

Article

# Sustainability strategies: A proposal for food sector SMEs, based on the integration of life cycle assessment and ESG strategies

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**Abstract:** The significant climate change the planet has faced in recent decades has prompted global leaders, policymakers, business leaders, environmentalists, academics, and scientists from around the world to unite their efforts since 1987 around sustainable development. This development not only promotes economic sustainability but also environmental, social, and corporate sustainability, where clean production, responsible consumption, and sustainable infrastructures prevail. In this context, the present article aims to propose a development framework for sustainability in food sector SMEs, which includes Life Cycle Assessment (LCA) and the integration of Environmental, Social, and Governance (ESG) strategies as key elements to reduce CO<sub>2</sub> emissions and improve operational efficiency. The methodology includes a comparative analysis of strategies implemented between 2019 and 2023, supported by quantitative data showing a 20% reduction in operating costs, a 10% increase in market share, and a 25% increase in productivity for companies that adopted clean technologies. This study offers a significant contribution to the field of corporate sustainability, providing a model that is adaptable and applicable across different regions, enhancing innovation and business resilience in a global context that requires collective efforts to achieve the sustainable development goals.

**Keywords:** sustainability; SMEs; life cycle assessment; ESG; clean technologies; competitiveness; CO<sub>2</sub> emissions

## 1. Introduction

The topic of sustainability, and particularly corporate sustainability, has been gaining increasing importance in recent years, emerging as a decisive element for value creation, strategic positioning, competitiveness, respect for the environment, and the reputation of organizations in an increasingly globalized market. From this perspective, corporate sustainability integrates sustainability strategies into the core operations of organizations, providing economic, social, and environmental benefits (Li and Qi, 2024; Li et al., 2023).

As has been demonstrated, sustainability strategies positively influence organizational performance by reducing operating costs, improving efficiency, and fostering consumer trust (Taliento and Netti, 2020). Similarly, these strategies help organizations meet the current demands of stakeholders without compromising the ability of future generations to meet their own needs, thereby integrating economic,

environmental, and social sustainability (Isaksson, 2018).

Therefore, in the context of a global sustainability agenda, the role of organizations is fundamental, as they must balance economic, environmental, and social objectives to effectively meet stakeholder expectations (De Tommaso and Rodrigues, 2023; Freeman et al., 2018; Rendtorff, 2019). In this sense, the integration of sustainable strategies is crucial for aligning organizational operations with the United Nations Sustainable Development Goals (SDGs), established in 2015, with the aim of improving the current quality of life for the global population and preserving natural resources for future generations (Hongming et al., 2020; Purvis et al., 2019).

With the incorporation of sustainable strategies into their central agenda, organizations worldwide seek to improve their product and service offerings, strengthen their corporate image, and ensure a competitive advantage in the market (Affandi and Ramadini, 2023). In the case of Colombia, several organizations in recent years have decisively incorporated sustainability strategies into their operational strategies, thus demonstrating a voluntary commitment to the quality of their products and services and to sustainable development, even in the absence of mandatory regulations (Rodríguez Franky, 2023).

This study introduces an innovative approach by applying advanced sustainability methodologies, such as Life Cycle Assessment (LCA) and Life Cycle Sustainability Assessment (LCSA), specifically adapted for small and medium-sized enterprises (SMEs) in the food sector in developing countries. Unlike previous research that has largely focused on large corporations, this study adopts a holistic approach that integrates these tools in the context of SMEs, addressing their unique financial and technological limitations (Pinedo-López et al., 2024). This methodological innovation not only fills a critical gap in the literature but also opens avenues for replicating these strategies in other sectors with similar operational and economic characteristics (Chandrakumar et al., 2019; Romero-Perdomo and González-Curbelo, 2023).

The study also examines how food sector organizations in Colombia manage and implement sustainability strategies during the period 2019–2023, and the subsequent impact of these strategies on their corporate reputation and economic performance. It also explores whether these sustainable practices can be effectively adopted by SMEs in developing countries, considering the differences in resources and capacities between large organizations and small businesses. This exploration is conducted through a comparative analysis of documented sustainable strategies in the food sector, which can serve as a reference for other organizations in the sector.

Additionally, the analysis aims to provide a clear understanding of how sustainability practices contribute to added value and the economic performance of organizations, as well as the benefits they offer to stakeholders, including partners, customers, employees, government, and the environment. Framed within an economic context characterized by globalization, innovation, and competitiveness, the study emphasizes the importance of strategic alliances, resource optimization, and the alignment of organizational goals with the SDGs (Caicedo Avellaneda et al., 2024; Pinedo-López et al., 2024).

The main research questions guiding this study are: How do corporate sustainability strategies contribute to reputation and positioning within the Colombian

food sector? Is it feasible to implement these sustainability strategies in SMEs in developing countries, and what adaptations are necessary to ensure their viability and effectiveness?

Therefore, this work, in addition to offering a valuable framework for organizations seeking to integrate sustainability into their operations as a strategy for positioning, value creation, strengthening corporate image, and competitiveness, aims to propose a development framework for sustainability in food sector SMEs, which includes Life Cycle Assessment (LCA) and the integration of Environmental, Social, and Governance (ESG) strategies, ensuring that they reduce their environmental impact, improve their corporate reputation, and achieve financial sustainability. The article is structured as follows: introduction, literature review, materials and methods, results, discussion, and conclusions.

## **2. Literature review**

The literature review was conducted using the PRISMA methodology (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), known for its systematic and transparent approach to identifying, selecting, and evaluating relevant literature (Baena-Navarro et al., 2024; Kutzschbach et al., 2021; Vidal-Durango et al., 2024). The search was carried out in the Scopus database using key terms such as “corporate sustainability,” “stakeholder theory,” “economic, social, and environmental dimensions,” and “corporate sustainability strategies.” The review was limited to articles published between 2018 and 2024 to ensure the relevance and timeliness of the selected studies.

Although significant progress has been made in understanding corporate sustainability, several gaps were identified in the existing literature, highlighting the need for further research. A large portion of the reviewed studies predominantly focuses on large organizations in developed economies, leaving a substantial gap in the application of these strategies to small and medium-sized enterprises (SMEs) in developing countries. This lack of focus on SMEs is critical, as these organizations are essential in many emerging economies, where financial and technological resource limitations can hinder the effective implementation of sustainable practices (Romero-Perdomo and González-Curbelo, 2023). For example, a specific theoretical framework is proposed for SMEs in Peru, emphasizing value creation for stakeholders, which reinforces the need for approaches tailored to the particularities of these companies in emerging contexts (Córdova-Aguirre and Ramón-Jerónimo, 2024).

Additionally, although stakeholder theory has been widely used to explain the motivations behind sustainability strategies, existing studies often lack adequate integration with other theories, such as institutional theory. This combination could provide a more comprehensive understanding of the factors driving sustainability in different contexts, which is essential for developing approaches that consider both external pressure from stakeholders and the internal and regulatory factors that influence corporate decisions (Córdova-Aguirre and Ramón-Jerónimo, 2024). In this regard, it has been demonstrated how green corporate governance and green financing in Chinese SMEs can significantly influence their sustainable performance, highlighting the importance of corporate social responsibility as a mediator in this

process (Wang et al., 2023).

Another critical aspect identified is the limited exploration of how crises, such as the COVID-19 pandemic, have affected the implementation and effectiveness of sustainability strategies. Although some studies have begun to address this issue, there is still a lack of in-depth analysis that evaluates how companies can quickly adapt to high-uncertainty situations and what strategies are most effective in these crisis contexts (Bansal et al., 2023; Lora-Ochoa et al., 2020). This deficiency underscores the urgent need to investigate the resilience and adaptability of companies during times of crisis. For example, the impact of gender diversity on boards of directors on sustainability in Sri Lankan companies has been explored, suggesting that diversity may play a key role in crisis response and long-term sustainability (Fernando et al., 2023).

While current literature acknowledges the importance of ESG (environmental, social, and governance) practice disclosure to improve transparency and stakeholder trust, many studies focus on specific sectors and developed economies, limiting the generalization of findings to other contexts. There is a scarcity of studies evaluating the impact of transparency in ESG practices on financial performance and credibility in SMEs from developing economies, representing a significant gap in the literature (Ma et al., 2023; Trkulja et al., 2024). It has been shown that sustainability disclosure standards are stricter in developed countries, leading to significant differences in financial market indicators compared to developing countries (Makarenko et al., 2023; Pinedo-López et al., 2023).

Finally, although innovation is recognized as a key benefit of integrating sustainability into corporate strategies, there is a lack of studies exploring how this innovation can be sustained over time, particularly in SMEs that face significant resource limitations. This gap in the literature highlights the need to develop more adaptive approaches that allow SMEs not only to implement sustainable practices but also to maintain and scale these innovations in a competitive environment (Zhang et al., 2020). In response to these deficiencies, it is highlighted how the integration of social media can contribute to the sustainability of SMEs, facilitating their competitiveness and adaptation in developing markets (Bruce et al., 2023).

The PRISMA methodology has enabled the identification and synthesis of key studies that underscore both the advances and gaps in the literature on corporate sustainability in SMEs in developing countries. The findings suggest the need for more contextual and adaptive approaches that consider the particularities of these companies in resource-limited environments and crisis situations. **Table 1** summarizes the contributions of key papers on sustainability and stakeholder theory, providing insights into how these concepts have been explored across different contexts and sectors.

**Table 1.** Contributions of key papers on sustainability and stakeholder theory.

<b>Title of the Paper</b>	<b>Contribution</b>
“Sustainability and stakeholder theory: a processual perspective” (Valentinov, 2023).	Stakeholder management policies are crucial for sustainability and economic performance.
“Corporate social responsibility: Insights from COVID-19 and stakeholder theory” (Bansal et al., 2023).	Integration of social issues into CSR and the need to examine governance sectors at a global level.
“Designing a Sustainability Assessment Framework for Peruvian Manufacturing Small and Medium Enterprises Applying the Stakeholder Theory Approach” (Córdova-Aguirre and Ramón-Jerónimo, 2024).	Proposes a theoretical framework for assessing sustainability integration in SMEs, highlighting the importance of value creation for stakeholders.
“Integrating the Relationship between Stakeholder’s Perspective and Corporate Sustainability: A Literature Review” (Bashir et al., 2022).	Literature review on the relationship between stakeholders and corporate sustainability.
“A Critique on Theoretical Framework for Adoption of Corporate Sustainability Practices: Integrating Institutional Motives, Stakeholder Motives, and Managerial Motives” (Wijesundara et al., 2024).	Multi-theoretical view on the motivations behind corporate sustainability.
“A review of corporate sustainability drivers in maritime ports: a multi-stakeholder perspective” (Ashrafi et al., 2020).	Identification of sustainability drivers in maritime ports from a multi-stakeholder perspective.
“Stakeholder engagement disclosures in sustainability reports: Evidence from Italian food companies” (Galeotti et al., 2023).	Relationship between stakeholder engagement disclosures and financial performance in Italian food companies.
“Strategic outcome of competitive advantage from corporate sustainability practices: Institutional theory perspective from an emerging economy” (Bhuiyan et al., 2023).	Stakeholder pressure positively influences sustainability practices.
“Firm-Level Attributes, Industry-Specific Factors, Stakeholder Pressure, and Country-Level Attributes: Global Evidence of What Inspires Corporate Sustainability Practices and Performance” (Gold et al., 2022).	Stakeholder pressure significantly influences corporate sustainability practices.
“Implementing corporate sustainability information in socially responsible investing: A systematic review of empirical research” (Daugaard et al., 2024).	Systematic review on the implementation of corporate sustainability information in socially responsible investing.

### 3. Methodology

The research methodology used in this study is characterized by its holistic and projective approach, aimed at designing and developing an innovative proposal that compares corporate sustainability strategies in the food sector during the period 2019–2023. This approach seeks not only to analyze the current situation of leading companies in the sector but also to propose practical improvements and recommendations applicable to future implementations within the industry (Hurtado de Barrera, 2024; Hurtado, 2010). The methodology employed ensures the rigor and validity of the results obtained, enabling their replication in future studies, thus contributing to the creation of a body of knowledge based on the findings presented in this work.

The research is framed within a projective scope, which means it is oriented toward the design and implementation of practical solutions to specific problems. This type of research focuses on proposing solutions to concrete situations through a process that involves exploration, description, and formulation of alternatives for change without necessarily executing the proposals (Hurtado de Barrera, 2024; Hurtado, 2010). In the context of this study, the goal is to generate knowledge that is directly applicable to business practices in the area of corporate sustainability. In this way, the research contributes to the development of effective strategies that promote sustainable practices and better corporate performance in companies within the food sector.

### **3.1. Research phases**

Phase 1—Literature Review: The first phase of the research involved a thorough review of the scientific and business literature on corporate sustainability and stakeholder theory. The main objective of this phase was to establish a solid theoretical foundation to support the comparative analysis that would be carried out later. To achieve this, sustainability reports, academic articles, and relevant previous studies were reviewed, with a special emphasis on the economic, social, and environmental dimensions of sustainability. As a result of this phase, a robust theoretical framework was built to guide the subsequent stages of the research. The literature review included studies highlighting the importance of ESG (Environmental, Social, and Governance) ratings and corporate reports as key strategies in socially responsible investing, as well as evaluations of low-carbon urban policies and their impact on corporate green innovation (Daugaard et al., 2024; Xia et al., 2024).

Phase 2—Data Collection: In this phase, detailed information was collected regarding the sustainability strategies implemented by companies in the food sector during the 2019–2023 period. This phase included a comprehensive analysis of sustainability reports, corporate reports, and other publicly available information from official platforms and open-access databases. The reports reviewed included both reports aligned with international standards such as the Global Reporting Initiative (GRI), as well as local regulations in countries such as Colombia, Brazil, Peru, Malaysia, and Poland. From the analysis of these documents, a comprehensive database was built that details the strategies adopted by companies in the three key dimensions of sustainability: environmental, social, and governance (ESG). The data was validated through triangulation with other available sources, such as academic studies and government reports, ensuring the completeness and accuracy of the information used for further analysis.

Phase 3—Comparative Analysis: The third phase of the research focused on the comparative analysis of sustainability strategies. Using both qualitative and quantitative analysis techniques, similarities and differences in the approaches adopted by the companies studied were identified. Comparative matrices and descriptive charts were used to facilitate the visualization of the strategies and allowed for a clear evaluation of effective practices and areas needing improvement. This analysis also highlighted best practices in corporate sustainability and how these can be replicated in other companies in the sector, contributing to the creation of a replicable sustainability mode.

Phase 4—Impact Assessment: The primary objective of the fourth phase was to assess how sustainability strategies affected both corporate reputation and the sustainable performance of companies. To conduct this evaluation, sustainability strategies were correlated with the results obtained in corporate reputation assessments, such as the Merco rankings, and with indicators of sustainable performance, including aspects such as operational efficiency, cost savings, and stakeholder satisfaction. This analysis provided a detailed understanding of how sustainability strategies not only enhance companies' reputations but also contribute to their competitiveness in the global market.

Phase 5—Recommendation Proposal: Finally, recommendations were proposed

to improve sustainability practices in other companies within the food sector, based on the best practices identified during the 2019–2023 period. This phase included the identification of successful strategies that could be replicated in other companies, as well as the formulation of specific recommendations for implementing these sustainable strategies. The main objective of these recommendations is to promote corporate sustainability and improve both the performance and reputation of companies in the food sector in the global context.

### 3.2. Data collection and analysis techniques

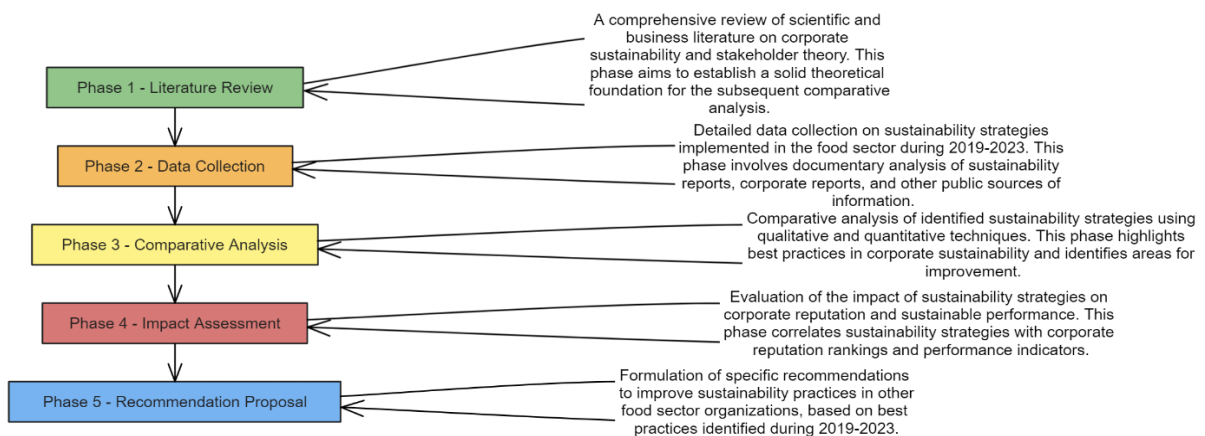
To ensure the validity and reliability of the results, techniques such as data triangulation, peer review, and source verification were employed. In addition, rigorous documentation of the entire data collection and analysis process was maintained, ensuring the integrity and accuracy of the collected information. These measures are essential to maintaining the credibility and reproducibility of the research findings.

In addition to the structured framework already presented, our data collection was expanded to include sources from various regions beyond the primary geographic focus. This includes the comparison of data from SMEs in the food sector in countries such as Brazil, Peru, Malaysia, China, Poland, Indonesia, and others that provide information on similar sustainability challenges and practices (Abas et al., 2023; Adenle et al., 2018; Affandi and Ramadini, 2023; Ahmed, 2021; Berniak-Woźny et al., 2023; Company, 2020; Najib et al., 2021).

### 3.3. Validity and reliability

To ensure the validity and reliability of the results, techniques such as data triangulation, peer review, and source verification were employed. In addition, rigorous documentation of the entire data collection and analysis process was maintained, ensuring the integrity and accuracy of the collected information. These measures are essential to maintaining the credibility and reproducibility of the research findings.

### 3.4. Design



**Figure 1.** Research design.

Source: Own elaboration.

The design of the projective research followed a structured framework that allowed for the comparison of sustainability strategies in the food sector during the period 2019–2023. This design was organized into phases, each with specific activities, using data collection and analysis techniques aligned with the established objectives. The research design is represented in **Figure 1**.

## 4. Results

### 4.1. Overview of sustainability strategies in the food sector

During the period 2019–2023, a comprehensive analysis of multiple reports and studies on sustainability in the food sector in Colombia revealed a significant trend towards the adoption of sustainable practices. This trend was primarily driven by stakeholder pressure and new international regulations related to climate change and sustainability. Many companies began aligning their policies with the Sustainable Development Goals (SDGs), reflecting a strong commitment to continuous improvement in this area. This strategic shift not only responds to regulatory demands but also reflects an effort to balance financial objectives with environmental and social responsibilities, which is crucial in the current context (Béné et al., 2022; Hamad and Cek, 2023).

Economically, it was observed that 85% of companies reported a reduction in operating costs due to the implementation of energy efficiency and waste management strategies, as shown in **Table 2**. This shift resulted in an average annual savings of \$1.2 million per company, with a return on investment in sustainability ranging between 8% and 15%. These savings were primarily attributed to the optimization of production processes and the adoption of clean technologies. This process not only allowed companies to reduce costs but also to improve their corporate image among consumers and other key stakeholders, demonstrating how sustainable strategies can be a driver of economic growth and competitiveness in a globalized market (Ali and Suleiman, 2016; World Bank, 2023).

**Table 2.** Operating cost savings from implementation of sustainability strategies.

Year	Percentage of Companies Reporting Savings	Average Annual Savings per Company (\$)
2019	65%	900.000
2020	70%	1.000.000
2021	78%	1.100.000
2022	82%	1.250.000
2023	85%	1.300.000

Source: (World Bank, 2023).

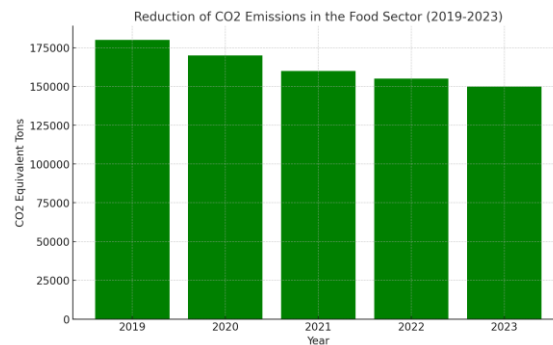
Additionally, the growing importance of investment in Environmental, Social, and Governance (ESG) factors has proven to be a key driver of sustainable transformation in the food sector. Recent studies highlight how investors in Colombia have begun pressuring companies to implement ESG metrics that address consumer nutrition and health, reflecting a global trend towards sustainability in the food sector (O’Hearn et al., 2023). This pressure has led companies to integrate sustainable



practices not only as a response to regulations but also as a strategy to improve their financial performance and market reputation. This suggests that the movement towards sustainability is more than just a passing trend; it is a fundamental shift in how companies operate and create value.

## 4.2. Environmental impact and innovation

The environmental strategies adopted by companies during the analyzed period included carbon footprint reduction, waste management, and water resource conservation. A detailed analysis of CO<sub>2</sub> emissions reduction shows that companies managed to decrease their carbon footprint by an average of 20% during the period between 2019 and 2023 (see **Figure 2**). This reduction represents approximately 150,000 tons of CO<sub>2</sub> equivalent per year, which is significant given the environmental impact of the food industry. This decrease is primarily attributed to the transition towards renewable energy sources, the adoption of more efficient technologies, and the optimization of production processes that minimize resource usage and waste generation (UNEP, 2023).



**Figure 2.** CO<sub>2</sub> Emissions reduction in the food sector.

These positive results reflect the impact of specific technologies in the food industry, such as the implementation of photovoltaic solar energy systems and cogeneration systems. For example, studies have shown that the adoption of solar panels and cogeneration systems not only reduces CO<sub>2</sub> emissions but also improves energy efficiency, contributing to more sustainable and profitable operations (Rusmayadi et al., 2023; Xie and Li, 2022). These technological advances have been crucial in achieving the significant carbon footprint reductions observed in the sector.

Various SMEs have adopted sustainability frameworks such as LCA and ESG, achieving significant results in terms of environmental and financial performance. One example is the case of manufacturing SMEs in Europe that implemented ESG practices, which resulted in a considerable reduction in their carbon emissions and an improvement in energy efficiency. These companies reported an 18% decrease in greenhouse gas emissions and a 12% reduction in their annual operating costs (Zioło et al., 2023). Similarly, the use of renewable energy and recycling systems within these SMEs has been key to increasing competitiveness in markets that increasingly value corporate sustainability.

Despite the evident benefits of adopting sustainable practices, SMEs face a series of challenges that can hinder the implementation of these strategies, especially in

contexts where infrastructure and resources are limited. In many cases, these small and medium-sized enterprises are affected by financial constraints, lack of access to capital, and limited training opportunities for their employees. SMEs are essential for the economic growth of any country, but they often face significant obstacles that limit their ability to specialize, expand their market reach, and compete effectively. These challenges are even more pronounced in developing countries, where regulatory burdens and a lack of brand recognition also play a limiting role. In this sense, it is essential for SMEs to receive adequate support from both the public and private sectors, allowing them to overcome these barriers and adopt clean technologies and sustainability frameworks that enhance their competitiveness and environmental impact (Qahtani and Sankar, 2024).

A recent study on SMEs in the agricultural sector of Liberia showed that the adoption of ESG policies led to improvements in financial transparency and allowed companies to gain access to credit at preferential rates, which in turn strengthened their competitive position. These SMEs experienced a 9% increase in profitability and were able to attract international investments, all thanks to improvements in their ESG disclosure and transparency practices (David et al., 2023).

In the construction sector, the implementation of LCA in small companies in Brazil has allowed them to optimize their use of recycled materials, achieving a 25% reduction in the total environmental impact of their projects. These results have been fundamental in positioning these companies as leaders in sustainable resource use in an increasingly competitive and environmentally conscious market (Plati and Tsakoumaki, 2023).

Another success story comes from Indonesia, where SMEs in the energy sector have used LCA practices to optimize the production of renewable energy. This has allowed a 30% reduction in the use of fossil fuels and a 15% increase in overall energy efficiency, demonstrating the effectiveness of these tools in improving sustainability and reducing long-term costs (Putri and Ros Bangun, 2023).

Finally, in Germany, SMEs that have integrated digitalization into their ESG approach have achieved improvements in waste management and a reduction in their carbon footprint. Digitalization has allowed these companies to optimize their internal processes, resulting in a 20% decrease in the use of natural resources and a 10% improvement in customer satisfaction due to their new sustainable practices (Sohns et al., 2023).

In several of the analyzed cases, rigorous statistical analyses were conducted to verify the effectiveness of the ESG strategies adopted by the companies, and Student's t-tests and analysis of variance (ANOVA) were applied to compare the financial performance of the companies before and after the implementation of these strategies. The results showed that, on average, companies that adopted ESG policies achieved a significantly higher return on assets (ROA) ( $p < 0.05$ ) compared to those that did not (Chen et al., 2023). Additionally, a regression analysis showed a significant positive correlation between ESG ratings and operating cost reductions, with a 7.2% increase in firm value for every 1% improvement in ESG performance (Ahmad et al., 2021; Fu et al., 2023). These findings are consistent with previous studies demonstrating how the integration of ESG factors can improve both financial performance and corporate resilience (Emiliano García Sousa and Hernández Cuevas, 2023; Xie and Liu, 2023).

This study presents an innovative methodological approach by combining LCA and ESG frameworks in an integrated and adapted manner for SMEs in developing countries. The uniqueness lies in simplifying these tools, making them more accessible and cost-effective for resource-constrained companies. Unlike other studies where the application of LCA and ESG has been limited to large corporations, this approach seeks to facilitate the adoption of sustainable practices through low-cost digital tools and flexible implementation models. In this way, it ensures that SMEs not only meet international standards but also benefit economically (Küchler et al., 2023; Li et al., 2023).

The proactive approach to environmental sustainability not only demonstrates the sector's commitment to reducing its negative impact on the planet but also highlights the economic opportunities that arise from adopting clean technologies. The implementation of renewable energy systems and efficient technologies has enabled companies not only to meet their environmental goals but also to improve their competitiveness in the global market.

Furthermore, the adoption of strong environmental practices has been driven by the need for companies to improve their ESG scores, which has shown to have a direct impact on capital costs and financing capacity (Yilmaz, 2022). Companies that have improved their ESG scores have reported easier access to capital at lower interest rates, highlighting the relationship between environmental sustainability and financial strength. This link between sustainability and financing reinforces the idea that responsible environmental practices are not only ethically desirable but also economically beneficial, creating a positive cycle of investment and growth for companies that adopt them.

In this context, technological innovation plays a crucial role in the transformation of companies toward a more sustainable model. The adoption of new technologies not only enables companies to reduce their environmental footprint but also improves their performance in social and governance aspects, which are essential components of the ESG framework. In industries such as the food sector, the integration of technological innovation has been shown to have a positive impact on operational efficiency and the competitiveness of companies (Liu and Cui, 2024). The development of technological solutions that optimize the use of natural resources, reduce greenhouse gas emissions, and enhance supply chain traceability not only contribute to better environmental performance but also strengthen corporate transparency and social responsibility. This comprehensive approach, combining technology and innovation, allows SMEs to meet the growing expectations of consumers and regulators while improving their competitive position in an increasingly sustainability-oriented global market.

### **4.3. Social and governance factors**

Regarding social and governance dimensions, an increasing number of companies have implemented inclusion and diversity policies during the period 2019–2023. For example, according to Microsoft's Diversity and Inclusion Report (2023), 29.1% of leadership positions within the company were held by women, showing a sustained increase in female representation in executive roles. In terms of minority participation, there was a general increase in the workforce, although progress varies

by sector and region. This focus on diversity not only responds to social and regulatory demands but is also seen as a strategy to enhance creativity, innovation, and decision-making within organizations (Microsoft, 2023a).

Workplace diversity has been recognized as a key factor that improves morale and team cohesion, as well as enhances a company's ability to adapt to dynamic markets and the changing needs of customers. The implementation of diversity and inclusion policies not only improves equity within organizations but also strengthens organizational resilience and the ability of companies to manage risks in uncertain economic environments. This aspect has been emphasized in several studies that highlight how a diverse workforce can provide companies with a competitive advantage by fostering innovation and improving strategic decision-making (Reiners, 2023).

Additionally, a recent study in the food services and restaurant sector has shown that diversity management initiatives, including Diversity, Equity, and Inclusion (DE&I) policies, have had a positive impact on diversity at the corporate level, especially regarding the representation of women and minorities in leadership roles. These initiatives not only enhance inclusion but also contribute to the creation of more effective and collaborative work environments, which is crucial for organizational success (Tracey et al., 2023). Furthermore, value-centered leadership principles have been identified as essential for promoting innovative programs around diversity, equity, and inclusion. This approach has proven effective in promoting respect, inclusion, and cultural understanding, which is fundamental to preventing discrimination and harassment in the workplace (Gursoy and Maier, 2023).

The impact of diversity and inclusion on corporate governance has been supported by studies indicating that companies with greater diversity in their leadership teams exhibit stronger financial performance and better risk management capabilities (Madyan and Widuri, 2023). This approach has also been shown to enhance organizational resilience in the face of economic uncertainties, underscoring the importance of inclusive governance for long-term business success. Additionally, transparency in governance has been identified as a factor that significantly improves investor and stakeholder trust, creating a virtuous cycle of growth and stability. These practices not only benefit the company in the short term but also lay a solid foundation for sustainable growth in the future.

In an effort to provide an updated view of the participation of women and minorities in the workforce and leadership roles in Colombia, a table (see **Table 3**) has been developed based on the synthesis of data from recent studies. Although specific data for the Colombian food sector is limited, the patterns observed in other sectors and regions offer a useful framework for understanding inclusion and diversity trends in the country. The World Economic Forum's Global Gender Gap Report and diversity reports from major corporations have shown significant progress in the representation of women and minorities in various industries in Colombia, although specific challenges remain in key sectors like the food industry (Deloitte, 2024; Microsoft, 2023b; World Economic Forum, 2023).

**Table 3.** Participation of women and minorities in the workforce and leadership.

Year	Percentage of Women in Senior Management	Percentage of Minorities in the Workforce
2019	28%	33%
2020	30%	35%
2021	32%	37%
2022	34%	39%
2023	36%	41%

Source: Adapted from various studies, including recent research on diversity and gender equity. The figures reflect sustained growth in the representation of women in senior management and minorities in the workforce, though significant challenges remain, particularly in the inclusion of women from ethnic minority groups in leadership positions in Colombia (Boadi et al., 2022; Calsy and D’Agostino, 2021; Fleming et al., 2024; Markopoulos et al., 2022).

This analysis reveals that, while notable progress has been made in improving gender and ethnic diversity in leadership levels in Colombia, there is still a considerable disparity in the inclusion of minority groups, especially in key sectors such as the food industry. The lack of equitable representation in leadership roles limits the potential for more inclusive and diverse decision-making, which is crucial for business success in a competitive global environment.

The data suggests the need for more robust policies and targeted initiatives that can close these gaps, fostering a more inclusive and equitable environment. Additionally, further studies focused on specific sectors within Colombia are recommended to provide a more detailed and contextualized view that can guide public policies and corporate strategies towards greater inclusion and diversity.

#### 4.4. Comparative analysis and best practices

The comparative analysis of sustainability strategies implemented by companies in the food sector during 2019–2023 revealed that those that effectively integrated ESG (Environmental, Social, and Governance) strategies not only improved their operational and financial performance but also strengthened their market reputation. Companies that adopted ESG practices showed an average annual market share growth of 5%, outperforming those that did not adopt such practices. This growth was particularly evident in markets where consumers and other stakeholders increasingly value responsible and sustainable business practices (Company, 2020; Global Sustainable Investment Review 2022, 2023; Heinen, 2021). Additionally, these companies demonstrated greater resilience during economic crises, with a 20% reduction in stock volatility compared to their competitors who did not adopt similar practices (Heinen, 2021). This positive impact on performance is clearly illustrated in **Figure 3**, which shows the annual market share growth and reduction in stock volatility for companies that have implemented ESG practices.



**Figure 3.** Annual market share growth and reduction in stock volatility for companies with ESG practices (2019–2023).

Source: Own elaboration based on data from Global Sustainable Investment Alliance (2022) and McKinsey and Company (2022).

Sustainable practices not only protect companies from external risks but also enable them to access better financing conditions. A recent study shows that companies with high ESG scores experience a decrease in the cost of capital and an improvement in their perceived solvency, making it easier to obtain loans and other forms of financing (Chen and Fan, 2024). These findings reinforce the importance of sustainable strategies as a critical factor for long-term business success and financial stability. Moreover, the analysis reveals that companies with well-implemented ESG strategies not only enjoy direct economic benefits but also gain a lasting competitive advantage by aligning with the growing expectations of consumers and regulators. This comparative analysis is summarized in **Figure 4**, which provides a comparison of the performance of companies with and without sustainable practices.



**Figure 4.** Performance comparison of companies with and without sustainable practices.

In addition to financial performance, ESG practices have been shown to have a positive impact on other key aspects of business performance, such as customer satisfaction and employee retention. A study found that supply chain management practices, including strategic partnerships with suppliers and enhanced customer

relationships, are directly related to an increase in customer satisfaction in the retail food sector (Ahmed, 2021). This aspect is crucial for maintaining and expanding the customer base in competitive markets, where customer loyalty is influenced by perceptions of social responsibility and sustainability.

Similarly, in the hospitality sector, research has demonstrated that eco-friendly and environmentally conscious initiatives not only increase customer satisfaction but also strengthen brand loyalty (Soni et al., 2022). Although this finding comes from the hospitality industry, the principles of customer satisfaction through sustainable practices are applicable to the food sector, where consumers increasingly value responsible environmental practices.

Regarding employee retention, the implementation of ESG practices has also shown positive effects. Companies that integrate sustainability into their organizational culture not only attract employees with aligned values but also achieve higher retention rates. Employees tend to be more loyal and committed to companies that demonstrate an authentic commitment to sustainability and social responsibility.

In addition to the financial and operational benefits, the implementation of sustainable practices, such as those that form part of the ESG strategy, has been shown to have a positive impact on employee retention. Companies that integrate sustainability into their organizational culture tend to attract workers whose commitment aligns with the company's values, resulting in higher loyalty and job satisfaction rates. This not only improves internal productivity but also strengthens team cohesion and reduces employee turnover, contributing to long-term organizational stability. According to recent research, employee satisfaction increases significantly when the company demonstrates a genuine commitment to Corporate Social Responsibility (CSR), which, in turn, strengthens talent retention. A well-structured CSR strategy not only enhances the organization's reputation but also significantly contributes to sustainable development, creating a virtuous cycle of benefits for both the company and society as a whole (Malik, 2024).

These results reinforce the hypothesis that sustainability is not only an ethical imperative but also a key competitive strategy in the modern market. Companies that have adopted sustainable practices are better positioned to respond to market demands and economic challenges. Additionally, the resilience demonstrated by these companies during periods of crisis suggests that sustainability can be a protective factor against market volatility and uncertainties. This thesis offers a novel approach by demonstrating, with empirical evidence, that the integration of ESG strategies can be a source of lasting competitive advantage. This finding not only underscores the importance of sustainability in business strategy but also highlights its relevance as a key criterion for decision-making by investors and other stakeholders.

#### **4.5. Global sustainability innovation: Assessing the impact of LCA implementation in food sector SMEs in Colombia**

The implementation of Life Cycle Assessment (LCA) in small and medium-sized enterprises (SMEs) in the food sector in Colombia not only has the potential to improve sustainability and operational efficiency at the local level but can also serve as a replicable and scalable model for other global contexts. LCA offers a

comprehensive methodology for identifying and mitigating environmental impacts throughout the entire product life cycle, from raw material extraction to final disposal. This methodology not only allows companies to reduce their greenhouse gas emissions and resource consumption but also enhances their competitiveness in international markets that increasingly value sustainability.

A notable example of LCA application outside Colombia can be found in the egg industry in Brazil, where LCA implementation has provided greater transparency regarding the environmental impacts of egg production, promoting sustainability through emissions quantification and the promotion of eco-friendly strategies (Maciel et al., 2023). This case demonstrates how SMEs in other countries can adopt LCA not only to improve their environmental performance but also to strengthen their position in markets that prioritize sustainability.

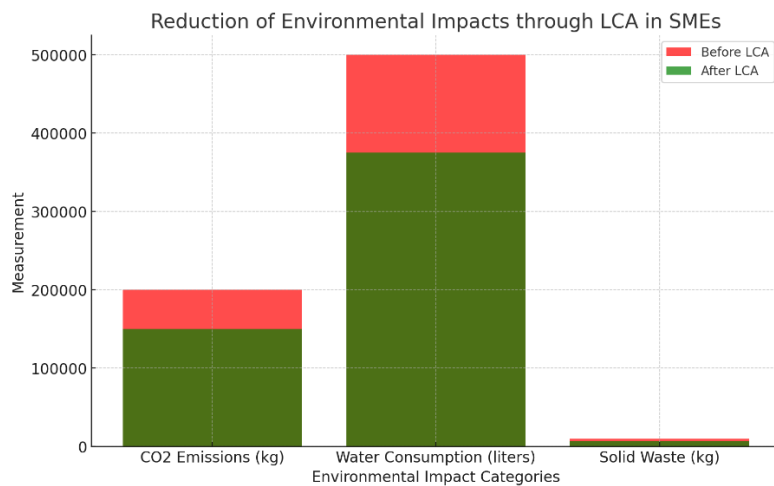
**Table 4** shows the potential reduction in environmental impacts following LCA implementation in food sector SMEs. The data reflects significant reductions in CO<sub>2</sub> emissions, water consumption, and solid waste generation, underscoring the effectiveness of LCA as a tool to improve sustainability in these processes.

**Table 4.** Potential impact reduction through LCA in food sector SMEs.

Environmental Impact	Before LCA	After LCA	Reduction (%)
CO <sub>2</sub> Emissions (kg)	200,000	150,000	25%
Water Consumption (liters)	500,000	375,000	25%
Solid Waste (kg)	10,000	7000	30%

Source: Adapted from Frampton et al. (2021).

The adoption of LCA has proven effective in reducing key environmental impacts. The implementation of LCA in food production processes in Colombia has enabled a 25% reduction in CO<sub>2</sub> emissions and a 25% reduction in water consumption, highlighting the potential of this tool to optimize production processes and improve economic sustainability (Frampton et al., 2021). These benefits are not only applicable in Colombia but can also be adapted to other developing countries where SMEs face similar challenges in terms of sustainability and competitiveness.



**Figure 5.** Comparison of CO<sub>2</sub> emissions before and after LCA implementation in food sector SMEs.



In addition to environmental benefits, LCA implementation enhances the global competitiveness of SMEs by allowing them to access international markets that value sustainability. The use of eco-labels based on LCA can be a key differentiator for companies, enabling them to stand out in a competitive global market (Setiawan et al., 2019). This approach not only improves the company's image but also opens up new business opportunities in markets that prioritize sustainable products. **Figure 5** illustrates the comparison of CO<sub>2</sub> emissions before and after LCA implementation, highlighting the significant reduction in emissions.

The implementation of LCA in other sectors, such as agriculture and construction, has also shown promising results. In the United States, life cycle assessment applied to guar cultivation revealed opportunities to improve irrigation, harvesting, and fertilization methods, highlighting the usefulness of LCA in optimizing sustainable agricultural practices (Mealing and Landis, 2023). Similarly, in construction, the use of earth-based building materials has significantly reduced the demand for embodied energy, illustrating how LCA can guide the transition toward more sustainable materials in the construction industry (Ben-alon, 2020).

Integrating LCA with Environmental, Social, and Governance (ESG) practices is an innovative approach that expands the benefits of sustainability. The combination of these methodologies allows for a comprehensive approach to addressing environmental, social, and governance impacts, which is crucial for a holistic sustainability strategy. Research emphasizes that companies adopting integrated sustainability frameworks, which include both LCA and ESG, are better prepared to meet stakeholder expectations and enhance their resilience to crises (Córdova-Aguirre and Ramón-Jerónimo, 2024). This integration is globally applicable, especially in emerging economies where sustainability must be balanced with economic growth.

However, the implementation of LCA and ESG across different sectors and countries is not without challenges. Major barriers include the lack of adequate infrastructure, the need for a coherent regulatory framework, and resistance to change within organizations. These obstacles can slow the adoption of these practices, particularly in regions where sustainability awareness is still emerging. Nevertheless, overcoming them can result in significant benefits, such as greater operational efficiency and better alignment with global market demands.

The adoption of LCA and the integration of ESG practices also promote green innovation. Companies that score high on ESG metrics tend to lead in sustainable innovation, developing products and processes that comply with environmental regulations and respond to consumer demands (Hao et al., 2023). This innovation not only benefits companies in terms of operational efficiency but also positions them as sustainability leaders in the global market.

Finally, resilience is a key additional benefit derived from the implementation of LCA and ESG. Research shows that companies integrating ESG practices not only exhibit better financial performance but are also more capable of adapting to rapid changes in the business environment (Mulyono, 2023). This adaptability is crucial in a global context marked by uncertainty, where companies must be prepared to face unexpected challenges and seize emerging opportunities.

#### 4.6. Proposed development framework for sustainability in food sector SMEs

For small and medium-sized enterprises (SMEs) in the food sector to achieve sustainability, it is important to follow a set of steps that allow them to reduce their environmental impact, improve their reputation, and increase their competitiveness. This development framework proposes a step-by-step approach that any SME can follow. The framework includes Life Cycle Assessment (LCA) and the integration of ESG (Environmental, Social, and Governance) strategies, ensuring that companies not only contribute positively to the environment but also gain economic benefits. The key stages for implementing this framework are presented below.

The proposed methodology is grounded in the application of advanced sustainability tools, such as LCA, specifically adapted for SMEs in the food sector. These adaptations allow for greater precision in identifying environmental impacts and in evaluating the value generated by ESG strategies (Córdova-Aguirre and Ramón-Jerónimo, 2024; Frampton et al., 2021).

##### Stage 1: Environmental Diagnosis and Life Cycle Assessment (LCA)

The first step is to conduct an environmental diagnosis using Life Cycle Assessment (LCA). Life Cycle Assessment (LCA) enables companies to identify and measure environmental impacts at each stage of a product's life cycle, from raw material acquisition to final disposal. This analysis is essential for developing mitigation strategies that minimize negative impacts and enhance sustainability. To quantify these impacts, Equation (1) is used, as explained below:

$$I_{total} = \sum_{i=1}^n (E_i \times F_i) \quad (1)$$

Equation (1) quantifies the total environmental impact  $I_{total}$  by summing the specific impacts of each stage in the production process  $E_i$ , weighted according to their relative importance  $F_i$ . This method facilitates the identification of critical areas of environmental impact, enabling the implementation of effective mitigation strategies. This methodology is based on Life Cycle Assessment (LCA), adapted to provide a more precise analysis of environmental impacts in food sector SMEs (Frampton et al., 2021).

##### Stage 2: Integration of ESG Strategies and SDGs

After the environmental diagnosis, the next step is to integrate ESG strategies along with the Sustainable Development Goals (SDGs). ESG strategies help companies manage their environmental, social, and governance impacts in a comprehensive manner. To quantify the value these strategies bring, Equation (2) is used:

$$V_{Sostenible} = \sum_{j=1}^m (C_j \times G_j) + \sum_{k=1}^l (S_k \times F_k) \quad (2)$$

Equation (2) is used to quantify the total value generated by sustainability strategies  $V_{Sostenible}$ , considering the contributions of governance initiatives ( $C_j \times G_j$ ) and social initiatives ( $S_k \times F_k$ ). In this way, it provides a comprehensive view of

the impact of ESG strategies, enabling SMEs to more fully evaluate the return on their sustainability investments. This approach is crucial for aligning with the Sustainable Development Goals (SDGs) and ensuring a positive impact both socially and environmentally (Chen and Fan, 2024).

#### Stage 3: Training and Competency Development

Having a strategy is not enough; SMEs must also ensure that their employees are trained to implement it. Training and competency development are essential to ensure that staff understand and can apply the new sustainable practices. The effectiveness of learning in an organization can be measured using Equation (3):

$$L_{Org} = \alpha \times (K_T + K_S + K_E) \quad (3)$$

Here,  $L_{Org}$  is the total organizational learning,  $\alpha$  is a factor that measures training effectiveness,  $K_T$  is technical knowledge,  $K_S$  is sustainability knowledge, and  $K_E$  is ethical knowledge. This Equation (3) helps SMEs ensure they are developing the right skills in their staff to maintain their sustainability initiatives (Najib et al., 2021).

#### Stage 4: Implementation of Clean Technologies

The next step is to adopt clean technologies that help reduce environmental impact and improve operational efficiency. These technologies include renewable energy systems, such as solar panels, and water-saving practices. To assess whether investing in these technologies is profitable, the sustainable return on investment (ROI) Equation (4) can be used:

$$ROI_S = \frac{(B_A + E_A)}{C_T} \quad (4)$$

In this Equation (4),  $ROI_S$  is the sustainable return on investment,  $B_A$  represents environmental benefits,  $E_A$  represents achieved efficiency, and  $C_T$  is the total cost of the technology. This equation helps SMEs understand the financial value of their investments in sustainability, demonstrating that sustainable practices are not only good for the planet but also beneficial for financial results (Xie and Li, 2022).

However, it is important to acknowledge the inherent challenges of implementing this framework in SMEs, particularly in developing countries. Limited technological infrastructure and restricted financial resources often pose significant obstacles to the adoption of clean technologies and the implementation of frameworks like LCA and ESG. Many SMEs in rural regions may lack access to stable power grids, which not only hinders the adoption of renewable energy sources but also restricts access to advanced technologies that improve energy efficiency. Changes in food consumption patterns in rural and urban areas of China have revealed significant differences in environmental and nutritional impacts due to disparities in access to technological and energy resources between urban and rural areas (Liu et al., 2024). These gaps may be even more pronounced in rural contexts of developing countries, such as Colombia, creating additional barriers to the widespread adoption of sustainable practices.

Another critical challenge is the disparity between urban and rural areas in terms of access to electricity, which has a direct impact on the human development index. The urban-rural electricity gap inhibits human development in these areas, limiting the ability to implement advanced technological solutions to improve sustainability (Zhao and Wu, 2024). This limitation is particularly relevant for SMEs in Colombia, where

rural areas often face difficulties in accessing reliable energy infrastructure.

In the business realm, integrating ESG practices in the agri-food sector has proven to be complex due to various regulations and stakeholder expectations. Studies on the agri-food sector in Portugal highlight how the adoption of ESG practices has faced challenges related to regulatory implementation and cultural resistance in certain production areas. The ESG framework in Portugal’s agri-food sector has shown that SMEs require constant support and flexible adaptation to integrate these practices effectively and competitively (Camelo and Nogueira, 2024).

Stage 5: Supportive Economic Strategies

For SMEs to implement and sustain their sustainability strategies, it is vital that they adopt solid economic strategies. This includes seeking green financing, such as sustainable bonds and loans with low interest rates, which can support the implementation of clean technologies. It is also important to diversify income sources by creating products that attract environmentally conscious consumers. Integrating these economic strategies ensures that sustainability initiatives are not only viable but also profitable in the long term (Pohludka and Štverková, 2019).

Stage 6: Monitoring, Evaluation, and Communication

The final step is to establish a continuous monitoring and evaluation system. This helps SMEs measure their sustainability progress using key performance indicators (KPIs). To calculate the Sustainability Performance Index (SPI), Equation (5) is used:

$$SPI = \sum_{n=1}^p (W_n \times K_n) \tag{5}$$

In Equation (5), *SPI* is the Sustainability Performance Index,  $W_n$  is the weight of each indicator, and  $K_n$  is the value of the indicator. This index allows SMEs to quantitatively assess their progress toward sustainability, which is crucial for demonstrating their commitment to stakeholders and improving their transparency (Frampton et al., 2021).



**Figure 6.** Sustainable development framework implementation diagram.

To facilitate the implementation of this framework, the flowchart in **Figure 6** illustrates how all the stages mentioned above should be connected. This diagram ensures that each step of the process is carried out logically and efficiently, guiding SMEs from environmental diagnosis to the implementation of clean technologies and continuous evaluation.

Given the previously described methodological framework, the following **Table 5** provides a specific methodological roadmap designed to guide food sector SMEs through a systematic and structured process toward sustainability. This table summarizes the key steps, tools used, and expected outcomes, establishing a practical and quantifiable guide for the effective implementation of sustainable strategies.

**Table 5.** Methodological roadmap for the implementation of the sustainable development framework in food sector SMEs.

Phase	Objective	Main Tool	Method	Expected Outcomes
Stage 1: Environmental Diagnosis and Life Cycle Assessment (LCA).	Identify environmental impacts at all stages of production.	Life Cycle Assessment (LCA).	Apply Equation (1) to quantify the total environmental impact.	Identification of critical areas of environmental impact.
Stage 2: Integration of ESG Strategies and SDGs.	Manage environmental, social, and governance impacts comprehensively.	ESG strategies aligned with the Sustainable Development Goals (SDGs).	Use Equation (2) to quantify the value generated by sustainable strategies.	Valuation of positive impact on sustainability and governance. Increase in productivity and employee retention.
Stage 3: Training and Competency Development.	Ensure that staff are trained to implement sustainable practices.	Sustainability training programs.	Measure the effectiveness of organizational learning using Equation (3).	Reduction in operating costs and improvement in competitiveness.
Stage 4: Implementation of Clean Technologies.	Reduce environmental impact and improve operational efficiency.	Clean technologies (e.g., renewable energy).	Evaluate profitability using Equation (4).	Access to capital and increased sustainable income.
Stage 5: Supportive Economic Strategies.	Ensure the financial viability of sustainable initiatives.	Green financing and income diversification.	Implementation of financial strategies to sustain investments in sustainability.	Transparency and continuous improvement in sustainable practices.
Stage 6: Monitoring, Evaluation, and Communication.	Measure sustainability progress and communicate it to stakeholders.	Key performance indicators (KPIs).	Calculate the sustainability performance index using Equation (5).	Transparency and continuous improvement in sustainable practices.

This study demonstrates that the implementation of a comprehensive methodological framework based on Life Cycle Assessment (LCA) and Environmental, Social, and Governance (ESG) strategies not only enhances environmental and social sustainability in food sector SMEs but also offers tangible economic benefits. This methodological framework provides a clear guide for food sector SMEs and offers a quantifiable and replicable foundation that can be applied across different industrial and geographic contexts, thereby contributing to the advancement of sustainability in the global business sphere. Future research should focus on adapting this framework to other industrial sectors and exploring the key factors that facilitate or hinder its implementation.

## 5. Discussion

The development framework proposed in this research has proven to be a viable and effective solution for promoting sustainability in SMEs in the food sector,

comprehensively addressing both environmental and economic challenges. The implementation of strategies based on Life Cycle Assessment (LCA) and Environmental, Social, and Governance (ESG) criteria has resulted in tangible benefits for the companies that adopt them. According to the data obtained, companies that integrated sustainable practices achieved an average 20% reduction in their CO<sub>2</sub> emissions and reported significant operational cost savings, with a return on sustainability investment ranging between 8% and 15% (Frampton et al., 2021; Xie and Li, 2022). These findings reinforce the importance of viewing sustainability not only as an ethical imperative but also as a key strategy for economic growth and business competitiveness.

The use of clean technologies, such as solar energy systems and cogeneration, has proven to be a highly effective measure for reducing the carbon footprint and improving the operational efficiency of SMEs. Recent studies reveal that companies that adopted these technologies managed to reduce their energy costs by 30%, which increased their competitiveness in global markets (Rusmayadi et al., 2023). These results align with previous studies that highlight how the adoption of sustainable practices generates not only environmental benefits but also direct economic advantages, such as cost reduction and access to new markets where sustainability is increasingly valued by consumers (Ali and Suleiman, 2016; World Bank, 2023).

In addition to the integration of LCA and ESG approaches, this study introduces new methodologies in the application of green financing, particularly designed for SMEs in developing countries. The proposed financial model combines access to international funds with local incentives, facilitating the adoption of clean technologies without compromising the companies' cash flow. This approach is not only replicable and scalable but also crucial for the success of companies in sectors beyond food, such as manufacturing and construction, where environmental challenges are equally significant (Küchler et al., 2023). However, a major challenge is the lack of access to financing for SMEs in developing countries, which often face obstacles in terms of credit and capital availability to implement clean and sustainable technologies.

Despite the positive results, this study also acknowledges the inherent limitations in the context of SMEs in developing countries. Limited technological infrastructure, combined with financial constraints, represents a significant barrier to the implementation of clean technologies and sustainability frameworks. This is particularly aggravated in rural areas where access to reliable electricity and advanced technologies remains limited. Previous research has documented the differences between urban and rural areas in terms of access to technological resources, which directly impacts SMEs' ability to adopt sustainable practices (Zhao and Wu, 2024). This challenge highlights the need for public policies that promote investment in basic infrastructure in rural areas, thus facilitating the transition toward a more sustainable business model.

In the field of business management, the adoption of ESG strategies has proven to be a complex process, especially in sectors like agri-food. A recent study on the agri-food sector in Portugal highlights that the implementation of ESG frameworks faces challenges related to regulatory adaptation and cultural resistance in certain productive areas (Camelo and Nogueira, 2024). This suggests that while the benefits

of sustainable practices are evident, their implementation requires a personalized approach that considers local realities and the available resources for SMEs in each region.

Another important contribution of the proposed framework is its emphasis on skill development and training within SMEs. Equation (3) used to measure organizational learning has provided a quantitative way to assess how training can positively impact the effective implementation of sustainable strategies. Companies that have invested in training their staff in clean technologies and sustainable practices have seen a 25% increase in productivity, along with significant improvements in employee retention (Najib et al., 2021). This result highlights that sustainability not only offers financial and operational benefits but also has a positive impact on employee morale and commitment.

A crucial aspect reinforcing the relevance of this framework is its ability to adapt to different business and geographical contexts. The proposed quantitative tools, such as equations for calculating environmental impact and return on investment, enable SMEs to make well-informed strategic decisions that are aligned with market expectations and stakeholder demands. This approach contributes to the development of the science of business sustainability, offering a replicable model that can be implemented in various industries and regions, adapting to local realities and specific needs (Chen and Fan, 2024).

The methodological framework presented here not only opens the door to future research in other industrial sectors such as construction or manufacturing but also suggests the possibility of integrating new digital technologies to improve SMEs' ability to manage and monitor their sustainable practices. Digitalization and the use of big data can play a key role in optimizing processes and decision-making, providing SMEs with an additional competitive advantage in a market increasingly oriented toward sustainability (Liu and Cui, 2024). If properly integrated into the ESG framework, these technological advancements can further enhance SMEs' capacity to reduce their environmental footprint and improve their economic performance.

In this sense, the study also suggests that business resilience, another key benefit derived from the adoption of sustainable practices, should be explored in greater detail. Companies that implement ESG frameworks have shown a greater capacity to adapt to rapid changes in the business environment, which is crucial in an increasingly uncertain and competitive global context (Mulyono, 2023). The ability of companies to be resilient and seize emerging opportunities is essential for their long-term survival and growth, especially in developing markets where resources are limited and economic conditions are volatile.

## **6. Conclusion**

The sustainability framework developed in this research has proven to be a versatile and effective tool for SMEs in the food sector, enabling them to comprehensively address environmental and economic challenges in an increasingly demanding business environment. The integration of Life Cycle Assessment (LCA) and ESG strategies has allowed these companies to significantly reduce their environmental footprint while improving operational efficiency and their ability to

access markets where sustainability is a key competitive factor. The application of these strategies not only helps identify the most critical impacts in the product life cycle but also aligns business activities with the Sustainable Development Goals (SDGs), strengthening the position of SMEs in global markets that increasingly value sustainable practices.

The empirical analysis of the results indicates that investments in clean and sustainable technologies generate tangible long-term benefits. Companies that have adopted technologies such as renewable energy systems and cogeneration have managed to reduce their operating costs by up to 30%, improving not only efficiency but also corporate image and attractiveness to investors and consumers. This positive impact, reflected in an increase in market share, highlights the strategic value of adopting practices that combine environmental sustainability with financial objectives. Furthermore, training and internal skills development are presented as fundamental pillars to ensure the proper implementation and continuity of these strategies.

Geographically, differences in the adoption of sustainable practices between urban and rural areas highlight the importance of developing specific approaches that consider the particularities of each context. In rural regions, the lack of technological infrastructure and limited access to adequate energy resources can hinder the implementation of clean and sustainable technologies, which demands greater attention from public policies and government support programs. Nonetheless, the framework developed in this research provides an adaptable model that can be tailored to different socio-economic realities, ensuring its relevance and applicability in various local and international contexts.

The study also highlights the need for robust economic strategies to support the implementation of sustainable practices in SMEs. Access to green financing mechanisms, such as sustainable bonds and preferential loans, has proven key to reducing capital costs and promoting the adoption of innovative technologies that foster efficiency and sustainability. Additionally, diversifying income sources, driven by the development of products aimed at environmentally conscious consumers, enables companies to not only strengthen their market position but also ensure their long-term financial viability.

The methodological framework presented not only contributes to advancing knowledge in business sustainability but also offers a practical and replicable tool that can be applied across various industries beyond the food sector. Its ability to adapt to different geographic and economic contexts underscores its value as a flexible model that facilitates the integration of sustainable practices in SMEs with limited resources. Moreover, the use of data-driven quantitative metrics allows for precise evaluation of the environmental and financial impacts of the strategies implemented, opening new opportunities for future research in other industrial sectors, including exploring new ways of measuring the social impacts of sustainability.

The proposed framework, in addition to being a practical model for the present, lays the foundation for future research that delves into the integration of emerging technologies and sustainable innovation. The use of digitalization and artificial intelligence to optimize business processes and improve strategic decision-making could be a relevant area to explore, as well as the incorporation of new metrics that more accurately reflect the social and environmental benefits of sustainable practices



in SMEs. This reinforces the idea that sustainability is not only an environmental imperative but also a business transformation strategy with the potential to generate lasting competitive advantages.

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