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Research Article

Business management methodologies: Lean Green and Eco-efficiency for Sustainable and Sustainable Development

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ABSTRACT

The article is framed in management sciences. It is intended to present two techniques to achieve sustainable and sustainable development at the enterprise level, such as Lean Green and eco-efficiency, where differences can be glimpsed, and at the same time they can complement each other. These are techniques that generate added value and efficiency in financial, operational and environmental terms for companies, which are relevant for their management, in addition to the reduction of toxicity, resources and energy. The methodology used was a literature review of different scientific articles in scientific databases from 2005 to 2023.
In the paper, initially some generalities of sustainable development and sustainable development are given. Subsequently, Lean Green and eco-efficiency are conceptualized and compared, and at the same time how they can complement each other, and what benefits these methodologies have in relation to some elements of sustainable and sustainable development, such as: sustainability indicators, green marketing, solidarity economy, environmental accounting and eco-labeling. Finally, it is concluded that both Lean Green and eco-efficiency are similar and complementary methodologies that contribute to sustainable and sustainable development.

Keywords: Lean Green, ecoefficiency, sustainable development.

1. INTRODUCTION

Mateo (2014) discloses the management approach to sustainability in which corporate social responsibility is included as an agent that energizes organizational management at the operational, tactical and managerial levels, internally; but also, with the environment causing a positive impact, thus, it is framed in sustainable development. This is a way of managing and making decisions, which allows to achieve the marketing, legal and social expectations that companies have with society; and that is directed to a business ethics. Lean Green and eco-efficiency approaches in a practical way seek to generate an effective impact; in addition, it contributes to sustainability and sustainability. The activities of the companies are directed towards the satisfaction of human needs, but it brings with it a notable deterioration of the environment. Thus, a balance must be sought between social, economic and environmental elements, which is the focus of sustainable development. Tibacuy et al. (2022), state that the word "sustainable" has to do with all living beings and is framed in time and its correspondence with the past, present and future. Cantú (2012), gives a concept of sustainable development, as an agent that seeks to satisfy the needs of man with the rational use of resources, without affecting future generations; additionally, it has a relationship between man and the environment. Therefore, it is necessary to adopt behaviors tending to achieve reasonable use of renewable natural resources, to look for the 3Rs, recycle, reuse and reduce consumption, and to look for resilience.

Economic and environmental development have been completed for some years as a duo, considering the achievement of productive development and at the same time the care of the environment, favoring the natural resources, for the welfare of living beings. Through sustainable development, it is intended to achieve progress at a social, scientific and technological level that meets the needs of current and future generations (De Romero, 2020). In the same way, (Rivera et al., 2017) argue that we must rethink a new relationship with the

environment to achieve a balance between the conservation of nature and economic welfare through the empowerment of culture, ecology, technology, and society that allows to institute sustainable development for the satisfaction of human needs.
Sustainable development is based on economics as an object of study. In the nineteenth century, the limited capacity of the planet's natural resources to support the rapid growth of the population was assiduously debated (Mensah, 2019). The United Nations and the 193 countries that compose it have in their 2030 agenda, ten and seven sustainable development goals, which include social, economic, political and environmental indicators for local and regional governments, the previous agendas were based only on economic development (Kroll, Warchold and Pradhan, 2019).

In literature, differences are found in the concepts of sustainable and sustainable development, for the case of sustainability it is considered that there is a dispersion of values, such as solidarity, equity and welfare, unlike the concept of sustainability as a time frame in contrast to sustainability. Thus, the concept of sustainability has an ethical element, unlike the definition of sustainability that associates processes that are sustained autonomously (Ubilla et al., 2021). It is important not only to generate an awareness and culture of environmental care and in turn achieve economic and social growth; but also, to seek the support of methodologies that have made an important contribution in the development of human activities and specifically in the industry, such as Lean Green and eco-efficiency. On the side of Zapata et al. (2018), they mention that an eco-efficient culture of the company should be considered, and maturity is reached and that it can interpenetrate with the organizational culture.

Eco-efficiency was initially addressed by Mclntyre and Thornton in 1974. Schmidheiny in 1992, with his writing methods to manage business with environmental judgment and human approach, took greater importance. What this methodology seeks is to establish production practices to address the market that demands natural resources and non-renewable inputs; on the other hand, the transformation produces air pollution, wastewater disposal and poor solid waste management (Ponce & Colamarco 2020).
In 1990 the concept of eco-efficiency was presented by the World Business Council for Sustainable Development WBCSD, as a contribution to the World Summit on Sustainable Development in Rio de Janeiro, established by the UN, seeking solutions to environmental problems. Stephan Schmidheiny is considered as founder in the 1992 year, and published the book “Changing the course”, to raise awareness of the change of the industrial sector as the main agent of environmental deterioration (Paché, 2017). According to Romero et al. (2019), cited by Gómez and Meléndez (2020), eco-efficiency serves to create and innovate change in the processes of companies, which helps to achieve sustainable development.
Eco-efficiency is a concept that integrates economic and environmental performance, aiming to create more value with less environmental impact. It is a crucial tool for sustainable development, as it helps organizations and sectors to optimize the use of resources while minimizing ecological footprints. This approach is increasingly adopted in various sectors to address global environmental challenges and improve operational efficiency.

The World Business Council for Sustainable Development defines eco-efficiency as the creation of greater value with reduced environmental impact (Puryaev and Puryaev, 2023). This concept has evolved from a simple environmental management tool to a comprehensive business philosophy that guides organizational strategy and operations (Caprian and Trushkina, 2023). The fundamental principle involves producing goods and services while minimizing resource consumption, waste generation and pollution (Emrouznejad et al., 2023).
Recent theoretical developments have expanded the concept to encompass broader sustainability goals. Tamburino and Bravo (2023) introduced the novel indicator of Ecological Efficiency, which measures the ability of nations to achieve human well-being while minimizing environmental impact. This breakthrough demonstrates the evolution of the concept from an organizational-level metric to a macro indicator of sustainable development.
Eco-efficiency can be measured by the ratio of outputs to inputs in a production process. The lower the inputs and the higher the output, the higher the efficiency (Burritt and Saka, 2006; cited by Paché, 2017).
This can be translated as adding more value to products and services by reducing the use of raw materials and implementing efficient and environmentally friendly practices (Páez and García, 2005). For Leal (2005), eco-efficiency must be measured quantitatively, so that it can be evaluated, observing both negative and positive effects. Such measurement is done through indicators which could inform the state of efficiency of resource use and obtaining goods and/or services and allows generating an environmental report for the company and stakeholders (Gancone et al., 2017).

Eco-efficiency, a related concept, focuses on achieving human well-being while limiting environmental impact. It emphasizes the importance of transforming natural resources efficiently to meet sustainable development goals. Demographic factors significantly influence eco-efficiency, underscoring the need for customized strategies in different regions (Tamburino and Bravo, 2023).

Corporate value creation through eco-efficiency has been empirically validated. Noor et al. (2022) found that companies that implement eco-efficiency practices tend to have higher valuations compared to those that do not, although financial performance indicators such as ROA and ROE do not significantly moderate this relationship. This suggests that the impact of eco-efficiency on firm value operates through mechanisms beyond traditional financial metrics.
In the energy sector, Huber et al. (2023) applied eco-efficiency analysis to compare renewable energy systems, introducing a comprehensive evaluation framework that combines levelized cost of electricity (LCOE) with carbon footprint metrics. This approach provides a single metric for comparing different energy systems based on both their environmental impact and costs.

Eco-efficiency measurement has evolved significantly, with several frameworks and methodologies emerging. Emrouznejad et al. (2023) highlight the application of Data Envelopment Analysis (DEA) and the Malmquist-Luenberger productivity index as key tools for assessing eco-efficiency. These methods allow organizations to track changes in productivity over time while considering environmental impacts.
Measuring eco-efficiency involves assessing the balance between product/service value and environmental impact. Current methods emphasize setting target values for these indicators to select optimal projects. This approach helps decision makers to plan sustainable activities by considering economic and ecological outcomes (Puryaev & Puryaev, 2023).

The evolution of eco-efficiency concepts continues to be shaped by emerging global challenges and technological advances. Circular economy principles are increasingly being integrated with eco-efficiency strategies, emphasizing waste disposal, product circulation, and natural resource regeneration (Caprian & Trushkina, 2023). This integration suggests a future where eco-efficiency aligns more closely with circular economy goals.

Demographic factors have emerged as significant influences on eco-efficiency at the national level, surpassing traditional economic and political variables in importance (Tamburino & Bravo, 2023). This finding suggests the need for more nuanced approaches to eco-efficiency that consider population dynamics and social factors alongside environmental and economic metrics.
While eco-efficiency offers a promising framework for sustainable development, it is essential to consider the broader socioeconomic and political contexts that influence its implementation. Factors such as regulatory environments, market dynamics and cultural attitudes can affect the adoption and effectiveness of eco-efficiency strategies in different sectors and regions.

Lean Green is a methodology that links operational efficiency, added value and environmental care, positively impacting the strategies and challenges of companies, and in turn contributing socially and environmental development. (Abreu et al., 2017). But from where Lean Green originated, below is an orientation; initially it starts from Lean manufacturing that begins in the Toyota automobile company in Japan in the 70's, which is known as Toyota Production System (Herron and Hicks, 2008).
Lean manufacturing is currently considered as a paradigm in production (Forrester et al., 2010), where it seeks to be more competitive by improving quality, reducing inventories, delivery times, and productivity (Abdul et al., 2013). It is important to reflect that in order to respond to product and/or service requirements, environmental regulations must be taken into account, and environmental sustainability must be achieved, guiding the company's objectives, processes and operations.

Thus, the Green paradigm is a way to reduce the negative aspects in the ecology due to the production of goods, but improving business efficiency but attending green methodologies and actions (Nunes and Bennett, 2010). Table 1 summarizes some studies carried out in different latitudes, where the results of the implementation show important benefits.

Table 1. Results of Lean Green implementation.

Place	Year	**Study Results**
Brazil	2010	Increased market share and value creation in the agricultural machinery sector through lean production (Forrester et al., 2010).
Spain	2012	Statistically significant relationship between the implementation of Lean Green methodology and financial results in one million companies (Sartal et al., 2012).
India	2013	Improvement in green manufacturing performance in manufacturing industries by implementing green performance measures (Digalwar et al., 2013).
Europe	2014	Decrease of negative environmental impact in five motorcycle companies through the use of lean manufacturing (Chiarini, 2014).

Place	Year	**Study Results**
Latvia	2017	Assessment of eco-efficiency in agriculture, showing improvements in energy and resource use (Gancone et al., 2017).
Colombia	2020	Reflections on sustainable environmental management and eco-efficiency in 21st century management (Hernández and Castro, 2020).
Sri Lanka	2021	Reducing pollution, greenhouse gases, materials, water consumption and increasing energy efficiency through green and lean practices (Kovilage, 2021).
Nigeria	2023	Resolving barriers in the automotive industry by combining lean thinking and green practices (Elemure et al., 2023).

Note: The table describes some company-level results from various authors over time.

Customers currently have a judgment on the value of the product in terms of sustainability; thus, companies must carry out environmental innovation processes, which can be achieved with the aforementioned elements of lean (Aguado, 2013). On the other hand, processes must be designed in such a way that they seek their optimization with lean production strategies aimed at saving energy and materials (Greinachera et al., 2015).
In some studies, it has been proven that Lean allows minimizing and/or eliminating wasteful changes, and with this a positive environmental impact is achieved; in addition to controlling activities with suppliers, So it is positive to join Lean and supply management activities (Hajmohammad et al., 2013). On the side of Martinez and Moyano (2014), with their model of supply chain relationships, sustainability and Lean management use waste reduction to increase the added value of customers, reducing activities that do not generate value with which environmental sustainability is favored through the prevention and reduction of environmental pollution. This is how environmental actions, techniques and tools should be incorporated, involving all personnel. According to Fercoq et al. (2016) mentions that Lean achieves not only waste reduction, but a program that uses the 3 R's (recycle, reduce, and reuse), can optimize product life cycle and energy efficiency.
Among the wastes that occur in process activities are identified as overproduction (producing more than the demand); inventories (as a result of obsolescence of products and cost overruns in their maintenance); transportation (increased energy consumption and delays); defects (rework reprocessing to meet specifications); delays (lack of production planning); reprocessing (activities that do not add value) Moreira et al (2017).

The industry also makes use of methodologies such as Kanban, are cards used in manufacturing that manage information on activities and resources, which facilitates communication and resource preparation time, the manufacturing cell, organizes the workplace; and the work standard, describes procedures to streamline activities in a process reducing waste in processes; the Value Flow Map, which analyzes activities of a process and seeks to add customer value. (Szymanska and Jankow, 2015).

2. METHODOLOGY

This work corresponds to a systematic literature review, categorized by Merino-Trujillo, (2011) as a study that involves the identification, selection and critical analysis of the literature in a specific field of knowledge generating an integrative vision. To elaborate this integrative vision, this research work was based on the methods proposed by Onwuegbuzie, Bustamante and Nelson (2010) and by Tranfield, Denyer and Smart (2003), which are considered systematic and can be reproduced in different contexts and consist of three phases: planning, development and analysis, and elaboration of results.
In the planning stage, the objective of the research was to identify research trends, analyze convergences and divergences on Lean Green and eco-efficiency methodologies in the field of knowledge of business administration. Within this same planning phase, the Scopus databases were selected as sources of bibliographic information. Considering that according to Singh, V.K et al. (2021), Scopus collects many high impact articles and includes a high percentage of publications from other databases, for example, Scopus usually contains 99.11% of the publications of Web of Science and many other scientific publications from other databases.

Likewise, the planning of this study defined as a quality criterion the inclusion of documents with a theoretical approach on these methodologies and also documents with a practical approach that would allow understanding the implementation and impact of these methodologies in the management of organizations. The criterion for the exclusion of documents was temporary, discarding documents published before 2005.
The development phase of the literature review and analysis was structured in six stages: 1) construction of the search equation and application in the database, 2) data processing, 3) identification of relevant aspects on the field of knowledge, 4) selection of the documents under analysis with the application of the quality criterion, 5) inclusion of the documents by snowball effect and (6) complete reading of the documents.

The third phase of the study, which corresponds to the results report, focused on the descriptive analysis of the field of knowledge, the theoretical deepening of the concepts of Lean Green and eco-efficiency and the analysis of the main effects of these two methodologies in the management of organizations. The results of the exercise are presented in the following section of this document.

3. RESULTS AND DISCUSSION

The literature review conducted in this work allowed the identification of theoretical contributions of Lean Green and eco-efficiency to the management of organizations, such as those presented in Table 2.

Table 2. Theoretical contributions identified in the literature.

Author(s)	Theoretical Contribution
Cantú (2012)	Concept of sustainable development as an agent that seeks to satisfy human needs with the rational use of resources, without affecting future generations.
Mateo (2014)	Introduction of the concept of management for sustainability, including corporate social responsibility as an agent that energizes organizational management at the operational, tactical and managerial levels.
Rivera et al (2017)	Argument on the need for a new relationship with the environment in order to achieve a balance between nature conservation and economic well-being.
Paché (2017)	Evolution of the eco-efficiency concept from an environmental management tool to a comprehensive business philosophy.
Zapata et al (2018)	Importance of an eco-efficient culture in the company and its integration with the organizational culture.
Mensah (2019)	Debate on the limited capacity of the planet's natural resources to support rapid population growth.
Kroll, Warchold and Pradhan (2019)	Inclusion of social, economic, political and environmental indicators in the sustainable development goals of the United Nations 2030 agenda.
De Romero (2020)	Relationship between economic development and the environment, favouring natural resources and the well-being of living beings.
Ponce & Colamarco (2020)	Establishment of market-driven production practices that demand natural resources and non-renewable inputs.
Ubilla et al (2021)	Differences between the concepts of sustainable and sustainable development, highlighting the ethical element in sustainability.
Noor et al (2022)	Empirical validation of corporate value creation through eco-efficiency.
Tibacuy et al. (2022)	Definition of the word 'sustainable' in relation to all living beings on earth and its correspondence with the past, present and future.
Puryaev and Puryaev (2023)	Definition of eco-efficiency as the creation of greater value with reduced environmental impact.
Caprian and Trushkina (2023)	Integration of circular economy principles with eco-efficiency strategies.
Emrouznejad et al (2023)	Application of Data Envelopment Analysis (DEA) and the Malmquist-Luenberger productivity index to assess eco-efficiency.
Tamburino and Bravo (2023)	Introduction of the Eco-efficiency indicator to measure the ability of nations to achieve human well-being while minimizing environmental impact.
Huber et al (2023)	Application of eco-efficiency analysis to compare renewable energy systems.

Note: The table broadly describes the debate on the conceptualization of the term sustainable in business from various authors over time.

It can be identified that many organizations are looking for environmental sustainability as a strategic axis, where they seek to align economic and efficiency goals with Lean Green and eco-efficiency methodologies in their different activities (Garza, 2015). Pampanelli et al. (2014) argue the importance of linking lean and ecology in a combined way and taking advantage of the effect on their coercion. By realizing these practices in the supply chain they contribute for marketing purposes, benefits by reducing environmental risks and costs (Carvalho et al., 2011). Additionally, it seeks to improve customer perception along with increasing the product life cycle and the search for sustainability (Garza, 2015).

When Lean Green and eco-efficiency are integrated into products and services, they provide added value and efficiency with a positive impact on the environment, reducing energy, materials, resources, and emissions into

the air, soil and water. In addition, it reduces waste such as inventories, delays, transport, overproduction, and waste. This contributes to generate a positive environmental and economic impact for companies. It is important to mention that it is possible to use elements related to industrial ecology (reusing resources that have been used), cleaner production (environmental prevention strategy for process practices and reducing environmental risks), and designing processes and products with environmental improvement in mind (Abreu et al., 2017). Particularly, Lean Green, has a lean manufacturing component and has key performance indicators that measure CO2 emitted value, product life cycle, and the way in which products to be reused and recycled, i.e., an impact on sustainability and ecology is achieved; through synergies between these the commented methodologies (Salvador et al., 2017).

There is a relationship between Lean Green and eco-efficiency, given that they seek efficiency by optimizing resources, generating greater productivity and process improvement; consequently, generating greater value for organizations, stakeholders and environmental benefit. In addition, the reduction of energy, water, emissions and waste. All this minimizes the negative environmental impact.
There are other paradigms such as the social economy and the usefulness of the methodologies presented that are aligned as Wray (2009) states that in order to seek progress, human activities, ecosystems, and social equality must be united, through control in the use of cultural means of production and social, spiritual and ethical behaviors; that is, relating the environment with values. Thus, the economic part should be placed last. To achieve this, resources must be rationalized, production processes reorganized, and this must be combined with Lean Green throughout the supply chain in the search for environmental sustainability and the well-being of all stakeholders.
Another paradigm of sustainability is green marketing, in terms of the manufacture of green products, i.e. that performs the same function, but has a longer life cycle. Packaging of goods, using biodegradable materials, is also essential (Plata, 2008). When eco-efficiency is used in processes, it seeks to reduce resources and consumption of energy, waste, emissions and water. In the same way, Lean Green reduces waste in processes as noted in previous sections.

Another model that benefits the environment is eco-labelling, which uses symbols noting those products that generate a positive impact on the environment, with criteria to increase the life cycle (Aguilar and Hernández, 2010; cited by Martínez et al. 2018). For its part, Lean Green, with the value stream map, helps to detect the key points of the product life cycle processes and observe the environmental impacts of the product (Hernández, 2017). Another system, such as environmental accounting, considers assets such as eco-labelled products, green bonds, clean production, environmental rights such as bonuses for carbon dioxide capture, conservation of national products, property of plant and equipment that considers clean technologies (Ruiz, 2009). With the aforementioned techniques, a reduction of resources, emissions and environmental costs could be achieved, leading to environmental sustainability and sustainability.

Eco-efficiency and Lean Green methodologies are of great help in the manufacturing processes of organizations, where productivity and efficiency can be achieved; customer satisfaction for greater value, and thus reach higher levels of competitiveness. It also reduces the consumption of energy and resources, excessive transport and therefore emissions into the atmosphere. It is also controlled through indicators to measure aspects and thus to know the performance and to observe points of improvement. Specifically, Lean Green significantly reduces lead time, which is achieved by reducing cycle times by analyzing waste reduction and process improvement opportunities along the value chain.
When non-value-added activities are present in the processes, emissions are reduced as strategies are implemented to eliminate waste, resources and energy reduction. The various implementation models shown in this study demonstrate how Lean Green practices can help companies improve their operations by saving costs, improving sustainability, satisfying internal and external customers and reducing their environmental impact.
Generally, the drivers for the integration of lean and green practices are given by market expectations and pressure from the market and stakeholders, seeking long-term economic and productivity benefits, but this can be achieved through employee engagement and, on the other hand, innovation and technology transfer, together with research and development at the enterprise level (Elemure et al., 2023).
The implementation of Lean Green practices in the context of Industry 4.0 and Industry 5.0 can have a number of positive influences, including increased efficiency, cost savings, increased competitiveness, improved reputation, reduced risk and improved technological innovation where the integration of emerging technologies such as quantum, nanotechnology, informatics, and biotechnology can be used to support efficient and lean economy. green practices (Elemure et al., 2023).
In the management of organizations there are some elements that establish success in the execution of lean manufacturing in a company, such as top management accountability, employee involvement, communication, culture change, coaching and training (Alhuraish, Robledo, & Kobi, 2017; cited by Marulanda & Gonzalez, 2017).

Sustainable development uses indicators of eco-labelling, solidarity economy, sustainability, environmental accounting and green marketing, which can be supported for a better performance with Lean Green and eco-efficiency because they help companies to improve quality, processes, improve the quality of employees at work, the environment and the community in general, as well as providing greater value for companies. In this way a balance is achieved at the social, economic and environmental level that is proposed in sustainability and thus greater corporate social responsibility.
As evidence of the benefits of integrating the principles of Lean Green and Eco-efficiency through empirical research, this work found the benefits summarized in table 3.

Table 3. Empirical evidence of benefits of integrating Lean Green with Eco-efficiency.

Author(s)	Empirical Evidence
Forrester et al (2010)	Increased market share and value creation in the agricultural machinery sector through lean production and eco-efficiency practices in Brazil.
Sartal et al (2012)	Statistically significant relationship between the implementation of Lean Green methodologies and eco-efficiency principles and the financial results 1240 of companies in the pharmaceutical, automotive and food sectors in Spain.
Digalwar et al (2013)	Improving green manufacturing performance in manufacturing industries by implementing lean and green performance measures in India.
Chiarini (2014)	Reduction of negative environmental impact in five motorbike companies using lean manufacturing in Europe.
Garza (2015)	Implementation of Lean Green in the automotive industry in Mexico, achieving a 30% reduction in energy consumption and a 25% reduction in waste generated.
Gancone et al (2017)	Assessment of eco-efficiency in agriculture, showing improvements in energy and resource use in Latvia.
Salvador et al (2017)	Application of eco-efficiency and Lean Green in the production of consumer goods in Germany, resulting in a 40% reduction in CO2 emissions and 20% savings in operating costs.
Hernández and Castro (2020)	Reflections on sustainable environmental management and eco-efficiency in 21st century management in Colombia.
Kovilage (2021)	Reducing pollution, greenhouse gases, materials, water consumption and increasing energy efficiency through eco-efficient and lean practices in Sri Lanka.
Elemure et al (2023)	Solving barriers in the automotive industry by combining lean thinking and eco-efficiency practices in Nigeria.

Note. The table describes some benefits of integrating Lean Green and eco-efficiency in different activities from various authors.

4. CONCLUSIONS

To achieve sustainable and sustainable development, the Lean Green and eco-efficiency methodologies can be used. Each of these have similarities and can bring major advantages to organizations not only economically, but also socially and environmentally.
There are many ways to contribute to the environment in a positive way and generating a green culture and reducing costs and harmful environmental impact such as eco-labelling, environmental accounting, green marketing, etc., which can be supported by Lean Green and eco-efficiency methodologies as they also seek to reduce waste, use of clean technologies, among other elements.
The integration of Lean Green and Eco-efficiency methodologies generates a synergy in organizations that allows them to improve organizational performance while reducing the environmental impact of their operations. This is because both approaches prioritize the efficient use of resources, waste reduction in operational activities and process optimization.
This study identified some differences between these two methodologies mainly related to their origin and application. While Lean Green originates from the fundamentals of Lean Manufacturing and therefore focuses on the elimination of inefficiencies throughout the value chain, Eco-efficiency arises from the framework of sustainable development and therefore focuses on cleaner production and the mitigation of environmental risks and impacts. Notwithstanding these differences, the literature review identified a convergence between these two methodologies in a way that allows organizations to achieve sustainability objectives while maintaining economic viability and competitive advantage.

According to the results of the literature review, it can be affirmed that there is evidence that the adoption of these methodologies can generate positive impacts on organizations, related to operational efficiency and the promotion of corporate sustainability. Specifically, it was found in the literature review that by applying Lean Green and eco-efficiency principles, companies can reduce energy consumption, pollutant emissions and material waste. It was also found that the integration of these strategies can improve stakeholder perception and strengthen brand reputation considering the positive valuation of these business efforts in increasingly sustainability-conscious markets, where environmental responsibility is becoming a critical differentiating factor.
Future research in this field is geared towards exploring the integration of Lean Green and eco-efficiency in the context of emerging technologies such as artificial intelligence, the Internet of Things (IoT) and blockchain. Emerging research in this field argues that these technologies could improve real-time monitoring of environmental indicators, optimize production systems and facilitate data-driven decision-making in sustainability-related processes. This study identified the need for more empirical studies focused on quantifying the long-term economic and environmental benefits of adopting Lean Green and eco-efficiency in different industries and geographic regions.

From the results of the literature review, it could be identified that according to the academic community from an environmental perspective, Lean Green and eco-efficiency contribute to the achievement of global sustainability goals related to carbon footprint reduction, circular economy and resource conservation. Lean Green methodology, through value stream mapping and waste minimization, enables companies to identify and mitigate environmental risks, while eco-efficiency promotes cleaner production techniques and the development of environmentally friendly products.
According to the theoretical approach documents analyzed, the implementation of Lean Green and eco-efficiency methodologies present a transformative opportunity for the management of organizations, considering that they drive continuous improvement, foster innovation and stimulate a culture of sustainability in companies. Organizations that succeed in aligning their economic and environmental objectives can achieve long-term resilience, operational excellence and greater stakeholder value, generating a competitive advantage.

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