensions (SEBRAE, 2022).

Elkington (2001, as cited in Ipiranga et al., 2011) emphasizes that sustainability should be understood as a business management model aimed at delivering returns (profit) to shareholders, while also promoting economic development, social advancement, and the protection of natural resources. He further notes that businesses should be managed not only from a financial perspective but also with attention to social and environmental aspects.

With regard to socio-environmental issues, which have been recognized since the *Meadows Report*, the economic model based on unlimited consumption growth has demonstrated its limitations. The economy can no longer be focused solely on the benefits generated by productive activities, thus giving rise to the need for a new way of thinking about the relationship between the economy and nature (Menuzzi & Silva, 2015).

Not by chance, companies have come under increasing societal pressure to contribute to improving living conditions and preserving the environment. This pressure often stems from the inability of the State to meet society’s demands, thus encouraging the emergence of new actors willing to fill this gap. This context led to the development of corporate socio-environmental responsibility (Chaves & Castello, 2013).

As socio-environmental problems intensify around the globe—including unemployment, pollution, and depletion of natural resources—and as governments struggle to address these challenges, businesses are increasingly compelled to adopt socially responsible approaches in conducting their operations. In this context, the concepts of socio-environmental responsibility and sustainable development have come to be used as corporate strategies for growth (Chaves & Castello, 2013).

There has been a noticeable increase within the Brazilian corporate sector in discussions regarding the social and environmental roles of companies, with the aim of assuming socially responsible postures. This shift has resulted in a range of changes within the scope and dimensions of corporate activities (Chaves & Castello, 2013).

Thus, companies have come to share responsibility in addressing social and environmental issues, as they possess political power and the capacity to mobilize financial and technological resources to develop actions that can be replicated by other social actors (Young, 2004, as cited in Busch & Ribeiro, 2009).

At the international level, the European Commission defined corporate social responsibility (CSR) in its Green Paper (2001) as the voluntary integration of social and environmental concerns into business operations and in their interaction with stakeholders (Eurocid, 2023).

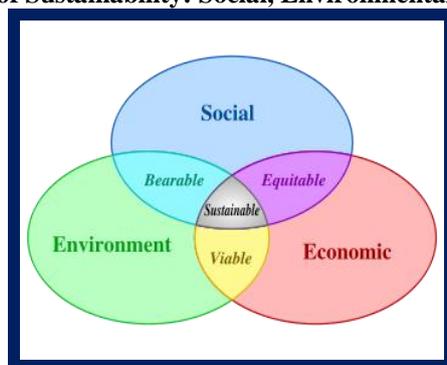
Following a global trend, Brazilian companies have become increasingly concerned with social responsibility, which is reflected in both organizational and strategic changes. In Brazil, the Brazilian Business Council for Sustainable Development (CEBDS) represents the business sector in promoting impactful sustainable solutions that enhance competitiveness for both companies and the country, through collaborative engagement with governments, academia, and civil society. Companies and industries operating in agribusiness, consumer goods, cosmetics, energy, finance, logistics, mining, oil and gas, petrochemicals, sanitation, transportation, and retail have already embraced socio-environmental responsibility (CEBDS, 2023).

CEBDS itself defines corporate responsibility as the ongoing commitment of business leaders to contribute to economic development while improving the quality of life of their employees and their families, as well as the local community and society at large (Almeida, 2002, as cited in Busch & Ribeiro, 2009).

The integration of socio-environmental variables as a core business strategy is essential for ensuring the survival of companies in a competitive market, particularly in times of global crisis (Busch & Ribeiro, 2009).

As can be observed, sustainable development is a multidimensional approach that considers the interdependencies among natural, social, and economic systems. It represents a process in which economic, financial, trade, energy, agricultural, and industrial policies—as well as all others—are implemented in a manner that promotes development that is economically, socially, and environmentally sustainable (University of Vermont, n.d.).

Figure 2. The Three Pillars of Sustainability: Social, Environmental, and Economic Intersections



Source: University of Vermont (n.d.).

As shown in Figure 2, the energy transition would not be socially just or environmentally responsible if the technological benefits and substantial capital investments it entails did not also extend to the societies to which they belong.

The world increasingly demands an energy transition, aiming to gradually replace fossil fuels—the predominant global energy source—with renewable energy sources that are less harmful to ecosystems. These emerging energy models are grounded in critical factors such as sustainable development, climate change mitigation, and technological innovation (Gomes et al., 2024).

Undoubtedly, the rapid and disruptive industrial development led to a significant increase in pollutant gas emissions, which prompted the international community to launch a global effort to mitigate its effects. This includes pursuing an energy transition capable of reducing global warming and its consequences (Barbosa & Gomes, 2024b).

In Brazil, the Ministry of Mines and Energy launched the National Plan for a Just and Inclusive Energy Transition in 2023, during the 78th United Nations General Assembly. This initiative is expected to generate multiple benefits for the country, including employment and income generation, social inclusion, reduction of socioeconomic inequalities, economic growth, reindustrialization, climate change mitigation, biodiversity preservation, and improved quality of life (Ministério de Minas e Energia [MME], 2024).

In 2025, the Ministry of Development, Industry, and Trade updated the "Action Plan for Neoliberalization 2024–2026," presenting the main strategies of the New Industry Brazil program. These strategies are designed to promote economic and social transformations and address structural barriers to Brazilian development (Ministério do Desenvolvimento, Indústria, Comércio e Serviços [MDIC], 2025).

In the industrial sector, for instance, the production of “green products” without greenhouse gas emissions represents a highly promising market for the coming years, given the growing likelihood that countries will impose carbon taxes on products generated through emission-intensive processes (Bezerra, 2023). As Mineiro et al. (2018) note, “Contemporary societies, increasingly aware of and concerned with ecological issues, will demand more sustainable solutions as a response to the challenges posed by global warming” (p. 82).

The benefits and advantages resulting from the implementation of the concepts of sustainable development and corporate socio-environmental responsibility are numerous. By prioritizing the sustainability triad, companies, industries, and economic sectors can positively impact society as a whole, with satisfactory reflections throughout the natural ecosystem (see Table 1).

Table 1: Benefits of Sustainable Development and Corporate Socio-environmental Responsibility

Economic	Social	Environmental
<ul style="list-style-type: none"> ● Economic development and efficiency; ● Job creation, income generation, and economic autonomy for local and regional communities; ● Attraction of investments; ● Improvement of business strategies; ● Better allocation and efficient management of resources; ● Energy efficiency; ● Incentive for improved production techniques; ● Increased productivity and profitability; and ● Incentives for innovation and technological development (R&D and S&T&I). 	<ul style="list-style-type: none"> ● Social inclusion; ● Better income distribution; ● Improved health, safety, education, and working conditions; ● Enhanced social justice; ● Promotion of social well-being; ● Improved quality of life and social indicators; ● Socially responsible behavior; and ● Reduction of social inequalities. 	<ul style="list-style-type: none"> ● Protection and conservation of natural resources; ● Reduction of environmental impact; ● Enhanced nature preservation; ● Reduction of air, water, soil, and subsoil contamination; ● Mitigation of atmospheric warming; ● Treatment of solid waste and pollutant substances in the environment; ● Preservation of energy resource sources; ● Promotion of recycling; ● Combating waste of natural and energy resources; and ● Reuse of inputs (raw materials).

Source: Researchers' Data

Partial conclusions indicate that sustainable development has increasingly permeated the policies, programs, and actions of various stakeholders. In response to the climate changes that have occurred over recent decades, sustainable development has emerged as a process of transformation and adaptation within contemporary society, whose implementation is understood to be a long-term endeavor.

In this context, organizations, companies, and institutions within the economic sphere have become increasingly aware that actions promoting social and environmental responsibility represent an appropriate and timely path toward mitigating the effects of climate change and global warming, while preserving a healthy and necessary balance across the human ecosystem.

Thus, it is essential to foster and sustain the continuous integration between humanity and nature in the construction of a way of life that harmonizes production and consumption, aiming to meet the needs of both current and future generations. A key component of this collective effort necessarily involves the generation of renewable energy, which serves as a driving force in the global energy transition process.

Sustainable Development and Socio-environmental and Corporate Responsibility in Ceará as a Competitive Advantage in the Energy Transition

As stakeholders within the economic system have become increasingly aware of the importance of sustainable practices within corporate business models, certifications and reports have been developed to guide actions, initiatives, and indicators related to sustainable development, as well as socio-environmental and corporate responsibility.

This section analyzes the application of ESG (Environmental, Social, and Governance) certification and the Global Reporting Initiative (GRI) report by industrial complexes in Ceará, highlighting their positive impacts on the State's competitiveness in the context of the energy transition.

ESG Certification

ESG refers to how the market evaluates and selects companies based on their environmentally responsible behavior and commitment to socioeconomic development. ESG also serves as a strategy for sustainable investment: rather than relying solely on financial indicators, investors consider environmental, social, and governance factors in their assessments (Federação das Indústrias do Estado do Ceará [FIEC], 2022).

In 2022, the Federation of Industries of the State of Ceará (FIEC) implemented the ESG-FIEC Program and Core Unit within its organizational structure. This initiative was unprecedented in the Brazilian industrial system and has become one of the most prominent topics in the corporate world (FIEC, 2022).

Through the “ESG-FIEC Certification Program,” the initiative aims to guide industries in Ceará in the development of sustainability projects, integrating best environmental preservation practices into production processes and minimizing operational impacts.

Audited by Bureau Veritas—one of the largest certification bodies in the world—the program enhances competitiveness, credibility, and reliability among stakeholders. It provides increased assurance, especially in negotiations and in attracting investment related to the energy transition in Ceará (FIEC, 2022, as cited in Barbosa & Gomes, 2024b).

The ESG-FIEC Core has incorporated environmental management into corporate strategy, encouraging companies to conduct their operations in an environmentally responsible manner. Under such conditions, the pursuit of sustainability can enhance the competitiveness of companies and industries in Ceará that are committed to the United Nations Sustainable Development Goals (SDGs), thereby supporting their efforts to secure supply contracts, attract investor financing, improve management practices, reduce costs, and gain competitive market advantages (FIEC, 2023).

Consequently, the growing demand for green products (those with reduced environmental impact) and social benefits has prompted companies to adopt ESG policies (Bezerra, 2023).

Global Reporting Initiative (GRI)

The GRI framework provides a clear, transparent, and globally recognized means of reporting the positive and negative sustainability impacts of corporate operations (Busch & Ribeiro, 2009). The GRI Standards represent global best practices for public disclosure of economic, social, and environmental impacts. Sustainability reports produced under GRI guidelines disclose information on an organization's positive or negative contributions to sustainable development (Global Reporting Initiative [GRI], 2025).

Actions and Initiatives in Ceará in Support of Sustainable Development

Studies concerning sustainable development and socio-environmental and corporate responsibility have investigated both national and international companies that are actively and decisively contributing to the energy transition in Ceará.

Qair Group

Qair, a French multinational, operates in Brazil through its subsidiary Qair Brasil, which holds a robust portfolio of projects, including the Serrote Wind Complex in Ceará. This complex consists of 49 wind turbines with a commercial operation capacity of 205.8 MW (Qair, 2024).

In 2021, Qair partnered with the State of Ceará in an investment initiative of €5.85 million aimed at green hydrogen production and offshore wind energy. The total projected investment amounts to US\$6.95 billion, with an estimated creation of 2,000 jobs during plant construction and 600 direct jobs once operations begin (Qair, 2024).

In alignment with sustainable development goals, the company prioritizes human development, social empowerment, health and safety of employees and neighboring communities, mitigation of environmental impacts, environmental responsibility, and socioeconomic development. Qair thus contributes to Ceará's economy by demonstrating how sustainable practices translate into positive business outcomes (Qair, 2024).

In 2023, Qair received the ESG-FIEC Award (AAA rating), recognizing its commitment to responsible business practices. Its 2023 Sustainability Report was developed in accordance with GRI standards (Qair, 2024).

Casa dos Ventos

Casa dos Ventos is a Brazilian company focused on Brazil's energy transition through the identification of renewable energy resources across the country. Currently, it operates and constructs projects totaling 3.4 GW. It is a signatory of the United Nations Global Compact Brazilian Network, the world's largest corporate sustainability initiative, and holds the Gold Seal of the Brazilian GHG Protocol Program for the 2023 cycle (Casa dos Ventos, 2025).

Under its environmental pillar, the company emphasizes environmental protection through efficient and sustainable resource and activity management. During the construction, implementation, and operation of its

wind farms, Casa dos Ventos conducts assessments of the potential impacts on local biomes, communities, and employees (Casa dos Ventos, 2025).

On the social front, the company fosters socioeconomic development in the municipalities where its projects are located, promoting engagement with communities, particularly those facing economic and social vulnerability. The company’s legacy also includes job creation, support for new business development, and improvement of human and social development indicators (Casa dos Ventos, 2025).

Pecém Industrial and Port Complex (CIPP)

The Pecém Industrial and Port Complex (CIPP) consists of a large industrial area, the Port of Pecém, and an Export Processing Zone, all of which boost Ceará’s economy. Its strategic geographic location—close to the United States, Europe, and the Global North—positions it as the epicenter of Brazil’s green hydrogen sector, hosting the country’s first projects in this area (CIPP, 2025).

Internationally, CIPP is a member of the International Association of Ports and Harbors (IAPH), a global trade association representing the interests of port operators. The IAPH works in collaboration with United Nations agencies, including the United Nations Conference on Trade and Development (UNCTAD), the United Nations Development Programme (UNDP), and the UN Global Compact (CIPP, 2024a).

CIPP plays a central role in positioning Ceará as a global leader in renewable hydrogen production and its derivatives, offering competitive prices for domestic distribution and international export. This supports decarbonization efforts and contributes to improvements in social, economic, technological, and environmental conditions (CIPP, 2024a).

The 2023 Sustainability Report aligns with global best practices and GRI standards, highlighting operational and financial outcomes, as well as commitments to the ESG agenda (CIPP, 2024a).

In 2024, the Port of Pecém was awarded the A3P (Environmental Agenda in Public Administration) seal by Brazil’s Ministry of the Environment and Climate Change. This recognition promotes new standards of production and consumption, encouraging raw material rationalization and input reuse across thematic axes such as: natural resource use, workplace quality of life, employee awareness on sustainability, sustainable procurement, green building, and solid waste management (CIPP, 2024b).

In 2025, the Port of Pecém joined the Ministry of Ports and Airports’ Sustainability Pact, which aims to reduce greenhouse gas emissions, implement social and environmental programs, and align with the global goals of the 2030 Agenda (Governo do Ceará, 2025).

Table 2: Major Companies Involved in the Energy Transition in Ceará

Company	Mission (servitude)	Sustainable development actions (social, environmental, and corporate responsibility)
Qair Brasil	<ul style="list-style-type: none"> Contribute to the energy transition, based on sustainability and the synergy of people. Produce renewable energy aligned with actions grounded in the continuous practice of socio-environmental sustainability, the promotion of synergy among people, and care for the environment. 	<ul style="list-style-type: none"> Promotion of World Climate Day and Clean Up Day (World Clean Up Day); CO2 ZERO Environmental Project; Solid Waste Management; Environmental Education Project; Corporate Sustainability Journey; Promotion of Physical Activity; “Internal Week for Occupational Accident Prevention and Environment” Project; Culture of Excellence Program; Mobile Library Project; and Reading Dressing Room Project.
House of Winds	Promote the socioeconomic development of the areas of operation, valuing environmental preservation and aligned with best governance practices.	<ul style="list-style-type: none"> Wind Forest Project; Wildlife Rescue Program; Environmental Education Program Action; Noise Monitoring and Control Program; Seedling Donation Project for Municipal Schools; Water Resources Protection and Monitoring Program; More Milk Project and More Lamb Project; Community Gardens Project; and Cistern Construction Project.

Pecém Industrial and Port Complex	Attract businesses by providing infrastructure, port services, industrial area, and Export Processing Zone, generating sustainable development.	<ul style="list-style-type: none"> Promotion of health and well-being in the workplace; BEM + CUIDADO Program; Annual Training Plan; New Employee Integration Program; Environmental Education Program; Social Communication Program; Participation in associations, committees, entities, forums, and relevant organizations; Establishment of Risk and Compliance Management; Occupational Health and Safety Program.
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Source: Sustainability Reports of CIPP, Qair Brasil, and House of Winds

By analyzing the sustainability reports of the companies Qair Brasil, Casa dos Ventos, and CIPP, the main information collected was consolidated and presented in Table 2, primarily involving actions within the framework of the sustainability triple bottom line.

By combining the principal programs, projects, actions, and initiatives of the companies (Table 2) with the information shown in Table 1, it is possible to verify the convergence of the triple bottom line as a business strategy in the economic, social, and environmental areas of these companies.

Another observation in Table 2 is that the main mission statements of the three companies include references to socio-environmental practices such as “sustainable development,” “sustainability,” and “environmental preservation.”

It is also noteworthy that, as a result of the Green Hydrogen Masterplan in Ceará, economic sectors such as energy, construction (civil and heavy), and metal-mechanics are essential in the development of the green hydrogen value chain, fostering job creation and income generation, enhancing education through the need to train specialized human resources (workforce development), and contributing to a just and inclusive energy transition (Barbosa & Gomes, 2024a), directly impacting the quality of life of the people of Ceará.

Thus, it can be partially concluded that in the ongoing energy transition process in the State of Ceará, companies and economic organizations have adhered to ESG Certification, the Global Reporting Initiative (GRI) sustainability reports, and certifications from the Brazilian Public Administration. The actions, programs, projects, and initiatives of these companies strengthen the mindset of the sustainability triple bottom line by incorporating, in their business models, the improvement of the socio-environmental conditions of the enterprises they conduct, demonstrating the adoption and promotion of sustainable practices.

Accordingly, aligned with the sustainability triple bottom line and within the context of climate change, Ceará is poised to hold a significant competitive advantage in the energy transition context, emerging once again as a global player in providing a worldwide solution for the decarbonization of the economy.

IV. Conclusion

This research fully achieved all the outlined objectives, providing an analysis of the importance of sustainable development, socio-environmental and corporate responsibility as a competitive advantage for Ceará in the energy transition. During the investigation, it was possible to recognize that unlimited consumption, driven by fossil fuel-based production, has caused climate change and negative impacts across all continents, which has awakened the international community’s awareness to trigger an energy transition benefiting both current and future generations.

Regarding the first axis of the theoretical framework, it was observed that, since the second half of the twentieth century, the concert of nations has conducted a series of studies, conferences, and international agreements aimed at demonstrating that economic development should proceed hand in hand with socio-environmental development. In this historical overview, it was characterized that the lack of balance between the economic, social, and environmental pillars would compromise the satisfaction of future generations’ needs, resulting in negative impacts on social well-being and nature.

The second axis, related to the concepts, definitions, importance, and benefits of socio-environmental and corporate responsibility in the contemporary world, confirmed the awakening of awareness among companies and economic organizations to strengthen their business models in favor of enhancing social and environmental aspects in their areas of operation. The study revealed a significant number of benefits arising from a corporate stance focused on socio-environmental responsibility within the productive sector.

Finally, the third axis demonstrated that companies within the Ceará industrial complex, participating in the energy transition, have adhered to the principles of sustainable development by incorporating a series of practices that could potentially provide the State of Ceará with competitive advantages in the ongoing global energy transition. These contributions emphasize the strong interface between sustainable development and the energy transition.

Considering the results obtained, it is suggested that future studies analyze the interrelation between socio-environmental and corporate responsibility actions in attracting investments to the Ceará industrial complex oriented toward the energy transition, as well as the monitoring of economic, social, and environmental indicators in the cities where these companies operate in renewable energy generation.

References

- [1]. Almeida, F. (2002). *The Good Business Of Sustainability*. Rio De Janeiro: Nova Fronteira.
- [2]. Barbosa, M. C., & Gomes, R. L. R. (2024a). The Projection Of The State Of Ceará On The International Stage Through FIEC In The Production And Exportation Of Green Hydrogen And Its Impact On Socioeconomic Development In Ceará. *IOSR Journal Of Business And Management (IOSR-JBM)*, 26(11, Series 4), 56–63. ISSN 2278-487X. <https://doi.org/10.9790/487X-2611045663>
- [3]. Barbosa, M. C., & Gomes, R. L. R. (2024b). Ceará, The Federation Of Industries Of The State Of Ceará (FIEC), And Green Hydrogen Production: A Global Benchmark In Energy Transition And Economic Decarbonization. *IOSR Journal Of Humanities And Social Science (IOSR-JHSS)*, 29(12, Series 9), 14–29. ISSN 2279-0837. <https://doi.org/10.9790/0837-2912091429>
- [4]. Bezerra, F. D. (2023). Banco Do Nordeste. Industry. Green Hydrogen: Opportunity For The Northeast. *ETENE Sectorial Notebook*, 8(320).
- [5]. Brazil. Ministry Of Science, Technology, Innovations And Communications (MCTIC). (2017). Paris Agreement. Retrieved March 11, 2025, From https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/sirene/publicacoes/acordo-de-paris-e-ndc/arquivos/pdf/acordo_paris.pdf
- [6]. Brazil. Ministry Of Defense. Superior War School (ESG). (2009). *Basic Manual. Volume II. Specific Subjects*. Rio De Janeiro.
- [7]. Brazil. Ministry Of Development, Industry, Commerce And Services (MDIC). (2025). *New Industry Brazil. Action Plan For Neoindustrialization 2024–2026 (Updated Edition)*. Retrieved April 3, 2025, From <https://www.gov.br/mdic/pt-br/composicao/se/cndi/plano-de-acao/nova-industria-brasil-plano-de-acao-2024-2026-1.pdf>
- [8]. Brazil. Ministry Of Mines And Energy (MME). (2024). *National Energy Transition Plan (PLANTE)*. Brasília. Retrieved April 28, 2025, From <https://www.gov.br/mme/pt-br/assuntos/noticias/mme-transicao-energetica-requer-alternativas-de-baixo-carbono-e-inclusao-social/plante2024.pdf>
- [9]. Brazil. Ministry Of Foreign Affairs (MRE). (2015, September 27). *Brazil's Contribution To The Paris Climate Agreement*. Updated March 12, 2025. Retrieved April 11, 2025, From <https://www.gov.br/mre/pt-br/assuntos/desenvolvimento-sustentavel-e-meio-ambiente/meio-ambiente-e-mudanca-do-clima/contribuicao-apresentada-pelo-brasil-as-nacoes-unidas-cop-21>
- [10]. Brazil. Presidency Of The Republic. (N.D.). *Update Of Brazil's Climate Target*. Retrieved April 11, 2025, From <https://www.gov.br/planalto/pt-br/agenda-internacional/missoes-internacionais/cop28/ndc-do-brasil> Brundtland, G. H. (1991). *Our Common Future: World Commission On Environment And Development (2nd Ed.)*. Rio De Janeiro: FGV.
- [11]. Busch, S. E., & Ribeiro, H. (2009). *Corporate Socio-Environmental Responsibility: Literature Review On Concepts*. *Journal Of Integrated Management In Health, Work, And Environment*.
- [12]. Casa Dos Ventos. (N.D.). *Sustainability*. Retrieved May 3, 2025, From <https://casadosventos.com.br/sustentabilidade#ambiental>
- [13]. Jacques Delors European Information Center (Eurocid). (2023). *Concept And Important Milestones In Social Responsibility*. Retrieved May 1, 2025, From https://eurocid.mne.gov.pt/entity_pdf/node/8848/full
- [14]. Chaves, D. A., & Castello, R. Do N. (2013). *Sustainable Development And Corporate Socio-Environmental Responsibility*. In *Symposium Of Excellence In Management And Technology, Resende*.
- [15]. Pecém Industrial And Port Complex (CIPP). (2024a). *Sustainability Report 2023*. Fortaleza. Retrieved May 2, 2025, From <https://www.complexodopecem.com.br/wp-content/uploads/2024/06/Relatorio-De-Sustentabilidade-Ed.-2023.pdf> Pecém Industrial And Port Complex (CIPP). (2024b, May 10). *Pecém Port And Ceará ZPE Receive A3P Seal From The Ministry Of Environment*. Retrieved May 5, 2025, From <https://www.complexodopecem.com.br/porto-do-pecem-e-zpe-ceara-recebem-selo-a3p-do-ministerio-do-meio-ambiente/>
- [16]. Pecém Industrial And Port Complex (CIPP). (2025). *Institutional*. Fortaleza. Retrieved May 3, 2025, From <https://www.complexodopecem.com.br/institucional/>
- [17]. Brazilian Business Council For Sustainable Development (CEBDS). (2023). *We Are The Voice Of The Business Sector For Sustainable Development In Brazil*. Retrieved May 1, 2025, From <https://cebds.org/quem-somos/>
- [18]. Costa, S. P. M., Et Al. (2024). *Energy Transition And Sustainability: Renewable Energy, Green Hydrogen, And Mining As Factors For Sustainable Development In The State Of Piauí*. Porto Alegre: Fundação Fênix Publishing. <https://doi.org/10.36592/9786554601337>
- [19]. Elkington, J. (2001). *Cannibals With Forks: The Triple Bottom Line Of 21st Century Business*. São Paulo: Makron Books.
- [20]. Estender, A. C., & Pitta, T. T. M. (2008). *The Concept Of Sustainable Development*. *Third Sector & Management Journal – UNG Proceedings*, 2(1), 22–28.
- [21]. Federation Of Industries Of The State Of Ceará (FIEC). (2022, April 18). *FIEC Launches Program Aimed At Global Best Practices*. Retrieved May 2, 2025, From <https://www1.sfiac.org.br/fiec-noticias/search/147932/fiec-lanca-programa-voltado-para-boas-praticas-globais>
- [22]. Federation Of Industries Of The State Of Ceará (FIEC). (2022). *ESG Program. About ESG*. Retrieved May 2, 2025, From <https://www1.sfiac.org.br/esg>
- [23]. Ferreira, D. D. M. (2014). *Sustainable Development: Textbook (1st Ed.)*. Palhoça: Unisulvirtual.
- [24]. Gilpin, A. (1996). *Dictionary Of Environmental And Sustainable Development*. John Wiley & Sons.
- [25]. Global Reporting Initiative (GRI). (2025). *The Global Standards For Sustainability Impacts*. Amsterdam. Retrieved April 16, 2025, From <https://www.globalreporting.org/how-to-use-the-gri-standards/gri-standards-portuguese-translations/> Government Of The State Of Ceará.
- [26]. Civil House Sustainability. (2025, January 28). *Pecém Port Adheres To The Ministry Of Ports And Airports Sustainability Pact*. Retrieved May 5, 2025, From <https://www.ceara.gov.br/2025/01/28/porto-do-pecem-adere-ao-pacto-pela-sustentabilidade-do-ministerio-dos-portos-e-aeroportos/>
- [27]. International Energy Agency (IEA). (2024). *Net Zero Roadmap: A Global Pathway To Keep The 1.5 °C Goal In Reach – 2023 Update*. Retrieved May 1, 2025, From https://iea.blob.core.windows.net/assets/8ad619b9-17aa-473d-8a2f-4b90846f5c19/Netzeroroadmap_Aglobalpathwaytokeepthe1.5cgoalinreach-2023Update.pdf
- [28]. Intergovernmental Panel On Climate Change (IPCC). (2023). *Global Warming Of 1.5°C: Framing And Context*. Retrieved April 27, 2025, From https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SR15_Chapter_1_HR.pdf

- [29]. Ipiránga, A. S. R., Godoy, A. S., & Brunstein, J. (2011). Mackenzie Management Review, 12(3), Special Edition. São Paulo. <https://doi.org/10.1590/S1678-69712011000300002>
- [30]. Juski, J. R., & Ribeiro, R. R. (2015). Sustainability: The Legitimation Of A New Culture. University Of São Paulo, Year IX, No. 16.
- [31]. Lomborg, B. (2012, July/August). Environmental Alarmism Then And Now. The Club Of Rome's Problem – And Ours. Foreign Affairs. Retrieved April 7, 2025, From <http://www.foreignaffairs.com/articles/137681/Bjorn-Lomborg/Environmental-Alarmismthen-And-Now>
- [32]. Mariani, A. De A. (2017). The Limits To Growth Revisited Report. Jurisfibi Magazine, 8(8), Bauru-SP.
- [33]. Meadows, D. H., Et Al. (1972). The Limits To Growth: A Report For The Club Of Rome's Project On The Predicament Of Mankind. New York. Retrieved April 28, 2025, From <https://www.clubofrome.org/publication/the-limits-to-growth/>
- [34]. Mckinsey & Company. (2021, November 25). Green Hydrogen: An Opportunity To Generate Wealth With Sustainability For Brazil And The World. Retrieved March 11, 2025, From <https://www.mckinsey.com/br/our-insights/hidrogenio-verde-uma-oportunidade-de-geracao-de-riqueza-com-sustentabilidade-para-o-brasil-e-o-mundo>
- [35]. Menuzzi, T. S., & Silva, L. G. Z. (2015). Interaction Between Economy And Environment: A Theoretical Discussion. Electronic Journal Of Management, Education, And Environmental Technology, Santa Maria. <https://doi.org/10.5902/2236117019148>
- [36]. Mineiro, A. A. C., Souza, D. L., Vieira, K. C., Castro, C. C., & Brito, M. J. (2018). From Triple To Quintuple Helix: A Systematic Review. PUC Minas. Economics And Management, Belo Horizonte.
- [37]. Montibeller Filho, G. (1993). Eco-Development And Sustainable Development: Concepts And Principles. Economics Texts, 4(1), 131–142.
- [38]. Oliveira, R. C. De. (2022). Hydrogen Panorama In Brazil. Discussion Paper 2787. Institute For Applied Economic Research (IPEA). Brasília.
- [39]. UNITED NATIONS ORGANIZATION. United Nations Brazil. The UN And The Environment. Brasília, 2020.
- [40]. UNITED NATIONS ORGANIZATION (UN) BRAZIL. Transforming Our World: The 2030 Agenda For Sustainable Development, 2015. Available At: <https://brasil.un.org/sites/default/files/2020-09/Agenda2030-Pt-Br.Pdf>. Accessed On: Apr. 12, 2025.
- [41]. QAIR BRAZIL. Sustainability Report 2023. Fortaleza, 2024. Available At: <https://www.brasil.qair.energy/>. Accessed On: May 2, 2025.
- [42]. SEBRAE. Sustainability: Healthy Practices That Boost Your Business. Published On June 28, 2022.
- [43]. Tayra, F. (2002). The Relationship Between The World Of Work And The Environment: Limits For Sustainable Development. Electronic Journal Of Geography And Social Sciences. Barcelona. Available At: <http://www.ub.es/Geocrit/Sn/Sn119-72.Htm>. Accessed On: Apr. 15, 2025.
- [44]. UNIVERSITY OF VERMONT. What Is Sustainable Development (SD)? Available At: https://www.uvm.edu/~jashman/CDAE195_ESCI375/What_Is_Sustainable_Development.Html. Accessed On: May 2, 2025.
- [45]. UNITED NATIONS. Our Common Future. Report Of The World Commission On Environment And Development, 1987. Available At: <https://www.are.admin.ch/are/en/home/media/publications/sustainable-development/brundtland-report.html>. Accessed On: Apr. 22, 2025.
- [46]. UNITED NATIONS DEVELOPMENT PROGRAMME (UNDP). The Climate Dictionary. Nature Edition. New York, 2024.
- [47]. WORLD ECONOMIC FORUM (WEF). The Global Risks Report 2024. Insight Report. Available At: https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2024.Pdf. Accessed On: Feb. 20, 2025.
- [48]. Young, R. Dilemmas And Advances In Corporate Social Responsibility In Brazil: The Work Of The Ethos Institute. Natural Resources Forum, V. 28, P. 291-301, 2004.