

Integrating Lean Philosophy and Sustainability: A Systematic Literature Review with a Focus on the Social Dimension

Elena Terradillos ^{1,2}, João Matias ^{2,3}, Helena V. G. Navas ^{4,5,*} and Olga Costa ¹

¹ Instituto Politécnico de Setúbal, Escola Superior de Tecnologia de Setúbal, Setúbal, 2910-761 Setúbal, Portugal; elena.terraddillos@estsetubal.ips.pt (E.T.); olga.costa@estsetubal.ips.pt (O.C.)

² DEGEIT, Departamento de Economia, Gestão, Engenharia Industrial e Turismo, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal; jmatias@ua.pt

³ GOVCOPP, Unidade de Investigação em Governança, Competitividade e Políticas Públicas, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal

⁴ UNIDEMI, Department of Mechanical and Industrial Engineering, NOVA School of Science and Technology, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal

⁵ LASI—Intelligent Systems Associate Laboratory, 4800-058 Guimarães, Portugal

* Correspondence: hvgn@fct.unl.pt

Abstract

In recent decades, the business paradigm has been transforming into the face of global challenges such as climate change and resource scarcity, consolidating sustainability as a strategic pillar that integrates the economic, environmental, and social dimensions. In parallel, Lean Philosophy, focused on eliminating waste and creating value, has been widely adopted as an effective management model. Despite the potential for its integration, literature reveals significant gaps, especially regarding the social dimension, which is often underexplored compared to the environmental and economic dimensions. To address this gap, this study identifies, analyzes, and synthesizes scientific literature on the integration between Lean and sustainability, with a special focus on the social dimension, using a systematic literature review conducted according to the PRISMA guidelines. A total of 132 articles published between 2011 and 2024 were analyzed, obtained from the Scopus, Web of Science, and ScienceDirect databases. The results demonstrate a growing convergence between the two concepts, highlighting the centrality of the human factor, namely well-being, safety and health at work, and ethical practices, and identifying challenges and opportunities for future research focused on a more holistic approach to organizational sustainability.

Keywords: lean; sustainability; social; social sustainability; PRISMA; systematic literature review



Academic Editor: Koichi Murata

Received: 29 December 2025

Revised: 30 January 2026

Accepted: 3 February 2026

Published: 6 February 2026

Copyright: © 2026 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article

distributed under the terms and

conditions of the [Creative Commons](https://creativecommons.org/licenses/by/4.0/)

[Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

1. Introduction

In recent decades, the business paradigm has undergone profound transformation in response to global challenges such as climate change, resource scarcity, and increasing social and environmental demands. In this context, sustainability has become a strategic pillar of organizations, reflecting the need to adopt management models capable of balancing, in an integrated way, the economic, environmental, and social dimensions of organizational performance. In parallel, Lean Philosophy, originally developed in the Japanese industrial context, has been widely adopted as a management approach oriented towards eliminating waste, continuous improvement, and creating value for the customer [1–3].

The integration between Lean Philosophy and sustainability therefore emerges as a promising approach to promote more efficient, responsible, and resilient business performance. Both approaches share fundamental principles, such as resource optimization, waste reduction, and a focus on process efficiency. However, despite the growing interest in analyzing the synergies between Lean and sustainability, the existing research has focused predominantly on the economic and environmental dimensions, often leaving the social dimension underrepresented or treated implicitly [4,5].

Although organizations demonstrate a growing concern in fulfilling their environmental responsibilities, significant difficulties continue to be observed in the integrated implementation of sustainable practices, constituting a cross-cutting and global challenge. In this sense, companies use tools, methodologies, philosophies, and management strategies with the aim of improving environmental performance, complying with legal requirements, and strengthening competitiveness. However, the impacts of these approaches at the social level, including worker well-being, working conditions, equity, employee engagement, and cultural contexts, remain insufficiently explored in a systematic way [6,7].

The literature generally shows a positive relationship between Lean and sustainability, with the potential to generate synergies that promote improvements in the three dimensions of sustainable development. Lean tools have facilitated the implementation of sustainable practices through efficiency gains and resource optimization, even when their initial focus was not on environmental or social sustainability. However, the application of certain tools and methodologies can also lead to limitations, tensions and trade-offs, particularly when operational efficiency is achieved at the cost of negative or neglected social impacts, requiring a more in-depth analysis of their effects on the economic, environmental and social dimensions [3,8–10].

In this context, the need for a systematic and critical analysis of the literature becomes evident, allowing us to understand how Lean Philosophy has been integrated with sustainability, with special attention to the social dimension, which is often neglected. The absence of a balanced approach to the three pillars of sustainability limits the holistic understanding of this integration and compromises the identification of truly sustainable practices in the long term.

Thus, the main objective of this study is to identify, analyze, and synthesize the existing scientific production on the integration between Lean Philosophy and sustainability, with a particular focus on the social dimension, mapping the main approaches, methodologies, areas of application, and emerging challenges. To this end, a systematic literature review (SLR) was conducted, following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), covering publications between 2011 and 2024, to capture the recent evolution of the topic and identify emerging trends. Based on this framework, the research seeks to answer the following research questions (RQs):

RQ1: What are the main objectives and approaches of studies on the implementation of Lean and sustainability practices (economic, environmental, and social) in companies?

RQ2: How does the implementation of Lean and sustainability practices (economic, environmental, and social, and social) influence competitive priorities and trade-offs in companies?

RQ3: What are the most common tools and methodologies used in the integration of Lean and sustainability concepts (economic, environmental, and social) in companies?

RQ4: What impact does the implementation of Lean and sustainability concepts have on companies?

The relevance of this research lies in providing a comprehensive and up-to-date overview of the state of the art of the integration between Lean and sustainability, identifying the main contributions, limitations, and opportunities for future research. In addition, it highlights the main tools and industrial sectors where this integration has been applied, as well as its practical implications for the competitiveness and sustainable performance of organizations.

Finally, the article's structure is organized as follows: Section 2 presents the materials and methods, including methodological approach, data sources and search strategy, inclusion and exclusion criteria, and data selection and extraction process. Section 3 describes the results of the SLR, addressing the temporal distribution of publications, geographical distribution, type of research, and application sectors. Section 4 discusses the main findings based on the research questions, and Section 5 presents the conclusions and directions for future research.

2. Materials and Methods

This section describes the methodological framework used in this study, including the procedures adopted for the systematic collection, selection, and analysis of the scientific literature. The methodological strategy was based on the application of internationally recognized guidelines for systematic reviews, with the aim of ensuring transparency, reproducibility, and scientific rigor at all stages of the research.

2.1. Methodological Approach

This research used an SLR as a methodological strategy to identify, analyze, and synthesize studies related to the integration of Lean Philosophy and sustainability concepts in industrial and business contexts.

The SLR constitutes a systematic, explicit, comprehensive, and reproducible method that allows for an evidence-based approach to locate, evaluate, and consolidate existing scientific knowledge [11,12].

To ensure transparency, repeatability, and scientific rigor, the PRISMA protocol was followed, as recommended by Page et al. [13] and Reis et al. [14]. This protocol guided the definition of research questions, the selection of information sources, the search strategy, the inclusion and exclusion criteria, as well as the data extraction and analysis procedures.

The analysis period encompassed publications between January 2011 and March 2024, to cover the recent evolution of the integration between Lean and sustainability in the last two decades.

2.2. Data Sources and Search Strategy Methodological Approach

The bibliographic search was conducted in the Scopus, Web of Science (WoS), and ScienceDirect databases, selected for their broad coverage, scientific relevance, and international recognition. These databases aggregate the peer-reviewed scientific literature in the areas of engineering, industrial management, sustainability, and applied sciences, and are widely used in systematic literature reviews and considered reliable sources for studies of this nature.

The search strategy was defined with the objective of identifying studies that addressed the integration between Lean Philosophy and sustainability concepts, considering its three fundamental pillars: economic, environmental, and social. To this end, the search terms were organized into three dimensions: (i) Lean Philosophy and practices; (ii) sustainability; (iii) management models, operational efficiency, layout, decision support, and quality.

Based on these dimensions, the main keywords that guided the search were: Lean, Lean philosophy, sustainable, management model, decision-making, layout, and efficiency. These keywords were subsequently combined using Boolean operators, organized into distinct conceptual groups, and explicitly delimited by parentheses to ensure logical clarity and reproducibility of the search process. The final search string applied to the databases was as follows: (“Lean philosophy” OR Lean) AND sustainable AND (“management model” OR “improved movement” OR layout OR “decision-making” OR prioritization OR efficiency OR “small teams” OR companies OR “quality service” OR “industrial operations” OR “classifying attributes”). The use of AND/OR operators, as well as parentheses, allowed for controlling the combination between primary and secondary concepts, ensuring thematic coherence and fidelity to the strategy effectively applied during the systematic literature review.

As a limitation, it is recognized that the search was restricted to the three selected databases and the terms defined in the search string, and there may be relevant studies published in other databases or that use different terminology. Additionally, truncations or a broad set of synonyms were not used, which may have limited the identification of some marginal publications. However, this methodological choice helped to maintain the thematic focus of the review and ensure the consistency and relevance of the results obtained.

2.3. Inclusion and Exclusion Criteria Data Sources and Search Strategy Methodological Approach

In order to ensure the relevance, quality, and thematic coherence of the included studies, the following inclusion criteria (IC) were defined: IC1: Articles published in scientific journals; IC2: Conference proceedings; IC3: Articles written in English; IC4: Studies related to the integration between Lean and sustainability; IC5: Studies applied to industry or companies in general; IC6: Studies that present reviews, empirical investigations, models, or case studies. Regarding the exclusion criteria (EC), the following criteria were taken into account: EC1: Articles not available in full text (automatic filter of the databases), including neither open access nor accessible open archive documents; EC2: Articles filtered by irrelevant title, abstract, or keywords (automatic filter of the databases); EC3: Articles in languages other than English (automatic filter of the databases); EC4: Articles published outside the analysis period (2011–2024); EC5: Duplicate articles between databases; EC6: Articles not available for full access; EC7: Articles outside the scope of the concepts under study (Lean and sustainability).

2.4. Data Selection and Extraction Process

The selection process was conducted in accordance with the PRISMA 2020 guidelines, as summarized in the flowchart in Figure 1. The initial search in the databases resulted in 1208 records, distributed in Scopus (n = 22), WoS (n = 1018) and Science Direct (n = 168). It is also important to emphasize that bibliographic databases are dynamic and constantly updated, so repeating the search at different times may lead to slight variations in the number of records obtained. The imbalance observed in the distribution of results between databases, i.e., the significantly higher number of records in WoS compared to Scopus or Science Direct, can be explained by differences in thematic scope, indexing policies, and other aspects.

After applying the automatic filters (EC1–EC4), 805 articles were excluded (Scopus: n = 18; WoS: n = 686; Science Direct: n = 101), leaving 403 eligible studies. Based on criteria EC5 and EC6, 349 articles were identified as potentially relevant. Subsequently, a manual review (EC7) was carried out, which involved reading the titles, abstracts, keywords and context of application, resulting in the final selection of 132 articles considered relevant to the objectives of this review.

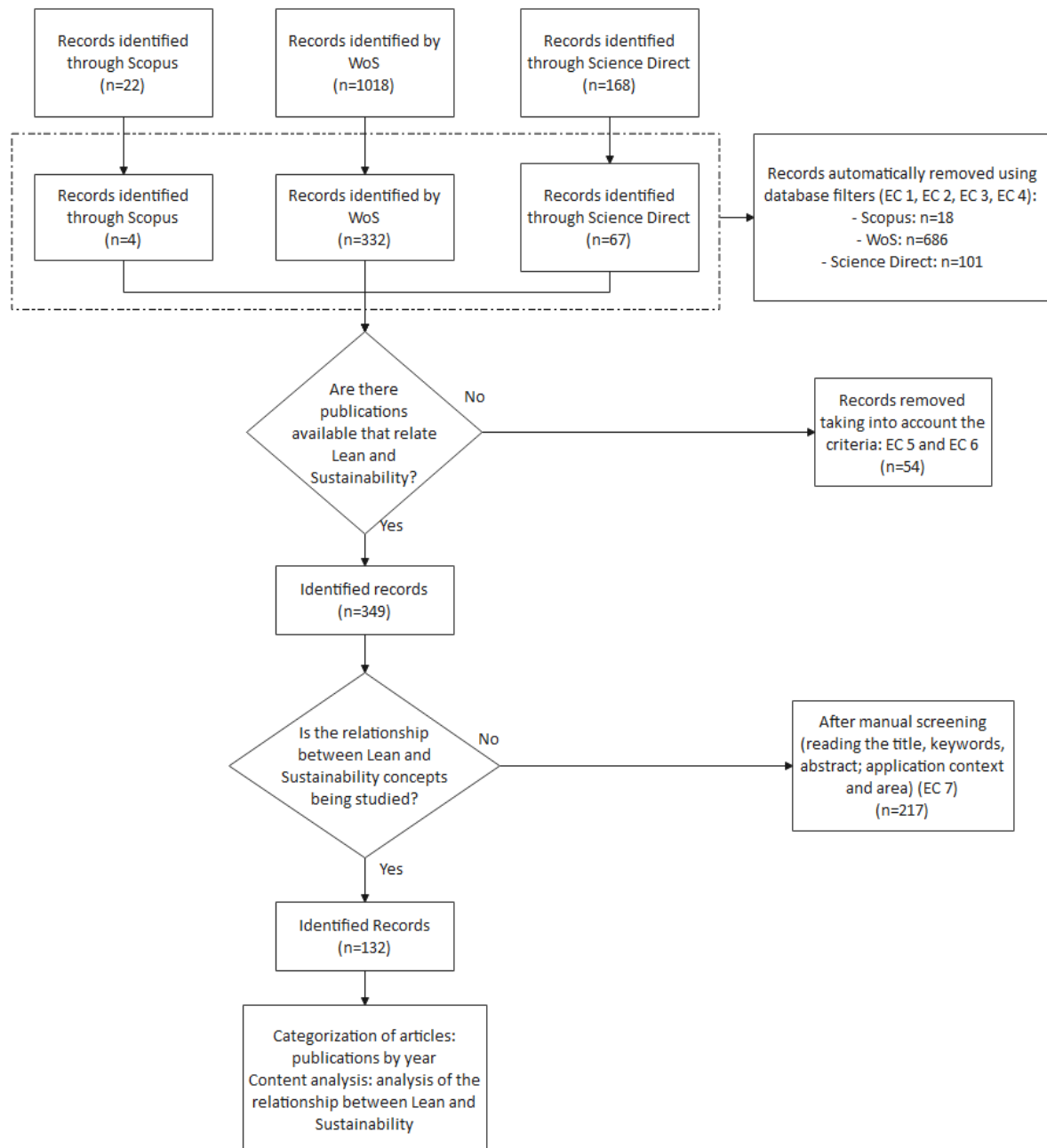


Figure 1. PRISMA flowchart for selecting the most relevant studies regarding the integration of the concepts under study (see Supplementary Materials). Source: The authors.

2.5. Quality Appraisal of Included Studies

To assess the methodological quality of the 132 studies included in this systematic review, a structured assessment matrix was applied, adapted from critical appraisal tools widely recognized in the literature, namely the Joanna Briggs Institute (JBI) checklists [15,16]. This approach ensured transparency and rigor in the analysis of the available evidence, considering the diversity of methodological designs identified. Thus, each study was evaluated based on seven criteria: (i) clarity of research objectives, (ii) definition of the application context, (iii) adequacy of the method used, (iv) rigor in data collection or empirical basis, (v) coherence of the analysis, (vi) relevance of the results presented, and (vii) discussion of the study's limitations. Each criterion was classified as Yes, Partially, or No, with a corresponding score assigned (1, 0.5, or 0 points), which

allowed for the calculation of an overall score and the classification of studies according to their methodological quality as high, moderate, or low.

Quality assessment was performed, and any disagreements regarding the classification of the seven criteria were resolved by consensus. The results indicate that 41 studies (31.1%) were classified as having high methodological quality, 83 studies (62.9%) as having moderate quality, and only 8 studies (6.1%) as having low quality. These results suggest that most of the evidence analyzed presents an adequate methodological level to support the synthesis carried out.

In general, case studies and systematic reviews tend to present greater methodological rigor, while studies classified as low quality reveal, above all, insufficient descriptions of the context, limitations in the explanation of data collection procedures, or the absence of a critical discussion of the study's limitations. Quality judgments were not used as an exclusion criterion but were considered in the interpretation of the results and in the discussion of the evidence, contributing to a more critical and contextualized reading of the findings.

The complete assessment of methodological quality, including the scores and classifications assigned to each of the 132 studies, is presented in Appendix A (Table A1).

3. Results

This section presents the main results obtained from the analysis of the 132 articles selected in the systematic review, highlighting the evolution of scientific production, the geographical distribution of research, and the main approaches that integrate the concepts of Lean Philosophy and sustainability. Each article was analyzed individually, and the data were organized in a summary table (Table A2), including information such as item, author and year, and key findings.

The analysis of the articles allowed us to examine the temporal evolution of publications, the geographical distribution of studies by country, as well as to identify the main tools, concepts, and models used in the integration between Lean and sustainability, among other aspects. On the other hand, it is also important to note that the extraction and categorization of data were performed manually by the author and validated by a second independent reviewer, ensuring the consistency and reliability of the results. This process allowed us to map the existing knowledge on the integration between Lean and sustainability, providing a solid basis for critical analysis and discussion in the following sections.

3.1. Temporal Distribution of Publications

Corporate environmental awareness emerged in the 1970s, driven by the need to comply with legislation and mitigate the environmental impacts of production processes. Since then, the concept of sustainability has gained prominence on business and scientific agendas, reflecting a growing concern to reconcile economic performance and environmental responsibility [3,17–21].

The literature converges on the idea that corporate sustainability requires the balanced integration of environmental, economic, and social dimensions, whose mutual reinforcement enhances lasting benefits [9,22–24]. However, an imbalance is observed in the approaches, with a predominance of the environmental dimension, followed by the economic one, and a persistent undervaluation of the social aspect [9,23,25–28]. This trend reveals a theoretical and practical gap in the holistic understanding of corporate sustainability.

The SLR identified, from 2011 onwards, a significant growth in studies exploring the integration between Lean and sustainability (Figure 2). Between 2011 and 2017, 41 articles were published, while between 2018 and 2024 the number increased to 91, with peaks in 2019, 2023, and 2024 (15 publications in each year). This evolution demonstrates the

maturation of research and the consolidation of the debate on the need for more integrated business strategies capable of balancing productive efficiency, social responsibility, and environmental performance.

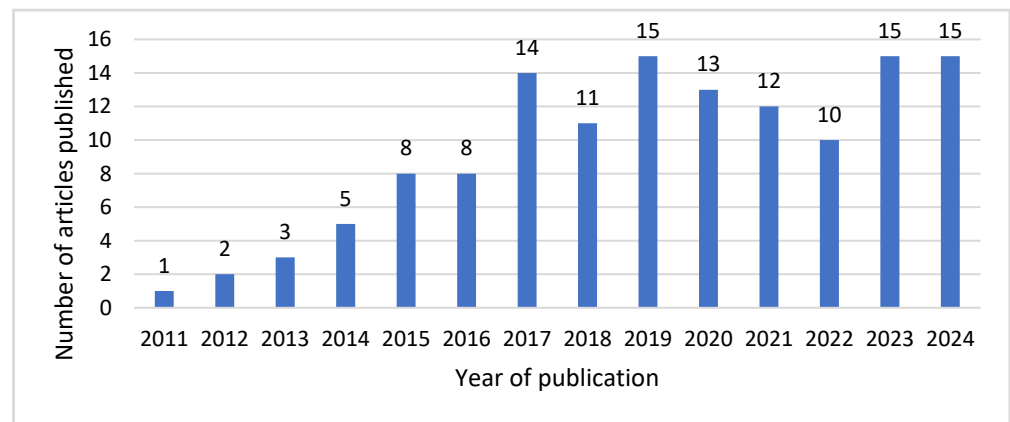


Figure 2. Distribution of articles by year. Source: The authors, based on Scopus, WoS and ScienceDirect.

3.2. Distribution by Country

The analysis of scientific production reveals a significant concentration in certain regions (Figure 3). Portugal appears as the main contributor, with 16 publications (10.5%), highlighting the growing interest of the national academy in the relationship between sustainability and Lean management practices. Next come Poland (13; 8.6%), Brazil and the United States of America (9; 5.9%), as well as Italy, South Africa and Turkey (7; 4.6% each).

This distribution demonstrates the global nature of the discussion on corporate sustainability, encompassing European and non-European countries. The geographical diversity, with contributions from Asia (China, Vietnam, Malaysia), Latin America (Mexico, Chile, Colombia) and Africa (South Africa, Angola, Namibia), shows that interest in the topic also extends to emerging economies.

Such heterogeneity suggests that different economic, social and environmental contexts shape the motivations and challenges of each country. Thus, the global expansion of research in this field reinforces the need for contextualized approaches capable of promoting more inclusive sustainability that is tailored to local specificities.

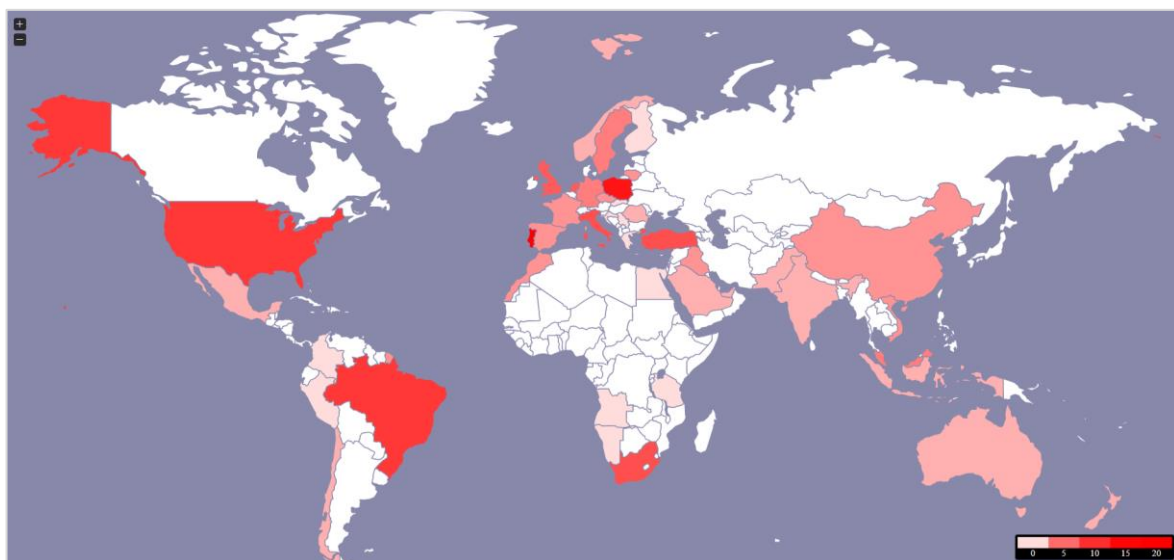


Figure 3. Geographic distribution of selected studies on the integration between Lean and sustainability. Source: The authors, based on Scopus, WoS and ScienceDirect.

3.3. Type of Research and Publication

Regarding the type of publication, 118 of the articles were published in journals and 14 in conference proceedings (Figure 4a). On the other hand, concerning the methodology used, Figure 4b presents the classification of the articles according to the methodology used. Throughout the SLR, it was possible to verify several approaches used regarding the interaction of Lean Philosophy and sustainability, such as the development of models and/or case studies. It was also possible to see that some of the publications used more than one method, such as SLR and model development and SLR, model development and application of the same in one or more case studies. Of the 132 publications analyzed, 16 are SLRs, 1 is an SLR and model, 41 are literature reviews, 40 are case studies, 7 are model development, and 14 are model development and application. On the other hand, 10 publications present a literature review and the development of a model, and three present a literature review and a case study.

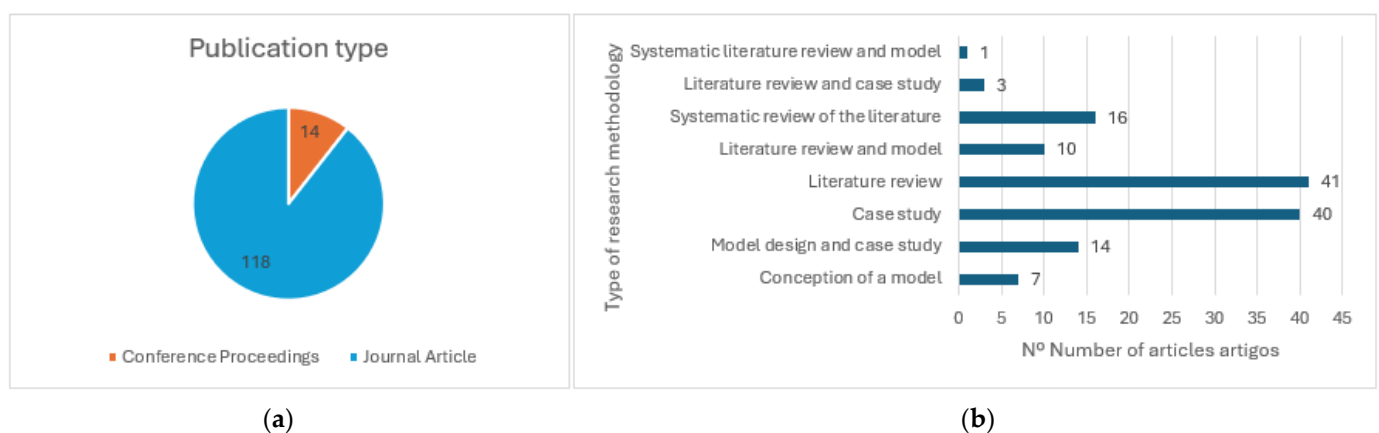


Figure 4. Publications analyzed: (a) Type of source (journal or conference); (b) methodological approach adopted in the studies. Source: The authors.

3.4. Industrial Application Sectors

Regarding the application of Lean and sustainability concepts, a wide variety of industrial sectors and other types of companies have fully or partially implemented the concepts studied in this thesis (Figure 5). After analysis, it was identified that 36 of the 132 articles (27.3%) did not specify the area of study, followed by the construction industry (precast concrete, etc.) with 11.4% (15/132). On the other hand, the third area with the most applications is the healthcare sector with 9.8% (13/132). The fourth area with the most application is the manufacturing industry (manufacturing components, parts and accessories, among others) with 6.8% (9/132). The fifth and sixth areas with the most application are the automotive industry (6.1%) and general industry (3.8%). Publications related to the following areas were also identified, designated in Figure 5 as “Other Industries (Ceramics, plastics, cork, among others)”: maintenance, metallurgical and metalworking industry, mining industry, aeronautical industry, food industry, wood and furniture industries, logistics, education, among others.

As mentioned, 36 of the 132 articles (27.3%) do not specify the industrial sector analyzed. This lack of information can be explained by the fact that some studies address the concepts of Lean and sustainability in a more generic, conceptual, or theoretical way, without focusing on a specific application to a particular sector. In addition, some publications may treat companies from different sectors in a combined or comparative way, without detailing each industrial context individually.

The lack of sector specification in some studies may partially limit comparability between different industrial areas, making it more difficult to identify specific patterns or

recurring practices in each sector. Therefore, the results should be interpreted by taking this particularity into account, without necessarily implying that the findings are not valid for varied contexts, but they should be explored carefully and according to each context and operational reality of each company.

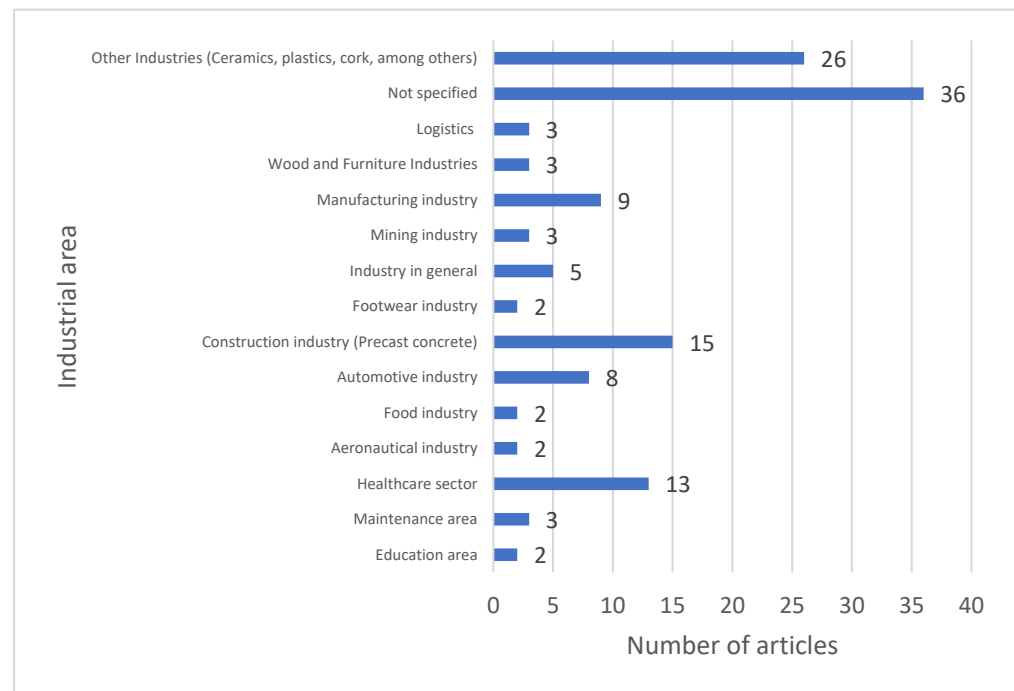


Figure 5. Distribution of items by industry sector. Source: The authors.

3.5. Keyword Analysis

Regarding keywords, a total of 585 keywords were identified and analyzed in 132 articles selected by SLR, and the 20 most frequently used keywords (Figure 6) in the publications are as follows: Lean manufacturing; Lean; Lean management; Sustainability; Continuous improvement; Lean Production; value stream mapping; Lean implementation; Lean construction; Lean philosophy; Waste; Kaizen; Lean Thinking; 5S; Lean Healthcare; Total Productive Maintenance; Six Sigma; Systematic literature review; A3 methodology; Healthcare. The keyword Lean manufacturing is the most frequent with a total of 17 occurrences (2.9%), which can be explained by the fact that it is a widely disseminated philosophy in the business context when compared to the concept and tools associated with sustainability. The keyword Lean appears with 15 occurrences (2.6%), and Lean management with 13 occurrences (2.2%). It is noteworthy that the word Lean is associated with approximately 51 of the 585 keywords identified. On the other hand, keyword sustainability is the fourth most used when analyzing the 132 articles, with 11 occurrences (1.9%). The word sustainability is still underutilized, thus reinforcing the need for further research, both separately and with other concepts. When associated with the social, environmental, or even economic dimensions, it is evident that a huge gap persists, which should be the target of new and intensive investigations, to make the concept of sustainability within companies stronger and more cohesive, becoming increasingly important for companies to assert themselves and consolidate in current markets.



Figure 6. Word cloud generated from the keywords of the 132 selected articles. Source: The authors.

4. Discussion

Based on the analysis of the scientific literature identified by SLR, it was found that the integration between Lean practices and sustainability principles has received increasing attention in both academic and business circles. This integration is recognized as a promising strategy to increase operational efficiency, reduce waste, and promote more balanced development in the economic, environmental, and social dimensions. Therefore, this section discusses in detail the main results obtained, considering the four research questions that guided this study.

4.1. RQ1: What Are the Main Objectives and Approaches of Studies on the Implementation of Lean and Sustainability Practices (Economic, Environmental, and Social) in Companies?

Although the industry has sought over the years to take environmental aspects into account in its production systems, thinking about this issue, as well as decision-making, is commonly a top-down approach, that is, it is taken by senior management, through the analysis of environmental data aggregated throughout the factory annually. This is mainly for the purpose of environmental reports for government entities and external stakeholders, or based on products for eco-design purposes, or as an assessment for the development of marketing strategies, as well as to improve the company's competitiveness and the insertion/capture of a market share that is increasingly demanding and concerned with issues related to environmental sustainability [4,19–21,29,30].

Due to the need to improve various sustainability indicators, and to avoid losing competitiveness in global markets, companies tend to seek ways to face these challenges. Also, in order for them to adapt to environmental demands, as well as remain competitive, it is no longer enough to improve efficiency within the organization itself; it is also necessary to focus on the management of the entire production chain, as well as other supporting areas, such as supply chain management, maintenance, and administration, among others [19,25,29,31–33].

Nowadays, sustainability is an extremely important topic that has been adopted by the business world, government policies, and society in general, to safeguard the ecosystem and as a strategy to gain competitive advantages [29,34–39].

Thus, through bibliographic research, it was possible to identify several publications that emphasize that the integration of Lean Philosophy contributes to improving sustain-

ability and is fundamental for companies to comply with current environmental laws, as well as improve their competitiveness. Lean Philosophy emphasizes the elimination or reduction in any waste without added value. It becomes evident that there are a high demand and scientific development in the design of models, among other works, that contemplate the alignment between Lean Philosophy and the concept of sustainability in terms of methods and tools [4,9,19,23,40–43].

Thus, there has been a greater demand for the development of scientific publications in the literature review, among which the studies by Dombrowski and Mielke [44], Minh and Quyen [18], Ince et al. [4], De Carvalho et al. [21], Tasdemir and Gazo [30], Bhasin and Found [45], Liu et al. [36], and Dieste and Panizzolo [3] stand out. Efforts in developing models that integrate Lean Philosophy to improve the environmental management of companies were also identified. AlManei et al. [46], Bajjou et al. [47], Duran et al. [48], Hammadi and Herrou [31], Hasibul et al. [49], Kurilova-Palisaitiene and Sundin [50], Mieke et al. [19], Tekez and Taşdeviren [51], Ngoc Thuy and Phuong Thao [52], Toussaint and Berry [53], Van der Merwe et al. [54] and Veres [55] have developed models that integrate Lean Philosophy. These models aim to: create and manage a more sustainable value chain; improve processes and production; enhance flexibility in the production of goods and/or services to ensure greater management capacity and responsiveness of the company to new environmental, economic and social demands; adopt sustainable environmental management; develop new products and services to satisfy consumers in more eco-efficient contexts; increase the production capacity of goods and/or services in order to maximize the trade-offs between results and resources allocated throughout the value chain and process flow optimization; increase operational advantages in terms of production, maintenance, logistics, and other areas, in order to improve economic gains resulting from a more efficient use of resources and all activities inherent to these areas; improve the company's image (with suppliers, customers, and authorities); strengthen the capacity for business innovation in general, as well as to improve the competitiveness of companies, through cost reduction, quality improvement, and the introduction of innovative and more environmentally friendly products/services and processes.

4.2. RQ2: How Does the Implementation of Lean and Sustainability Practices (Economic, Environmental, and Social) Influence Competitive Priorities and Trade-Offs in Companies?

Lean Philosophy is beneficial for achieving a sustainable production system with less environmental impact. Due to its versatility, it can be used in various areas of companies beyond the production system, such as supply chain management, allowing companies to improve any area intrinsic to them. Implementing this philosophy allows companies to reduce waste without added value, such as transportation, inventory, movement, waiting, overproduction, over-processing, and defects, among other aspects. It also allows for cost reduction and improved efficiency and competitiveness. Lean Philosophy aims to eliminate or reduce waste, but also to improve the use of resources, thus improving the efficiency of the production system and reducing costs, indirectly allowing companies to improve environmental issues such as pollution and excessive use of natural resources and energy, among others. This philosophy allows most companies to avoid generating waste and byproducts, instead of managing them after they are generated [9,17,20,36,56,57].

Given that Lean Philosophy has a positive correlation with waste reduction, some authors such as Salonitis and Tsinoopoulos [58], De Carvalho et al. [21], Veres [55], Burka [59], Caretta Teixeira et al. [60], Vijverberg et al. [61], Mieke et al. [19], Antosz and Stadnicka [62], Antonioli et al. [63] and Nassereddine and Wehbe [6] also report that there is a positive correlation with the reduction in industrial waste generated and with the prevention of pollution, mainly with regard to the coexistence of manufacturing process efficiency and environmental performance of the industry in general.

Thus, Lean Philosophy can be expanded to improve the management of the productive and environmental system of companies in general and thus improve their environmental sustainability indicators.

Although the main objective of Lean Philosophy is not directly focused on improving the environmental performance of companies, it is aimed at integrating a culture of continuous improvement, and its tools/methodologies can contribute to a positive relationship regarding the integration of the concept of sustainability and business objectives on this subject, since Lean Philosophy makes it possible to minimize waste. The inclusion of Lean Philosophy in companies contributes to the reduction in non-value-adding activities related to the inefficient use of resources, whether time, transportation, inventory, movement, waiting, overproduction, over-processing, or defects. With the inclusion of the concept of sustainability, companies can look at the benefits of Lean, but with a focus on minimizing the adverse environmental impacts of production systems. This should be achieved by reducing or eliminating waste, including the excessive consumption of natural resources, energy, or raw materials, as well as the release of harmful gases and hazardous waste into the environment, which, according to the authors, substantially contributes to improving the environmental and economic performance of companies. On the other hand, authors point out that the Lean Philosophy allows balancing the tripod of sustainability (environmental, economic and social), which allows companies to reach new levels of competitiveness [24,26,36,50,64–66].

Sanda et al. [42], Hasibul et al. [49], Dieste and Panizzolo [3], da Silva et al. [22], Satolo et al. [67], Tasdemir and Gazo [30], Rampasso et al. [68], Tasdemir and Gazo [30], Solaimani and Sedighi [25], Dieste et al. [69], Rauch et al. [70], and Karam et al. [71] reported that as companies reflect on their business models to facilitate sustainability, they are also seeking new manufacturing approaches to meet the challenges of competition. The authors note that many authors emphasize that there are good synergies when relating Lean concepts and sustainability concepts, with companies achieving greater performance gains compared to other companies that have not integrated these concepts. The same authors also cite an interconnection regarding waste reduction; that is, when waste identified by Lean Philosophy is reduced, environmental waste can also be reduced directly or indirectly.

Solaimani and Sedighi [25], Hernandez Marquina et al. [26], Liu et al. [36], Pardillo Baez et al. [72], Abu et al. [73], Mendes et al. [74], Kanyemba et al. [75], Murmura et al. [76], Sá et al. [38], Vienažindienė and Čiarnienė [77], and Alanya et al. [40], among other authors, highlight that Lean Philosophy, when correctly applied to supply chain management, production systems, or any business area, contributes to improving the three dimensions of Triple Bottom Line (TBL). Regarding the social dimension, Lean concepts make it possible, to a certain extent, to improve socio-environmental behavior, ethics, and transparency in business, and increase the number of stakeholders in this area. Regarding the economic pillar, the adoption of Lean makes it possible to improve resource use and efficiency, which can lead to a reduction in operational costs. Concerning the environmental pillar, the use of Lean Philosophy reduces business waste and reduces the use of materials and energy, contributing to better environmental performance, as well as improved economic performance. The study also indicates that for companies intending to integrate, or already having integrated, Lean Philosophy into their structure, the inclusion of sustainability concepts is, in a way, easier due to the total involvement of employees (operators, middle management, and top management). When all these actors are aware of their roles, the pursuit of environmental improvement is more easily achieved, largely due to the established characteristics for achieving the objectives of Lean Philosophy, such as discipline, camaraderie, commitment, continuous improvement, standardization, and other aspects developed throughout the integration of Lean. As mentioned initially, the integration of

these concepts positively influences the sustainable development of businesses, improving their environmental, social, and governance indicators. They also note that both concepts influence factors that go beyond economic measures (operating cost, inventory cost, and environmental cost) and social measures (corruption risk, supplier screening, local suppliers), but also the environmental measures of companies (business waste and image).

However, on the other hand, Rampasso et al. [68], Tasdemir and Gazo [30], Solaimani and Sedighi [25], Bamford et al. [78], Salonitis and Tsinoopoulos [58], Ioppolo et al. [17], Čiarnienė and Vienažindienė [79], AlManei et al. [46], Nassereddine and Wehbe [6], Elkhairi et al. [80], Bayhan et al. [81], Ishak et al. [35], Abu et al. [73], Aslam et al. [82], Maware and Parsley [83], Ainul Azyan et al. [84] and Zaporowska and Szczepański [85] stated that Lean Philosophy may not always coincide with sustainability objectives, highlighting some less positive aspects, namely: (1) the correct integration of the Philosophy is not always achieved on a “first attempt”, and combining Lean and sustainability can create some trade-offs; (2) it is often necessary to customize the operational profile of companies; (3) ensuring supplier involvement; (4) it often involves considerable investments, not being feasible in situations where there are resource limitations; (5) the application of Just-in-Time (JIT) can result in adverse environmental impacts, due to changes in supply chain management, contributing to increased emissions of polluting gases; (6) the flexibility of production systems can contribute to increased competitiveness, facilitate production, improve monitoring of market volatility, and maintain the level of programming in terms of variety and volume of items produced, but on the other hand requires a high number of setups, which may contribute to increased use of cleaning products and greater disposal of unused material during the process; (7) flexibility and customer demand satisfaction can contribute to increased disposal of chemical products, resulting in increased generation of harmful waste, contributing to an increased environmental burden; (8) the use of less harmful raw materials, on the one hand, is beneficial to the environment, but in economic terms it can be substantially more expensive, increasing production costs and even reducing the quality of products and/or services; (9) quality-oriented practices such as Total Quality Management (TQM) and Six Sigma can generate trade-offs, meaning that the reduction in resource consumption may be limited due to the technical requirements of the process and the product; (10) small batch production to meet customer demands can lead to an increased use of transport, resulting in higher emissions of polluting gases. Finally, (11) the high diversity of products/services to meet customer needs and demands may imply, to some extent, an increase in the quantity and diversity of packaging, which implies frequent replenishment, and the generation of more waste from packaging, both at disposal when it reaches the end customer, and throughout the packaging manufacturing process.

Thus, it is concluded that, although the implementation of Lean practices offers clear benefits for both operational efficiency and sustainability (economic, environmental and social), and its integration requires a careful balance to avoid trade-offs that may harm the competitiveness and environmental performance of companies. Companies should conduct an analysis of their initial state (pre-changes) and understand/be familiar with the tools/methodologies they intend to apply to face the challenges that may arise from their integration, ensuring that the outlined objectives are achieved without compromising aspects related to the environment, social and governance (ESG).

4.3. RQ3: What Are the Most Common Tools and Methodologies Used in the Integration of Lean and Sustainability Concepts (Economic, Environmental, and Social) in Companies?

The analysis identified 361 tools and methodologies used in the construction of the analyzed models, highlighting high diversity. It is observed that 35.5% of the tools (128/361) were used only once, reflecting the heterogeneity of approaches in the literature.

These less frequently used tools can be grouped into different functional categories: conceptual tools, such as Lean principles, Lean Philosophy concepts, and industrial ecology, which provide the theoretical basis for the integration between Lean and sustainability; process planning and analysis tools, such as BPMN, Process Flowchart, and multi-criteria decision matrices, used for process modeling and optimization; tools associated with continuous improvement and quality, including Total Quality Management, FMEA, Poka-Yoke, and Continuous Improvement Process; and tools supporting sustainability, such as Life Cycle Assessment (LCA) and sustainable concepts. Complementing this classification, Figure 7 presents the most recurrent tools identified in the analyzed studies, considering those with at least two occurrences. It can be observed that the most used tool is value stream mapping (VSM), with 5.5% (20/361), followed by 5S, with 4.4% (16/361), direct observation, with 4.2% (15/361), Lean concepts, with 3.3% (12/361), visual management and standard work, both with 2.5% (9/361), and the Kaizen methodology, with 2.2% (8/361). Next, with 1.9% (7/361), are the tools Ishikawa diagram, questionnaires, and single minute exchange of die (SMED), and with 1.7% (6/361) are the tools 5 Whys, Line Balancing, Checklist, Define, Measure, Analyze, Improve and Control (DMAIC), flowcharts, and Kanban.

The following tools were used with 1.4% (5/361): Gemba walk, Just-in-Time (JIT), A3 Methodology, Plan-Do-Check-Act (PDCA), and Pull System. With three occurrences, corresponding to 0.8% (3/361), the following stand out: root cause analysis, brainstorming, spaghetti diagram, layout study, Microsoft Excel, Kano model, Poka-Yoke, surveys, and site visits.

Finally, at 0.6% (2/361), the following tools are found: 8 types of waste, Analytic Hierarchy Process (AHP), Fuzzy Analytic Hierarchy Process (FAHP), Gantt chart, Pareto chart, time and methods study, Lean tools, failure mode and effects analysis (FMEA), Life Cycle Assessment (LCA), overall equipment efficiency (OEE), total quality management and total productive maintenance (TPM).

4.4. RQ4: What Impacts Does the Implementation of Lean and Sustainability Concepts Have on Companies?

Nowadays, due to increased global competitiveness, companies seek to achieve better results to stand out from their competition, and they must focus on what brings value to their customers. The integration of Lean Philosophy, also considering the integration of sustainability concepts (environmental, social and economic), contributes positively to achieving these objectives, as well as improving the environmental performance of companies, as well as their operational performance, competitiveness, and social aspects. They also emphasize that the greater the improvement in environmental performance in companies, the better and more competitive they can be, making it easier for companies to remain in increasingly global markets [9,19,25,32,36,58,86].

Considering climate change, population growth, scarcity of natural resources, as well as the establishment of new goals, laws, and regulations related to environmental aspects, the environmental performance of companies has been the subject of greater scrutiny, study, analysis, and monitoring by the organizations' stakeholders so that companies can have greater responsibility. On the other hand, today's customers, in addition to being followers of fads and trends, are progressively changing their ways of thinking and acquiring products/services, becoming increasingly aware of climate change and its negative effects. They thus pay closer attention to environmental aspects, both in the products/services offered by companies and in aspects related to their production [3,17,29,30,71].

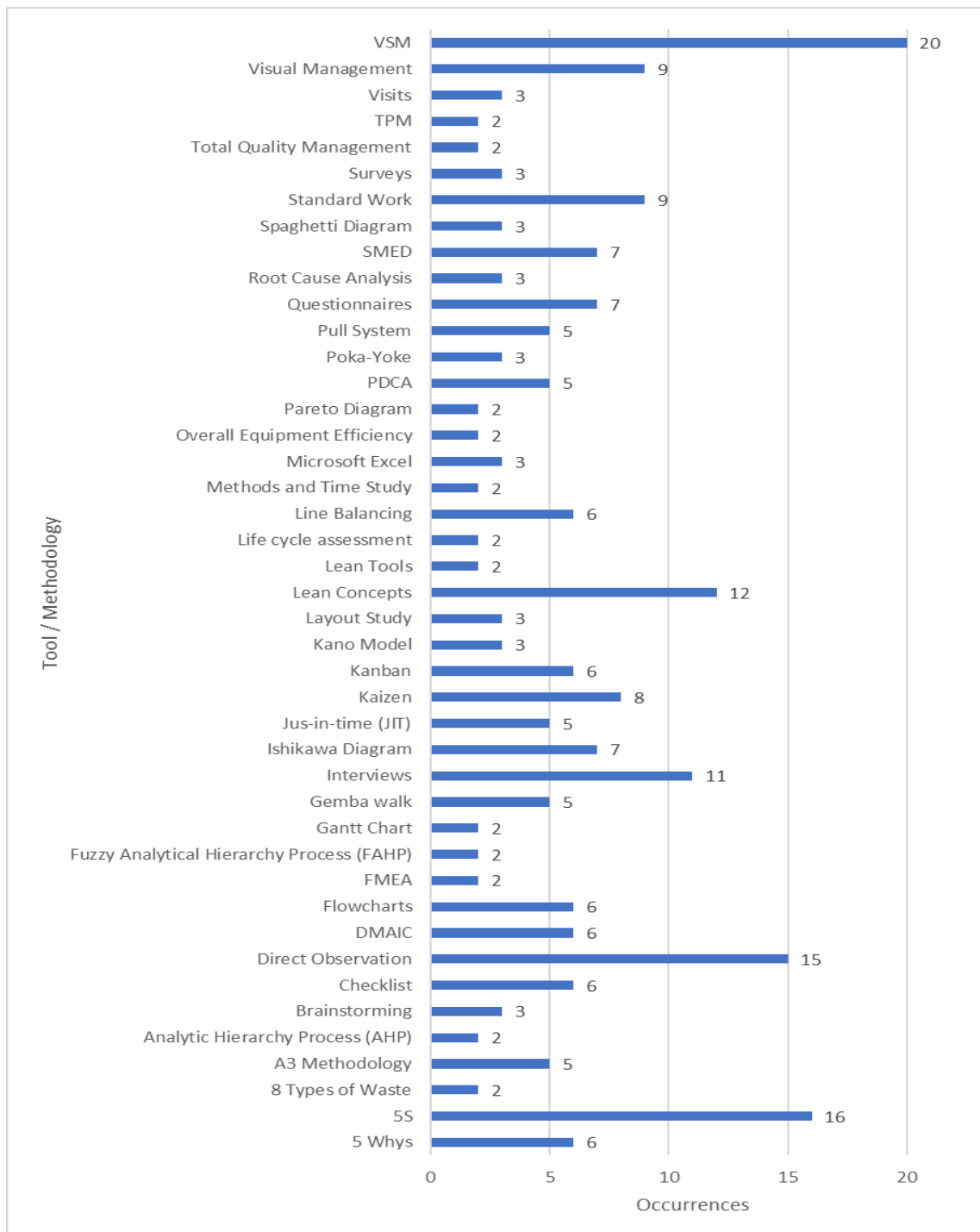


Figure 7. Frequency of occurrence of tools and methodologies with at least two occurrences in the analyzed models. Source: The authors.

For companies to achieve such benefits, they must focus their efforts on what they can access and best control, with the factory floor being one of the areas to explore, as it is within the domain of each company. Thus, companies must strive throughout the entire production chain, as well as in the areas that support it, to improve environmental aspects, as well as obtain a more solid competitive advantage [19,26,83,87,88].

Regarding operational performance, there is a positive relationship when Lean and TBL are integrated, resulting in competitive advantages, such as the reduction in lead time and elimination of waste, which leads to greater financial profitability for companies, making it easier for them to offer more competitive prices than their competitors. On the

other hand, in social terms, there are daily risks for companies regarding workers or visitors who may have accidents, which can lead to additional expenses for the companies. In this sense, the health and safety of employees in the workplace is essential, because when accidents occur, it can negatively impact on the company's image and, consequently, its social and economic standing. Therefore, adopting Lean Philosophy can lead to improved working conditions for employees, thus achieving better performance in relation to the social pillar of sustainability [24,27,48,68,71,85,87,89].

Furthermore, it is important to improve performance associated with each of the pillars of sustainability so that companies can increase their competitive advantage. According to scientific literature, Lean Philosophy positively affects the competitive advantages of companies through operational, economic, social, and environmental performance [20,25,36,87,90].

Thus, companies can, through environmentally competitive advantages, consolidate their positions in their respective business areas and explore new opportunities to remain competitive in current markets. On the other hand, by respecting environmental laws and offering what customers want, the integration of Lean Philosophy, even if its main objective is not to improve the environmental aspects of companies, can contribute to better compliance with environmental standards, as well as reinforce their environmental reputation, resulting in customer loyalty and the attraction of new customers [24,39,41,52,76,77,91].

4.5. Managing Trade-Offs: Towards Synergistic Integration

The literature reviewed acknowledges that, although Lean Philosophy and sustainability principles share objectives related to efficiency and waste reduction, their conceptions of value do not always automatically converge. While Lean favors the elimination of activities that do not add value to the end customer, approaches such as the circular economy emphasize closing material cycles, resource regeneration, and creating long-term value for multiple stakeholders, leading to operational tensions that require conscious and contextualized management [4,26,30,63,82].

Several studies [4,18,26,87,92] identify practical conflicts associated with the simultaneous implementation of these approaches. The application of Just-in-Time, despite being effective in reducing inventories, can increase logistics intensity and the emissions associated with transportation when it is not articulated with green logistics principles. Similarly, the growing demand for flexibility and customization, often translated into reduced production batches and frequent setup changes, tends to increase energy and material consumption, contradicting resource efficiency objectives. In the social sphere, some authors [18,37,92,93] also warn of the risk of Lean approaches that are excessively productivity-oriented neglecting human development, compromising the social sustainability of organizations.

Despite these tensions, the literature shows that hybrid solutions allow potential conflicts to be converted into opportunities for synergistic integration. The combination of Just-in-Time with green logistics practices, supported by e-Kanban systems and real-time monitoring, has been shown to simultaneously reduce operational waste and environmental impacts, particularly in sectors such as industrial maintenance and health [64]. Similarly, approaches based on pull planning, production leveling and variability reduction, such as the use of Heijunka and Takt Time, contribute to the stabilization of production flows and the predictable use of resources, as evidenced in the case of Schnell S.p.A. analyzed by Murmura et al. [76].

The integration between Lean and the circular economy also emerges as a promising way to manage structural trade-offs. Adapting value stream mapping to incorporate circularity and longevity metrics allows visualization not only of traditional production flows, but also of recovery, remanufacturing and recycling processes, reinforcing the economic viability of circular supply chains [4,22,26,49,92].

More recently, the literature has highlighted the role of Industry 4.0 digital technologies as central enablers of this integration. Digital Twins and metaverse environments allow for the simulation of operational scenarios, anticipating failures, and evaluating environmental and economic impacts before the physical implementation of decisions. Jebbor et al. [92] demonstrate that these technologies support sustainable circular operations by enabling the integrated visualization of material, energy, and informational flows, while Mirali et al. [94] show that Lean strategies supported by artificial intelligence and digitalization promote adaptive learning and sustain improvements in operational performance.

Overall, the evidence analyzed points to a progressive and deeply contextual integration between Lean and sustainability. The effective management of trade-offs does not result from the isolated application of Lean tools, but from their strategic articulation with sustainability principles and digital technologies, reinforcing the need for systemic and adaptive approaches to achieve a synergistic integration between operational efficiency, environmental responsibility, and social well-being [4,26,38,55,82,95,96].

4.6. Implications for Future Research

The results of the SLR demonstrate significant progress in integrating Lean Philosophy and sustainability, particularly in the economic and environmental dimensions. However, the literature review reveals significant gaps that limit a more holistic understanding of this integration. In particular, the social dimension is the least explored, with studies focused predominantly on environmental and economic aspects. There is also a scarcity of empirical studies investigating the impacts of Lean on issues such as worker well-being, social equity, and the ethical implications associated with implementing Lean practices in different organizational contexts.

Additionally, the literature reviewed shows a lack of consensus regarding metrics and indicators capable of systematically evaluating the social outcomes of Lean–sustainability integration. Although there are consolidated proposals for measuring economic and environmental performance, social indicators remain fragmented, poorly operationalized, and frequently absent from evaluation models. Similarly, it is observed that the explicit incorporation of circular economy principles into traditional Lean tools is still limited, which may contribute to the persistence of unintended environmental trade-offs.

Given these gaps, the need to orient future research towards more integrated, contextual, and empirically grounded approaches becomes evident. Future studies should consider organizational, cultural, and sectoral factors that condition the simultaneous implementation of Lean practices and sustainability objectives, promoting a balanced vision between operational efficiency, environmental responsibility, and social justice. In this context, this review allows us to identify a set of specific and actionable research questions that can guide future agendas. Therefore, future research could be based on the following research questions:

- How do Lean practices influence worker well-being, social equity, and ethical behavior in industrial and healthcare contexts?
- What key performance indicators can effectively measure social outcomes in Lean–sustainability integration initiatives?
- How can circular economic principles be incorporated into Lean tools, such as VSM, to mitigate environmental trade-offs?
- What organizational or contextual factors influence the successful integration of Lean and sustainability in the economic, environmental, and social dimensions?

5. Conclusions

In an increasingly demanding global scenario in terms of environmental, social, and economic responsibility, companies face the challenge of reconciling productive efficiency

with sustainable practices. The integration between Lean Philosophy and sustainability emerges, in this context, as a strategic opportunity to align continuous improvement and the elimination of waste with the creation of long-term sustainable value. By articulating the principles of Lean operational efficiency with the environmental, economic, and social pillars of sustainability, organizations can not only optimize processes and reduce costs, but also strengthen their ethical and environmental commitment, contributing to competitiveness and business resilience.

Thus, the present study aimed to analyze, through an SLR, the integration between Lean Philosophy and sustainability, with the intention of mapping existing approaches, identifying the main benefits, challenges, and tools used, and understanding the impacts of implementing these practices in the economic, environmental, and social dimensions. Throughout the analysis, we sought to answer the research questions related to the objectives, approaches, competitive advantages, most used tools, and the observed impacts of Lean–sustainability integration by companies.

The analysis reveals a growing and close relationship between Lean Philosophy and sustainability, highlighting the integration of these approaches as a promising strategy to achieve more efficient, competitive, and responsible business performance. Both share essential fundamentals, resource optimization, waste elimination, and a focus on process efficiency, which explains their natural complementarity.

Scientific production on the integration between Lean Philosophy and sustainability has registered continuous and significant growth in recent years, reflecting the increasing attention of companies and the academic community to the importance of balancing the environmental, economic, and social dimensions of sustainability as an essential condition for effective business sustainability. However, the analysis reveals that, despite this growing interest, there is an imbalance in the approach to these dimensions, with the environmental dimension being the most frequently explored, followed by the economic one, while the social dimension remains considerably less addressed. This gap highlights the need to develop more integrated and holistic approaches that promote balanced and sustainable development in all its aspects.

The results indicate that the integration of Lean and sustainability provides multiple benefits, namely improved environmental and economic performance, reduced resource consumption, and compliance with environmental standards, in addition to fostering operational and strategic competitive advantages. Although less explored, the social dimension can also be strengthened through Lean Philosophy by promoting ethical behaviors, organizational transparency, valuing employees, and reinforcing occupational health and safety conditions.

Despite the benefits, the integration between Lean and sustainability is not without challenges and trade-offs. Some Lean practices, such as Just-in-Time, can generate adverse environmental impacts, such as increased gas emissions due to intensified transportation. Similarly, production flexibility and a focus on small batches can imply greater use of resources and disposable materials. For this reason, implementation must be carefully planned, considering the organizational context and ensuring alignment with ESG objectives.

Among the most widely used tools are VSM, 5S, Kaizen, visual management, and standard work, especially applied in the construction and healthcare sectors. The success of these initiatives depends heavily on committed leadership, employee involvement at all hierarchical levels, and the consolidation of a culture of continuous improvement. However, barriers persist, such as resistance to change, lack of training, and insufficient planning, which limit the effectiveness and sustainability of implementations.

In summary, there is now a growing body of scientific evidence that proves the synergies between Lean Philosophy and sustainability, confirming its potential to promote sustainable development and improve the environmental, social, and economic perfor-

mance of organizations. Still, it is necessary to deepen the social dimension and develop models that mitigate the trade-offs between efficiency and sustainability.

The Lean–sustainability integration should be understood as an organizational ecosystem, in which Lean Philosophy acts as the gardener that removes waste to strengthen processes, while sustainability represents the fertile soil that ensures the balanced and lasting growth of the organization. Only when both coexist in harmony, supported by appropriate tools, a culture of continuous improvement, and a systemic vision, is it possible to achieve truly sustainable, resilient, and innovative companies.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su18031666/s1>.

Author Contributions: Conceptualization, E.T., H.V.G.N. and J.M.; methodology, E.T., H.V.G.N., O.C. and J.M.; software, E.T. and O.C.; validation, H.V.G.N., O.C. and J.M.; formal analysis, E.T.; investigation, E.T.; resources, E.T., H.V.G.N., O.C. and J.M.; data curation, E.T., H.V.G.N. and O.C.; writing—original draft preparation, E.T., H.V.G.N. and O.C.; writing—review and editing, E.T., O.C. and J.M.; visualization, E.T. and H.V.G.N.; supervision, H.V.G.N., O.C. and J.M.; project administration, H.V.G.N., O.C. and J.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created or analyzed in this study.

Acknowledgments: The authors sincerely thank the editors and anonymous reviewers for their kind view and constructive suggestions. Helena Navas acknowledges Fundação para a Ciência e a Tecnologia, I.P., for its financial support via the project UID/00667: Unidade de Investigação e Desenvolvimento em Engenharia Mecânica e Industrial.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

SLR	Systematic Literature Review
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RQ	Research questions
WoS	Web of Science
IC	Inclusion Criteria
EC	Exclusion Criteria
TBL	Triple Bottom Line
JIT	Just-in-Time
ESG	Environment, Social and Governance
TQM	Total Quality Management
TPM	Total Productive Maintenance
BPMN	Business Process Model and Notation
VSM	Value Stream Mapping
SMED	Single Minute Exchange of Die
DMAIC	Define, Measure, Analyze, Improve, Control
PDCA	Plan-Do-Check-Act
AHP	Analytic Hierarchy Process
FMEA	Failure Mode and Effects Analysis
FAHP	Fuzzy Analytical Hierarchy Process
LCA	Life Cycle Assessment

Appendix A

Appendix A.1

Table A1 presents the methodological evaluation of the 132 articles included in this systematic review. Each study was evaluated according to its type, clarity of objectives, defined context, adequacy of methods, rigor in data collection, coherence of analysis, relevance of results, discussion of limitations, overall score, and ranking. The table provides a comprehensive overview of the methodological quality of the selected studies, highlighting strengths and weaknesses in case studies, literature reviews, models, surveys, and combined approaches.

Table A1. Evaluation of 132 studies according to JBI quality criteria, including study type, score, and overall ranking. Source: The authors.

Item	Reference	Type of Study	Clear Objective	Defined Context	Appropriate Method	Rigorous Data Collection	Coherent Analysis	Relevant Results	Limitations Discussed	Overall Score	Ranking
1	[42]	Case study	Yes	Yes	Yes	Yes	Yes	Yes	Partial	6.5	High
2	[97]	Literature review	Yes	Partial	Yes	Partial	Yes	Yes	No	5.0	Moderate
3	[27]	Literature review	Yes	Partial	Yes	Partial	Yes	Yes	No	5.0	Moderate
4	[98]	Literature review and case study	Yes	Partial	Yes	Partial	Yes	Yes	No	5.5	Moderate
5	[20]	Literature review	Yes	Yes	Yes	Partial	Yes	Yes	No	5.5	Moderate
6	[53]	Literature review	Yes	Yes	Yes	Partial	Yes	Yes	No	5.5	Moderate
7	[99]	Literature review and case study	Yes	Yes	Yes	Yes	Yes	Yes	Partial	6.5	High
8	[17]	Literature review	Yes	Partial	Yes	Partial	Yes	Yes	No	5.5	Moderate
9	[44]	Literature review	Yes	No	Yes	Partial	Yes	Yes	No	5.0	Moderate
10	[100]	Case study	Yes	Yes	Yes	Yes	Yes	Yes	Partial	6.0	High

Table A1. Cont.

Item	Reference	Type of Study	Clear Objective	Defined Context	Appropriate Method	Rigorous Data Collection	Coherent Analysis	Relevant Results	Limitations Discussed	Overall Score	Ranking
11	[54]	Theoretical model	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.5	High
12	[79]	Literature review + empirical study	Yes	Yes	Partial	Partial	Yes	Yes	Partial	5.0	Moderate
13	[101]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.5	High
14	[102]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.5	High
15	[103]	Literature review	Yes	No	Yes	Partial	Yes	Yes	Partial	4.5	Moderate
16	[78]	Literature review/ case study	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.0	High
17	[70]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate
18	[50]	Model/case study	Yes	Yes	Yes	Partial	Yes	Yes	Yes	6.0	High
19	[104]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	Yes	6.0	High
20	[57]	Literature review & model	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.0	High
21	[51]	Model	Yes	Yes	Yes	No	Yes	Yes	Partial	5.0	Moderate
22	[105]	Literature review	Yes	No	Yes	No	Yes	Yes	Partial	4.0	Moderate
23	[58]	Literature review & questionnaire	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.0	High
24	[106]	Literature review & survey	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.0	High
25	[107]	Literature review	Yes	No	Yes	No	Yes	Yes	No	4.0	Moderate
26	[39]	Case study	Yes	Yes	Yes	Yes	Yes	Yes	No	6.0	High

Table A1. Cont.

Item	Reference	Type of Study	Clear Objective	Defined Context	Appropriate Method	Rigorous Data Collection	Coherent Analysis	Relevant Results	Limitations Discussed	Overall Score	Ranking
27	[19]	Model & case study	Yes	Partial	Yes	Yes	Yes	Yes	Yes	6.0	High
28	[21]	Systematic literature review	Yes	Yes	Yes	Partial	Yes	Yes	Yes	6.0	High
29	[89]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate
30	[108]	Literature review & model	Yes	Partial	Partial	No	Yes	Yes	No	4.0	Moderate
31	[46]	Literature review	Yes	No	Partial	No	Yes	Yes	No	4.0	Low
32	[109]	Systematic literature review	Yes	Partial	Yes	Partial	Yes	Yes	No	5.0	Moderate
33	[48]	Model & case study	Yes	Yes	Yes	Partial	Yes	Yes	No	6.0	Moderate
34	[62]	Literature review/survey	Yes	Yes	Partial	No	Partial	Yes	No	4.0	Moderate
35	[67]	Literature review/multiple case studies	Yes	Yes	Partial	No	Partial	Yes	No	4.0	Moderate
36	[68]	Literature review	Yes	Partial	Partial	No	Partial	Yes	No	4.0	Low
37	[110]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	6.0	Moderate
38	[63]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	6.0	Moderate
39	[111]	Systematic literature review/bibliometric analysis	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate

Table A1. Cont.

Item	Reference	Type of Study	Clear Objective	Defined Context	Appropriate Method	Rigorous Data Collection	Coherent Analysis	Relevant Results	Limitations Discussed	Overall Score	Ranking
40	[84]	Case study/ theoretical framework	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate
41	[112]	Mixed-methods exploratory research	Yes	Partial	Yes	Partial	Yes	Yes	No	5.0	Moderate
42	[30]	Systematic literature review	Yes	Partial	Yes	Partial	Yes	Yes	No	5.0	Moderate
43	[49]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	6.0	Moderate
44	[113]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	6.0	Moderate
45	[114]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	6.0	Moderate
46	[87]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	6.0	Moderate
47	[6]	Literature review	Yes	Partial	Yes	Partial	Yes	Yes	No	5.0	Moderate
48	[115]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	6.0	Moderate
49	[116]	Case study	Yes	Yes	Yes	Yes	Yes	Yes	No	6.0	High
50	[117]	Literature review	Yes	Yes	Partial	No	Yes	Yes	No	4.0	Moderate
51	[3]	Literature review	Yes	Partial	Partial	No	Yes	Yes	No	4.0	Moderate
52	[71]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	6.0	Moderate
53	[33]	Literature review & model	Yes	Partial	Yes	Partial	Yes	Yes	No	5.5	Moderate
54	[118]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	6.0	Moderate
55	[80]	Literature review	Yes	Partial	Yes	Partial	Yes	Yes	No	5.0	Moderate
56	[47]	Literature review +conceptual model	Yes	Yes	Yes	Partial	Yes	Yes	No	6.0	Moderate

Table A1. Cont.

Item	Reference	Type of Study	Clear Objective	Defined Context	Appropriate Method	Rigorous Data Collection	Coherent Analysis	Relevant Results	Limitations Discussed	Overall Score	Ranking
57	[90]	Literature review/meta-analysis	Yes	Partial	Yes	Yes	Yes	Yes	No	6.0	Moderate
58	[52]	Model/case study	Yes	Yes	Yes	Partial	Yes	Yes	No	6.0	Moderate
59	[81]	Literature review	Yes	Yes	Partial	Partial	Yes	Yes	No	5.0	Moderate
60	[93]	Case study	Yes	Yes	Yes	Yes	Yes	Yes	No	6.0	High
61	[119]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate
62	[120]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate
63	[72]	Literature review	Yes	Partial	Partial	No	Partial	Yes	No	4.0	Low
64	[37]	Conceptual model	Yes	No	Partial	No	Yes	Partial	No	3.0	Low
65	[121]	Case study	Yes	Yes	Yes	Yes	Yes	Yes	No	6.0	High
66	[122]	Case study	Yes	Yes	Yes	Yes	Yes	Yes	No	6.0	High
67	[123]	Literature review	Yes	Yes	Yes	Partial	Yes	Yes	Yes	5.5	High
68	[124]	Model and case study	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.0	High
69	[35]	Systematic literature review	Yes	Partial	Yes	Partial	Yes	Yes	Partial	5.0	Moderate
70	[24]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	Partial	6.0	High
71	[29]	Systematic literature review	Yes	Partial	Yes	Partial	Yes	Yes	No	5.0	Moderate
72	[55]	Model and case study	Partial	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate

Table A1. Cont.

Item	Reference	Type of Study	Clear Objective	Defined Context	Appropriate Method	Rigorous Data Collection	Coherent Analysis	Relevant Results	Limitations Discussed	Overall Score	Ranking
73	[125]	Model and case study	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate
74	[59]	Literature review	Yes	Partial	Partial	No	Partial	Yes	No	3.0	Low
75	[31]	Model and case study	Yes	Partial	Partial	No	Partial	Yes	No	3.0	Low
76	[126]	Model	Yes	Partial	Partial	No	Partial	Yes	Yes	4.0	Moderate
77	[127]	Case study	Yes	Yes	Partial	Partial	Yes	Yes	Partial	5.0	Moderate
78	[128]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate
79	[25]	Systematic literature review	Yes	Partial	Yes	Partial	Yes	Yes	Partial	5.0	Moderate
80	[129]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate
81	[130]	Model + case study	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate
82	[69]	Systematic literature review	Yes	Partial	Yes	No	Partial	Partial	No	3.0	Low
83	[73]	Literature review	Yes	Yes	Partial	No	Partial	Yes	No	4.0	Moderate
84	[26]	Model/case Study	Yes	Yes	Partial	No	Partial	Yes	No	4.0	Moderate
85	[131]	Model/case Study	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate
86	[64]	Model/case Study	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate
87	[82]	Model	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.0	High
88	[132]	Literature review	Yes	Yes	Partial	Partial	Yes	Yes	No	4.0	Moderate

Table A1. Cont.

Item	Reference	Type of Study	Clear Objective	Defined Context	Appropriate Method	Rigorous Data Collection	Coherent Analysis	Relevant Results	Limitations Discussed	Overall Score	Ranking
89	[76]	Case study	Yes	Yes	Yes	Yes	Yes	Yes	Partial	6.0	High
90	[74]	Model and case study	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.5	High
91	[60]	Model	Yes	Yes	Partial	No	Yes	Yes	Partial	4.5	Moderate
92	[45]	Systematic literature review	Yes	Partial	Yes	Partial	Yes	Yes	No	5.0	Moderate
93	[133]	Systematic literature review	Yes	No	Yes	Partial	Yes	Yes	No	5.0	Moderate
94	[134]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	6.0	Moderate
95	[85]	Literature review	Yes	Yes	Partial	No	Yes	Yes	No	5.0	Moderate
96	[18]	Model and case study	Yes	Partial	Yes	Partial	Yes	Yes	No	5.5	Moderate
97	[135]	Literature review/survey-based study	Yes	Yes	Partial	Yes	Yes	Yes	No	5.5	Moderate
98	[32]	Systematic literature review and conceptual model	Yes	Yes	Yes	Partial	Yes	Yes	Partial	6.0	High
99	[136]	Systematic literature review	Yes	Partial	Yes	Yes	Yes	Yes	Yes	6.5	High
100	[83]	Literature review	Yes	Yes	Yes	Partial	Yes	Yes	Partial	6.0	High
101	[38]	Literature review	Yes	Yes	Partial	Partial	Yes	Yes	No	5.0	Moderate
102	[36]	Literature review	Yes	Yes	Partial	Partial	Yes	Yes	Yes	5.5	High

Table A1. Cont.

Item	Reference	Type of Study	Clear Objective	Defined Context	Appropriate Method	Rigorous Data Collection	Coherent Analysis	Relevant Results	Limitations Discussed	Overall Score	Ranking
103	[137]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.0	High
104	[75]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.0	High
105	[138]	Systematic review	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.0	High
106	[95]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.0	High
107	[91]	Systematic literature review	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.0	High
108	[139]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.0	High
109	[88]	Literature review	Yes	Partial	Yes	Partial	Yes	Yes	No	4.0	Moderate
110	[96]	Case study	Yes	Partial	Yes	Partial	Yes	Yes	No	5.0	Moderate
111	[61]	Systematic review + model	Yes	Yes	Yes	Partial	Yes	Yes	Partial	6.0	High
112	[34]	Literature review	Yes	Yes	Partial	Partial	Yes	Yes	No	5.0	Moderate
113	[4]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	6.0	Moderate
114	[43]	Case study	Yes	Yes	Yes	Yes	Yes	Yes	No	6.0	High
115	[79]	Literature review + conceptual model	Yes	Partial	Yes	Partial	Yes	Yes	No	5.0	Moderate
116	[140]	Literature review	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate
117	[22]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate
118	[141]	Case study/model	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate
119	[40]	Case study	Yes	Yes	Yes	Partial	Yes	Yes	No	5.0	Moderate

Table A1. Cont.

Item	Reference	Type of Study	Clear Objective	Defined Context	Appropriate Method	Rigorous Data Collection	Coherent Analysis	Relevant Results	Limitations Discussed	Overall Score	Ranking
120	[23]	Literature review	Yes	Partial	Partial	No	Yes	Partial	No	4.0	Low
121	[142]	Literature review	Yes	Yes	Yes	Partial	Yes	Yes	Partial	5.0	High
122	[41]	Literature review	Partial	No	Yes	Partial	Yes	Yes	No	4.0	Moderate
123	[56]	Systematic literature review	Yes	Partial	Yes	Partial	Yes	Yes	No	5.0	Moderate
124	[28]	Literature review	Yes	Partial	Yes	No	Yes	Yes	No	5.0	Moderate
125	[9]	Literature review and model	Yes	Yes	Partial	No	Yes	Yes	Partial	5.0	Moderate
126	[143]	Literature review and conceptual model	Yes	Yes	Partial	No	Yes	Yes	Partial	5.0	Moderate
127	[144]	Literature review and integrated model	Yes	Partial	Yes	Partial	Yes	Yes	Partial	5.0	Moderate
128	[145]	Literature review and model	Yes	Partial	Yes	Partial	Yes	Yes	Partial	5.0	Moderate
129	[66]	Literature review	Yes	Yes	Partial	Partial	Yes	Yes	No	5.0	Moderate
130	[86]	Case study	Yes	Yes	Yes	Yes	Yes	Yes	No	6.0	High
131	[146]	Model & case study	Yes	Yes	Yes	Yes	Yes	Yes	No	6.0	High
132	[147]	Literature review & case study	Yes	Yes	Yes	Yes	Yes	Yes	No	6.0	High

Appendix A.2

Table A2 summarizes the 132 articles included in the systematic review, analyzed with the aim of understanding the integration between Lean Philosophy and sustainability. For each study, the table presents the sequential article number in the analysis, the author's reference and the year of publication, as well as the main results and contributions, highlighting benefits, challenges, tools used and the impacts observed in the economic, environmental and social dimensions.

Table A2. Synthesis of the 132 articles selected by the SLR. Source: The authors.

Item	Author and Year	Key Findings
1	Sanda et al. [42]	The tacit knowledge of miners, transmitted mainly through practical experience, is essential for the effective implementation of Lean Philosophy, facilitating the integration of new workers, improving operations, and eliminating non-value-added activities. The importance of valuing human skills, optimizing processes, and capturing technical knowledge is also highlighted.
2	Bakri et al. [97]	From the study it was possible to observe that there is a research gap, where it is relevant to explore the need for a comprehensive integration between the TPM methodology and the Lean Philosophy. Also, from the study it is possible to verify that the beneficial result of the TPM methodology is quite difficult and not exposed in some studies related to Lean Philosophy.
3	Monroe et al. [27]	Ergonomics is a critical factor for continuous process improvement and operator well-being, but its integration with methodologies such as Lean, 5S, and Six Sigma requires overcoming organizational barriers. The active involvement of engineers and managers is essential for ergonomic initiatives to effectively contribute to organizational performance.
4	Krogstie and Martinsen [98]	Collaboration between departments and teamwork is essential for the effectiveness of continuous improvement initiatives. Integrating Lean and Six Sigma philosophies, with the participation of all company members, promote significant gains in operational efficiency, product quality, and adherence to production tolerances.
5	Wu et al. [20]	Applying Lean Philosophy improves production by prioritizing value-adding activities and eliminating non-value-adding ones, preventing defects and reducing costs. Furthermore, reducing non-value-adding activities contributes to lower carbon emissions and material waste.
6	Toussaint and Berry [53]	Lean Philosophy is applicable to both industrial production and complex knowledge areas, such as healthcare. When well implemented, it transforms organizational culture, promotes continuous improvement, increases the efficiency and quality of operations, controls costs, and requires the involvement of all stakeholders to maximize benefits without compromising quality.
7	Ramnath et al. [99]	The authors point out that the result of the study gives a clear picture to workers about the improvement of their working conditions after the implementation of EKAS. In addition to improving working conditions with EKAS, it has also improved worker morale. On the other hand, the improvement of working conditions and the morale of workers contributed to improving productivity.
8	Ioppolo et al. [17]	Integrating Lean Philosophy with Environmental Efficiency (EE) promotes more efficient and sustainable production, reducing waste and improving resource management. This combination contributes to operational and environmental gains, enabling industries to reduce environmental impacts and increase overall efficiency.
9	Dombrowski and Mielke [44]	Fifteen practical requirements for the effective implementation of the Lean Philosophy have been identified, serving as a guide for managers. Success depends on strengthening leadership and developing employee skills, which are essential to sustaining the integration of Lean culture and promoting sustainable continuous improvement.

Table A2. Cont.

Item	Author and Year	Key Findings
10	Wu [100]	The study shows that applying Lean Philosophy to construction sites using precast concrete elements contributes to reducing carbon emissions and improving operational efficiency. The use of methodologies such as value stream mapping (VSM) allows for the identification of non-value-adding activities, responsible for approximately 71% of emissions in the installation cycle, thus promoting more sustainable processes.
11	Van der Merwe et al. [54]	The study proposes a model to support the implementation of Lean Philosophy in the automotive industry, integrating factors such as leadership, communication, and training. The authors emphasize that cultural change is crucial for Lean success, requiring strong leadership and continuous training to overcome challenges and consolidate the organizational culture.
12	Čiarnienė and Vienažindienė [79]	The authors highlight that implementing Lean Philosophy improves operational and economic performance, as well as quality, although it presents different levels of maturity among companies. The success of Lean depends heavily on organizational culture, with barriers identified such as resistance to change, lack of knowledge, and difficulties in adapting Lean principles to operational specificities.
13	McCann et al. [101]	The study analyzes the implementation of Lean Philosophy in a hospital, highlighting that an accelerated and simplified application compromises its long-term sustainability. The authors emphasize that the success of Lean depends on adequate planning, in-depth knowledge of the philosophy, and continuous commitment from stakeholders.
14	Goerke et al. [102]	The authors emphasize that the holistic application of Lean Philosophy in Learning Factories allows for the practical and contextualized teaching of its principles, better preparing students for the job market. Success depends on the involvement and commitment of managers, teachers, and partner companies, as well as the appropriate adaptation of Lean tools to educational objectives.
15	Mardani et al. [103]	The authors state that the choice of problem-solving approaches and decision-making techniques depends on the objectives, the actors involved, and the information available. These tools are particularly useful in complex and multi-criteria contexts, although their application may be limited by difficulties in defining criteria and obtaining data.
16	Bamford et al. [78]	The authors emphasize that Lean Philosophy provides strategic benefits and supports operational changes, with its gradual implementation associated with better results and greater team engagement. However, adopting Lean requires a balanced approach, considering costs, risks, and resources, as well as a continuous commitment to monitoring and consolidation.
17	Rauch et al. [70]	The authors highlight that the Lean Enterprise approach is particularly relevant in the ETO sector, as it promotes waste reduction and the synchronization of engineering, production, and on-site execution activities. Effective communication and coordination, supported by tools such as ERP and simulation, are essential to avoid rework, delays, and additional costs, thus improving organizational performance.
18	Kurilova-Palisaitiene and Sundin [50]	The study shows that the Lean Pull Kanban system improves inventory management and material flow according to actual demand, mitigating uncertainties and increasing efficiency. Implementation faces challenges such as internal resistance, the need to adapt information systems, and the integration of external suppliers.
19	Rohac and Januska [104]	The application of value stream mapping (VSM) allows for the identification of waste, mapping of processes, and location of bottlenecks, promoting efficiency and a culture of continuous improvement. However, resistance from employees and managers, scarcity of resources, and difficulties in obtaining accurate data can compromise the expected results.

Table A2. Cont.

Item	Author and Year	Key Findings
20	Minh and Há [57]	For the process of implementing and consolidating Lean to occur in the best possible way, it is important that there is training of workers. The model presented enables companies to know how to maintain a Lean thinking, as well as increase the effectiveness of the implementation of Lean practices to achieve sustainable development.
21	Tekez and Taşdeviren [51]	The model presented allows companies to comprehensively assess Lean capability from various perspectives, including knowledge management, customers, resources, and performance, enabling them to measure the potential benefits of implementing Lean practices.
22	Elizondo et al. [105]	The implementation of Lean practices must align with the company's real objectives and reinforce the commitment of management and employees. They also emphasize that effective cultural change requires not only intention, but concrete actions to consolidate the Lean culture.
23	Salonitis and Tsinopoulos [58]	The authors highlight that Lean Philosophy increases competitiveness, improves quality, and reduces waste, being recognized in Greece for its economic, social, environmental, and competitive benefits. However, barriers such as resistance to cultural change, lack of knowledge, financial limitations, and insufficient support can hinder implementation, although the long-term benefits make adoption advantageous.
24	Vavrušová and Vitásková [106]	In the health sector, the Lean Philosophy has been applied to improve the efficiency and quality of services. Professionals report that Lean optimizes workflow, improves the organization of care, and increases patient satisfaction, reducing waiting times and better coordinating services. However, implementation faces challenges such as resistance to change, lack of adequate training, and low involvement of managers during the process.
25	Coetzee et al. [107]	The study indicates that, despite the emphasis on responsibility and cooperation, Lean principles related to the human element are frequently neglected in implementation. The authors suggest that this uneven prioritization may explain the high failure rate in Lean adoption.
26	Stadnicka and Ratnayake [39]	The use of Lean tools, more specifically VSM, allows you to map the entire value stream from the customer's request to the delivery of the service. Through the inclusion of VSM, it was possible to identify critical points of failure that cause service interruptions and are responsible for increasing downtime and customer dissatisfaction.
27	Miehe et al. [19]	The study shows that the correct application of Lean Philosophy, integrated with sustainability, improves operational, economic, and environmental efficiency, as well as enhancing the company's image. Implementation requires a high level of commitment from management and employees, changes in organizational culture, and appropriate training, posing challenges for companies.
28	De Carvalho et al. [21]	The integration of Lean and sustainability concepts in construction can improve the life cycle management of buildings, reduce waste, increase operational efficiency and minimize environmental impact. However, challenges such as lack of knowledge, need for training, resistance to change, and internal cultural limitations can compromise implementation and expected results.
29	Diaz et al. [89]	The study demonstrates that Lean tools, such as VSM, 5S, and standardization, allow for the identification of bottlenecks and opportunities for improvement in the spar assembly process, optimizing production, reducing costs, and increasing efficiency. Variations in cycle time, resulting from operator speed and the use of inadequate tools, reveal inefficiencies in the process.
30	Laureani and Antony [108]	The study highlights that the integration of tools, methodologies, and concepts (FMCs) depends on the knowledge, commitment, and leadership of those responsible, making it essential to train employees and have effective communication to consolidate practices and promote continuous improvement and cultural change.

Table A2. Cont.

Item	Author and Year	Key Findings
31	AlManei et al. [46]	The study indicates that the implementation of Lean Philosophy must be adapted to the type, size, and area of the company, facing financial, human, and leadership barriers. Despite these limitations, Lean promotes greater efficiency, waste reduction, quality improvement, and better resource management, being particularly advantageous for small and medium-sized enterprises.
32	Aij and Teunissen [109]	The study highlights the importance of Lean leadership in the implementation of Lean Philosophy in healthcare. Leadership attributes serve as a guide to promote appropriate behaviors in employees and in the production system, allowing the benefits of Lean to be fully achieved. Leadership must be adapted to the context and overtime, and the involvement of all those involved is essential for successful implementation.
33	Duran et al. [48]	As for the results of the two case studies, they are encouraging. In the first case study, they indicate that by applying the 5S tool it would be possible to reduce costs and increase profit margin. As for the second case study, it was based on the integration of the SMED methodology and the use of VSM. By identifying inefficiencies, it was possible to reduce the costs and maintenance time of the sprayer, thus increasing its availability.
34	Antosz and Stadnicka [62]	The study reveals that small and medium-sized Polish companies are receptive to implementing Lean Philosophy, motivated by improved operational management, waste reduction, and increased competitiveness. The main wastes identified include waiting time, machine breakdowns, and unnecessary movements, with the 5S methodology being the most widely used tool by companies that have implemented Lean.
35	Satolo et al. [67]	The study highlights that, despite the application of Lean in various industries, the literature in the agribusiness sector is limited. Companies in this sector demonstrate concern for long-term organizational performance and apply Lean only partially, recommending closer collaboration with academia to create synergies and deepen knowledge. Furthermore, the tools, methodologies, and concepts (FMCs) should be selected according to organizational needs.
36	Rampasso et al. [68]	The study indicates that the implementation of Lean can increase the intensity of work, generating more stress and injuries in workers, in addition to impacting the effectiveness of management. To mitigate these effects, it is essential to prepare and train managers, provide continuous training to employees, and promote a cultural change, focusing on eliminating activities that do not add value and that contribute to overload and health risks.
37	Nowotarski et al. [110]	The study analyzed construction workers, managers, and engineers, observing that the implementation of Lean causes behavioral changes and resistance to change. The Lean Philosophy demonstrated relevance in the construction sector by streamlining processes, reducing recurring problems, and improving productivity and quality; the applied tools proved effective in achieving the objectives of the case study.
38	Antoniolli et al. [63]	The study demonstrates that eliminating waste, balancing activities, and introducing a new bending machine enabled the simultaneous production of parts and a reduction in the number of operators. Standardizing processes helped to decrease discrepancies in cycle times between shifts, increasing the average efficiency of the line by approximately 16%.
39	Filser et al. [111]	The study highlights the growing demand for the introduction of new tools, methodologies, and concepts (FMCs) in industry and healthcare, presenting relevant examples of Lean application in the USA, UK, Australia, and Sweden. It contributes to expanding knowledge about Lean in healthcare and supporting those responsible for its implementation.

Table A2. Cont.

Item	Author and Year	Key Findings
40	Ainul Azyan et al. [84]	The study highlights the growing demand for the introduction of new tools, methodologies, and concepts (FMCs) in industry and healthcare, emphasizing relevant experiences in the US, UK, Australia, and Sweden. Despite Lean's potential to improve processes and support healthcare management, it is a relatively recent approach in this sector, facing uncertainties and challenges during implementation.
41	Van Dun et al. [112]	The study indicates that effective management of Lean Philosophy depends on core values such as honesty, participation, teamwork, responsibility, and continuous improvement. Managers must demonstrate positive behaviors, promote employee training, encourage participation, recognize results, and provide constructive feedback to consolidate the Lean culture.
42	Tasdemir and Gazo [30]	The study highlights that the integration of Lean Philosophy with sustainability has been explored in response to climate change, resource scarcity, and increased environmental awareness, with most studies coming from Europe, the USA, and Asia. Despite some trade-offs, the synergies between Lean and sustainability outweigh the differences, and limitations can be mitigated through the introduction of additional methodologies within Lean-driven sustainability frameworks.
43	Hasibul et al. [49]	The analysis of the tasks allowed the identification of activities that add value or not, as well as variations in cycle times depending on the type and model of the vehicle. The introduction of Kaizen, by creating an improved workstation design, helped to reduce operator movement and improve the flow of activities. The study also showed that two operators working together at a single station can have similar performance to working individually at two stations, promoting station reduction and knowledge sharing.
44	Rocha et al. [113]	The adoption of Lean proves to be important for the jewelry industry to generate changes in the business world, as well as for companies to be more competitive and improve management, among other aspects. Introducing some Lean tools and MES software contributes to achieving improvements in process management, improved task performance and gaining greater knowledge.
45	Sousa et al. [114]	The study demonstrates that the integrated application of Lean tools, such as VSM, SMED, A3, and OEE, allows for the identification of value-adding and non-value-adding activities, reduces tool changeover time, and monitors the production system, contributing to the overall improvement of production systems.
46	Antosz and Pacana [87]	The study shows that applying the SMED tool allows for the identification of non-value-adding activities, increasing production flexibility and machine performance, which constitutes a competitive advantage in highly competitive business environments.
47	Nassereddine and Wehbe [6]	With globalization and increased competitiveness, companies are looking for FMCs that improve performance. Lean stands out for optimizing production systems and reducing waste. Despite the benefits, barriers such as lack of planning and increased customer needs can hinder full implementation. The education and training of employees, as well as the attitude of top management, are decisive factors for the success of the introduction of Lean.
48	Makumbe et al. [115]	The study shows that the Learning Factory is effective in transmitting skills associated with Lean Philosophy in the short term, improving employees' understanding regardless of their initial level. Integrating this approach makes it possible to increase employees' skills and operational performance.
49	Rosa et al. [116]	The application of Lean tools made it possible to optimize the production process and get closer to the initial budget, through the identification of activities that add value and those that do not, reduction in waste, balancing of tasks, standardization of work methods, and analysis of times and movements to quantify the main points of waste.

Table A2. Cont.

Item	Author and Year	Key Findings
50	Singh et al. [117]	The authors point out that Lean can contribute beneficially to the Indian manufacturing industry. According to the literature, the implementation of the 5S methodology is an extra advantage for the company that implements it. The adoption of Lean should be seen as a philosophy, and as such it should be implemented starting with top management, as well as in all phases of the production system.
51	Dieste and Panizzolo [3]	The study shows that integrating Lean Philosophy benefits environmental indicators such as atmospheric emissions, energy consumption, and solid waste. Although Lean reduces emissions, the application of JIT can increase them, making it necessary to assess its suitability. The importance of supplier and customer involvement in optimizing environmental performance and achieving high levels of sustainability is also highlighted.
52	Karam et al. [71]	The study shows that integrating Lean tools, such as SMED, visual management, and Gemba Walk, improves operational performance, reduces production times, and eliminates waste, generating greater added value. Significant results were obtained in six months, although objectives such as CO ₂ reduction still need to be achieved.
53	Solaimani et al. [33]	The study shows that integrating Lean principles can drive innovation in companies through the interaction between hard and soft process management. Goal-oriented leadership coaching and employee support contribute to the proper functioning of these factors, improving processes and achieving overall business goals.
54	Pereira et al. [118]	The study demonstrates that the creation of working groups, with the involvement of employees and management, combined with the application of A3 and DMAIC methodologies, allowed for the adjustment of processes and indicators, balanced the production line, and brought cycle times closer to the Takt time. These actions contributed to increased productivity, efficiency, and improved overall auditing.
55	Elkhairi et al. [80]	The study shows that integrating Lean Philosophy into small and medium-sized enterprises significantly contributes to improving operational management. Implementation should be adapted to the type, size, and area of operation of the company, requiring a high level of commitment from management and conditions that allow employees to accept change and adopt a culture of continuous improvement.
56	Bajjou et al. [47]	This study presents a model that organizes the principles of Lean construction into management and culture & behavior, subdividing it into nine main principles and 33 sub-principles. The model helps to clarify the implementation of Lean in civil construction and to improve the understanding of the principles and supporting tools.
57	Gonçalves et al. [90]	The study shows that implementing Lean management does not guarantee a universally positive correlation with company performance, although it can favorably influence financial and operational results depending on the tool used. Systems such as Pull, Heijunka, and Jidoka improve operational performance; Kaizen, Pull, equipment layout, and autonomous teams influence financial performance; and Pull, Jidoka, and autonomous teams are associated with competitiveness and market performance.
58	Ngoc Thuy and Phuong Thao [52]	The study shows that certain high-quality attributes increase customer satisfaction, although their absence does not always generate dissatisfaction. However, essential attributes, such as the accuracy of information, are crucial, and it is fundamental to understand the impact of each action on the customer experience to guide management in improving processes and optimizing financial resources.
59	Bayhan et al. [81]	The study identifies facilitators and barriers to the implementation of Lean in construction, including financial, managerial, technical, cultural, and communication aspects. Technical knowledge of Lean facilitates implementation, while a lack of commitment and support from management is one of the main barriers. The integration of Lean allows for better management of construction processes.

Table A2. Cont.

Item	Author and Year	Key Findings
60	Siqueira et al. [93]	The study shows that applying Lean Philosophy in healthcare mitigates inefficiencies caused by the non-use of protocols and the inadequate transmission of information. Tools such as clear records, visual management, VSM (value stream mapping), continuous flow, and resource management improve administrative and operational efficiency, optimizing performance, increasing service quality, and generating economic and social benefits.
61	Khan et al. [119]	The study indicates that Lean Philosophy has been progressively adopted in the industry of developed countries, including the banking sector. Successful implementation depends on the full adoption of methodologies, employee training, and customer information. The application of Lean has contributed to reducing branch visits and emphasizes the importance of integrating paperless banking services, thus reducing waste.
62	Azevedo et al. [120]	The Lean concept offers companies tools that make it possible to implement and offer solutions at low cost, contributing to increased productivity and competitiveness, as well as improving other factors. Through the implementation of Lean it was possible to improve the production process. To improve the process, it was necessary to eliminate waste such as over-processing, transportation, and movement.
63	Pardillo Baez et al. [72]	The integrating Lean Six Sigma allows for improved business processes, but the exclusion of all stakeholders can limit results. To overcome these barriers, it is essential to engage suppliers and partners in the company's projects and methodologies, promoting alignment and greater competitiveness.
64	Prasetyawan et al. [37]	Simple methodology to determine the production strategy with the advantages of reducing or eliminating waste within Lean production. The indicators for each waste have been formulated to adapt to the various types of waste in different ways.
65	Morgado et al. [121]	The Pareto chart allowed the identification of the downtime that most affects operational performance, caused by organizational tasks, format/product changes and equipment failures. The integration of Lean with TRIZ, especially with SMED, reduced setup times by about 70% and operator movements by 26%. The application of methodologies such as 5S, checklists, manuals, and analysis matrices contributed to organizing the work environment, reducing waste, and increasing employee motivation.
66	Nowotarski et al. [122]	The analysis of the causes made it possible to identify the source of excessive waste, and it was possible to reduce this waste by half with the integration of Lean and quality tools. Hiring an additional engineer improved efficiency and communication between teams. The authors point out that the involvement of employees, suppliers and top management is essential to maintain workflow improvements and achieve better financial and time results in the execution of the works.
67	Rotter et al. [123]	While there are other definitions for the central topic, the authors note that this is the first data-driven Lean operational definition in healthcare. The definition presented has the potential to be biased towards organizations in the early phases of Lean implementation. The authors hope that the presented definition will be a first step towards solidifying the definition, conceptualization, and quality of reporting on Lean in healthcare.
68	Issa and Alqurashi [124]	The authors indicate that Lean in the construction area can contribute to improving this business area, increasing the levels of control and implementation of Lean construction, as well as reducing waste levels. The model can help top management in choosing the most suitable project, if there is a comparison between several projects in different countries, based on waste levels and the effect of Lean.

Table A2. Cont.

Item	Author and Year	Key Findings
69	Ishak et al. [35]	The study highlights that, around the year 2000, new leadership styles emerged, such as ideological, pragmatic, authentic, ethical, distributed, and integrative styles, which are still relatively unexplored. Lean and Six Sigma gained popularity in manufacturing, general services, and utilities, promoting a culture of continuous improvement, although implementation faces barriers such as lack of leadership, internal resistance, and limited resources. Furthermore, it is necessary to investigate the social impacts of the success of these methodologies. The authors point out that Lean Six Sigma can improve the quality of healthcare but lacks generalizable approaches.
70	Liu and Yang [24]	The study demonstrates that integrating simulation and VSM allows for a dynamic approach to value stream mapping. Applying the Grey–Taguchi method enables prioritization of scenarios with minimal testing, proposing two alternative VSMs that reduced lead time, inventory, and defect rates, while increasing order satisfaction. The enhanced VSM allows managers to reach ideal solutions considering multiple performance criteria.
71	Niñerola et al. [29]	The study highlights a growing interest in applying quality management methodologies to address sustainability challenges. Lean has been applied in this context, while the potential of Six Sigma remains largely unexplored. The integration of Lean and Six Sigma allows for reduced energy consumption and environmental impact, improving industrial efficiency and generating economic, social, and competitive benefits for companies.
72	Veres [55]	The study presents a model that guides the correct implementation of Lean, facilitating the interpretation and sequencing of the necessary steps. The application of the CCTP model in the healthcare field proved effective, allowing for improved results, organized activities, increased productivity, optimized perception of the work environment, and reduced wasted time and movement within four months.
73	Ömürgönülşen et al. [125]	The application of methodologies allowed the identification of priority criteria in course evaluation, such as the professor's theoretical and industrial knowledge, teaching skills, effective classroom management, and empathy. Course quality depends on the professor's qualifications, and attractive attributes include industry interaction and support for career goals. Faculty workload and high faculty quality are critical factors for academic success, and reducing the number of students can improve industry interaction and communication with students.
74	Burka [59]	The study shows that applying Lean/Kaizen contributes to increased productivity, efficiency, and competitiveness in companies. The concept of Personal Kaizen allows for the application of continuous improvement in personal life, promoting better task management, organization, waste reduction, and the development of positive habits, benefiting discipline, assertiveness, self-control, and family relationships.
75	Hammadi and Herrou [31]	The study highlights that integrating Lean with sustainability can improve operational, environmental, and economic factors, but faces significant challenges, especially in industrial maintenance. Success depends on the human factor, requiring collaboration, commitment, and responsibility, as well as standardization, systematization, and clear and effective communication.
76	Zhiwen et al. [126]	Although the model will be useful and contribute to evaluating the quality of logistics information, it only considers the supply of a single type of material, as well as time and quantity.
77	Nedeliakova et al. [127]	The study shows that Lean Philosophy, known for improving quality and efficiency in production, has been applied in other industrial sectors, including rail transport. Its implementation aims to reduce operational risks, increase efficiency, improve risk management, and allow for a rapid response to market changes.

Table A2. Cont.

Item	Author and Year	Key Findings
78	Kowalski et al. [128]	The study highlights that implementing continuous workflow in the workstation requires specific adaptations, such as U-shaped organization, arranging machines according to the process, and making materials available as needed. Ergonomic measures, including tool positioning, appropriate workbench height, and suitable lighting, contribute to improving production, ensuring continuous workflow, and reducing operator injuries.
79	Solaimani and Sedighi [25]	The application of Lean positively impacts the Triple Bottom Line, improving economic, productive, and environmental aspects. The emphasis on quality promotes the standardization of processes, reducing variability, costs, and manufacturing time and increasing safety and transparency. However, trade-offs may arise, such as reduced job opportunities, the need for more qualified employees, and increased costs due to process changes.
80	Martins et al. [129]	The study shows that high investments are not always necessary to achieve continuous improvement. It was possible to increase production, maximize capacity and available resources, optimize preparation areas and create loading zones, reducing transport distances. To maintain continuous improvement, it is essential to control all activities and perform systematic analyses, applying appropriate methodologies to consolidate and sustain the results obtained.
81	Morell-Santandreu et al. [130]	The study demonstrates that the proposed model allows for the implementation of changes and improvements, showing that Lean Philosophy contributes to improving management and achieving defined objectives. In the healthcare field, it was possible to increase the quality of care, reduce wasted time, and cultivate a culture of continuous improvement, information sharing, and collaboration. Furthermore, there was a reduction in stress among healthcare professionals, including doctors and administrative staff.
82	Dieste et al. [69]	The study highlights that, although many articles exist on the effects of Lean, few focus on the financial impacts on companies. This research stands out for its focus and may encourage organizations that have not yet adopted Lean to consider its implementation to reap the benefits of this philosophy.
83	Abu et al. [73]	The study highlights that, although Lean Philosophy is perceived as beneficial for improving the overall performance of companies, its implementation faces barriers such as resistance to change, lack of knowledge, and traditional management. To overcome these difficulties, the authors suggest awareness and collaboration programs with stakeholders, promoting adequate time, resources, and training for the adoption of Lean.
84	Hernández Marquina et al. [26]	The study demonstrates that adapting the traditional VSM (value stream mapping) model to circular environments is feasible, allowing for the representation of circular systems and providing information that supports decision-making. The inclusion of indicators enables a global view and multidimensional evaluation of system performance. Lean and its tools contribute significantly to improving aspects related to the Triple Bottom Line, making it necessary to evaluate circular products considering this perspective and not just the product life cycle.
85	Gaudenzi and Qazi [131]	It presents a useful tool to support risk-based thinking required by ISO 9001. The integration of the Bayesian Belief Networks model demonstrates how the careful choice of suppliers and risk can be determinants in strategy, cost and time. Without the integration of the tool, the project indicated in the study would not have been completed.
86	Agostinho et al. [64]	The study presents a model based on Lean principles that allows for the calculation of minimum and maximum inventory quantities, indicates order urgency, and classifies items according to demand. The model proved to be effective and intuitive and contributes to adding value by correctly identifying the items to be ordered, enabling cost reduction, especially relevant in the healthcare sector, where storage costs are high.

Table A2. Cont.

Item	Author and Year	Key Findings
87	Aslam et al. [82]	The study identified 32 challenges related to sustainable construction, with organization/culture and management/construction being the highest priority categories. The application of Lean tools in construction, assessed using the LAST matrix, shows the capacity to address many of these challenges. However, limitations such as lack of government interest or the absence of strict regulations remain. The LAST matrix provides a strategic guide to overcome obstacles and implement more sustainable practices in the construction industry.
88	Ulewicz et al. [132]	The study indicates that many companies, especially small ones, do not use Lean tools systematically. Among the tools applied, ISO 9001, statistical process control, standardization, pull system, continuous flow, and 5S stand out. Companies that integrate these tools gain competitive advantages, with integration being most effective in fixed and high-volume production systems in the ceramic industry. Ancillary companies face greater challenges in implementing Lean methodologies.
89	Murmura et al. [76]	Implementing Lean Six Sigma can help reduce constraints and inefficiencies in production processes, improve customer satisfaction, and promote quality improvement and cost reduction. The methodology encourages continuous training, data-driven culture, and problem-solving, developing skills, knowledge sharing, and employee motivation, demonstrating effectiveness in customer focus and waste elimination.
90	Mendes et al. [74]	The study highlights that integrating decision support systems requires stakeholder knowledge, identification of value-adding steps through VSM (value stream mapping), and assessment of the organization's current state using indicators and tools such as PDCA and 5W2H. Successful Lean implementation depends on understanding and adopting the philosophy within the organizational culture. Common barriers include cultural resistance, insufficient communication, lack of prioritized training, and undervaluing team skills, limiting the benefits of Lean.
91	Caretta Teixeira et al. [60]	In the healthcare sector, data and service management present challenges due to the diversity and complexity of medical information. The integration of Lean principles allows for improved information management, quality, and services provided, optimizing medical procedures. Implementation requires organizational restructuring, elimination of non-value-adding activities, and prioritization of those that do. The adoption of computerized systems facilitates information flow, continuous improvement, and innovation, resulting in significant gains in the quality of healthcare services and the efficiency of primary care.
92	Bhasin and Found [45]	Lean transformation requires a holistic approach, considering the system as a whole and its interactions, not isolated parts. Implementation involves changes in organizational structure, culture, behaviors, and other internal aspects. It is necessary for the company, employees, and management to deeply understand the Lean concept, supported by adequate infrastructure and a favorable organizational culture, to overcome typical barriers and ensure the effectiveness of the process.
93	Mangaroo-Pillay and Coetzee [133]	Lean and the Ubuntu philosophy are people-centered, sharing values such as teamwork, leadership, respect, collective thinking, decision-making, and continuous improvement. However, specific Lean principles, such as continuous flow, pull system, load balancing, and visual management, are not related to Ubuntu. The correlation between nine Lean principles and thirteen Ubuntu principles allows for the adaptation of Lean to the South African context, facilitating the acceptance and explanation of the philosophy. However, specific education and training are essential for successful implementation.
94	Velásquez et al. [133]	Integrating Lean into companies increases productivity, improves customer service, and facilitates the exploration of new markets. Lean enhances the planning and preparation of activities, reducing unnecessary movements and human errors, with checklists helping to minimize interruptions. Success depends heavily on employee engagement, demonstrating that the correct implementation of Lean significantly increases operational performance.

Table A2. Cont.

Item	Author and Year	Key Findings
95	Zaporowska and Szczepański [85]	The authors highlight that risk management is not always considered when selecting improvement processes in shared service centers, and cooperation between Lean and risk teams is limited. The simultaneous integration of Lean and risk management is essential, especially with the rise in remote work and outsourcing during the COVID-19 pandemic. Combining Lean with risk management emerges as an effective solution to address emerging challenges such as cybersecurity and new work realities.
96	Minh and Quyen [18]	From the study it was possible to observe that it is feasible to improve the quality of human resources from the integration of Kaizen. Using training and Genchi-Genbutsu, employees can achieve levels of skills and abilities of excellence. Kaizen, in addition to improving the skills and abilities of employees, makes it possible to foster an environment and culture of cooperation and continuous improvement.
97	Keleş and Yılmaz [135]	The study concludes that employees do not fully understand the concept of Lean in the construction industry. Despite some variations in the responses of the 343 interviewees, the majority believe that applying Lean will bring benefits to the sector. The interviews showed that participants have a limited understanding of the concepts and their practical application. To improve this situation, the authors highlight the importance of greater collaboration between the construction industry, universities, and public/institutional bodies, as well as the need to train employees, reduce waste, identify those responsible for Lean processes, standardize and update processes, and ensure the active participation of all employees to maximize the benefits of Lean Philosophy.
98	Moradi and Sormunen [32]	It was observed that the isolated integration of the Lean concept, sustainability or BIM brings less benefits when compared to the joint integration of these concepts. Although there are some studies that promote the partial integration of these concepts, there is a need for a project delivery system that integrates the principles and practices of Lean, sustainability and BIM concepts. The model presented will contribute to improving the construction sector in terms of sustainability, but also in terms of social, economic and productive aspects.
99	Mangaroo-Pillay and Coetzee [136]	The authors identified a demand for articles, papers, and other documents on the benefits of Lean, its limitations, and frameworks that can aid in creating an implementation guide. However, there is no standardized method for developing models that integrate the Lean concept. To validate the developed models, the authors suggest conducting interviews, case studies in companies, questionnaires, mathematical calculations, or surveys. Despite the great potential for success in implementing Lean Philosophy, approximately 90% of implementations fail, largely due to a lack of focus on change management and human factors, among others.
100	Maware and Parsley [83]	Companies face several challenges when integrating Lean, the most common being resistance to cultural change, lack of knowledge about Lean, limitations in management, and employee resistance. Other frequent barriers include a lack of strategy, organizational commitment, and insufficient skills. For successful Lean implementation, it is essential to overcome these barriers, as well as others that may arise throughout the process. Senior management plays a crucial role, being responsible for reducing resistance from employees and suppliers, as well as promoting education, training, and dissemination of Lean to all those involved in the process.
101	Sá et al. [38]	The authors indicate that outsourcing aligns with some Lean principles, as it allows companies to focus on their core activities and delegate secondary tasks, reducing non-value-adding activities. It contributes to cost reduction, increased efficiency, productivity, and quality, as well as enabling the absorption of new ideas and management practices. The division of labor reduces rework and errors, improves task distribution, and increases customer satisfaction. Although generally applied to secondary activities, outsourcing can generate strategic competitive advantages, making it important for the company to maintain a balance between internal and external production, preserving negotiating power and autonomy.

Table A2. *Cont.*

Item	Author and Year	Key Findings
102	Liu et al. [36]	The authors indicate that implementing Lean combined with innovation and sustainability can significantly contribute to improving aspects related to the Triple Bottom Line (environmental, social, and economic). Sustainable innovation can act as a partial mediator between Lean and sustainability, enhancing the effects of Lean implementation in all three dimensions. Despite the positive prospects of this integration, the authors highlight the need for further studies to delve deeper into the challenges and barriers faced by companies when applying these concepts in the business environment.
103	Pawlak et al. [137]	Through the integration of the 5S methodology and standardization, it was possible to reduce the time in all production operations, concluding that the changes made contribute significantly to the alteration of the duration of the individual operations included in the production process. The results can serve as an incentive for production managers to integrate Lean tools to improve the operational performance of their companies.
104	Kanyemba et al. [75]	The authors identified the main factors influencing the dense media separation process, related to viscosity, cycle pressure, and part wear. The integration of Lean Six Sigma allowed for the reduction in waste and process variability, as well as improved efficiency. Using the DMAIC methodology, it was discovered that replacing the PC100 densifier with the PC200 would be important for controlling critical factors. To ensure sustainability and motivate stakeholders, it was necessary to clearly communicate the results obtained based on data.
105	Fuentes et al. [138]	Although Lean Philosophy is widely studied and applied in various industries, in the healthcare field, especially in the management of patient admissions and discharges, it is still underexplored. Despite its potential to generate benefits in hospital management, many healthcare institutions lack adequate support to ensure the sustainability of Lean application. When well implemented, Lean improves discharge planning, allowing for process mapping, identification of waste, detection of improvement opportunities, and support for healthcare professionals' decision-making. Furthermore, it promotes teamwork, accountability, and other essential aspects to improve service quality. It is necessary to continue investigating the barriers, limitations, and challenges of Lean integration, as well as to clearly understand the benefits of its application in healthcare.
106	Sá et al. [95]	Integrating Lean principles into the production of custom-made footwear faces challenges due to the artisanal nature of the process and variations. Tools such as Gemba Walk and TPM have reduced cycle time, increased efficiency, eliminated non-value-added activities, improved maintenance planning, decreased equipment failures, and increased productivity. The use of labels and visual management has facilitated the identification of delays, prioritization of urgent tasks, and adherence to deadlines, in addition to reducing accidents and increasing safety. The continuous application and updating of SVSM (Safety, Health, and Management System) has allowed for the evaluation of production pace and safety. While many Lean tools are easy to implement, the introduction of Yokoten (a Lean method) presented challenges. Success depends heavily on the involvement of operators, managers, and senior management, which is essential to ensure sustainable results.
107	Simonsen et al. [91]	Interest in applying Lean in the public sector has increased by approximately 9.4%, highlighting the relevance and constant development of studies in this area. The most frequently addressed topics include efficiency, government, Lean, logistics, and management. Applying Lean in public construction offers benefits, contributing to cost reduction, improved quality, and faster project completion times. However, integration faces internal challenges such as resistance to change, collaboration, and trust, as well as external challenges related to regulations and laws.

Table A2. Cont.

Item	Author and Year	Key Findings
108	Baskiewicz et al. [139]	The hospital management is complex and demands the full involvement and collaborative spirit of all employees, including doctors, assistants, and technicians. Despite efforts, services do not always meet patient expectations. Analyzing patient satisfaction allows for the evaluation of the achievement of the hospital unit's objectives. The integration of the Kano model identified factors that influence satisfaction, such as medical behavior, reception, and bureaucracy. Furthermore, the implementation of an information system can optimize hospital management, benefit patients and increasing their satisfaction.
109	Becker and Endenich [88]	Entrepreneurial ecosystems together with the Lean concept influence management in start-ups. It verifies that some kind of pressure by the ecosystem leads to incorporating scalable business models into start-ups. The authors also indicate that the fast-growing culture in start-ups can lead to the marginalization of financial metrics, which undermines the balance between growth and profits.
110	Basulo-Ribeiro et al. [96]	The study presents a study that involves two very different aspects of a company. It has a high maturity in the application of Lean and a low technological level. The authors point out that sometimes the use of some Lean tools and the combination with some less complex technologies contributed to the smooth functioning of companies, as well as supporting Lean development.
111	Vijverberg et al. [61]	The study identified gaps in the literature regarding the identification and quantification of waste and factors related to the improvement of clinical services. Although several studies apply Lean in healthcare, mainly using tools such as value stream mapping and waste reduction, there is a need for models that assess the improvement potential of a clinical pathway and measure the impact of implemented actions. Application in Integrated Practice Units, which adopt a horizontal view of the system and a closed patient flow, facilitates the integration of Lean, promoting more consistent and comprehensive improvements.
112	Craveiro et al. [34]	The integration of Lean and Six Sigma philosophies enables companies to gain competitive advantages and improve operational performance. Although few clinical, testing and calibration laboratories know or apply these methodologies, those that implement them have more employees, greater financial flow and superior operational results compared to those that do not use them.
113	Ince et al. [4]	Integrating Lean and sustainability into multi-criteria decision-making methodologies is feasible, although it increases the complexity in developing decision support models. The most relevant criteria were "distance to the customer" and "work practices," while "quality level" was less important. The Fuzzy ARAS and Fuzzy TOPSIS methodologies indicated Supplier 2 as the best choice due to its better Lean and sustainability indicators.
114	Santos et al. [43]	The case study demonstrated that the application of Lean tools significantly improved the company's production system. There was a 47% reduction in non-value-adding activities, resulting in a 26% decrease in lead time and a 33% increase in production. The integration of Poka-Yoke reduced defects and corrected errors more efficiently. In addition to economic and competitive benefits, there was an improvement in occupational safety. A simplified inventory management system allowed for better inventory monitoring and the elimination of waste related to excess inventory, material shortages, and unnecessary movements.
115	Vienažindienė and Čiarnienė [79]	The Lean Philosophy aims to eliminate waste and increase efficiency in companies, but its implementation can face barriers and challenges related to change, lack of knowledge, poor leadership and communication. To overcome these difficulties, it is essential to consolidate Lean throughout the organization, invest in employee training and motivation, and promote a culture of continuous improvement. When applied correctly, Lean makes it possible to increase productivity, reduce costs, improve quality, and increase customer satisfaction.

Table A2. Cont.

Item	Author and Year	Key Findings
116	Vaz et al. [140]	The study shows that the TPM methodology has a positive impact on the operational performance of companies. Planned maintenance and education and training practices are the most used and the ones that contribute the most to improvements. However, factors such as headcount, team size, and barriers such as lack of support from top management or low employee engagement can limit the benefits of TPM.
117	da Silva et al. [22]	The study highlights the need for more research that relates the Lean Philosophy and sustainability, specifically in solid waste management. The application of VSM allows solid waste management companies to identify waste and inefficiencies in processes. Additionally, it makes it possible to base decisions, optimizing operations with a focus on sustainability, reducing costs and increasing safety at work.
118	Moso and Olanrewaju [141]	The integration of the model allowed for the identification of problems such as quality non-conformities, safety incidents, and engineering failures. Improvement can be achieved by updating existing systems or implementing more efficient management systems. Combining Lean with risk analysis helps companies identify improvement opportunities from existing problems and define future development projects. Furthermore, it ensures adherence to ISO standards, improves profitability through continuous improvement projects, and strengthens the company's market position.
119	Alanya et al. [40]	The application of tools such as VSM, SMED and others has made it possible to eliminate non-value-added activities, reducing constraints in the production system and losses. In addition to the operational gains, with a reduction of around 16.7% in non-value-added activities, there was also a greater decrease in costs. The authors emphasize that the success of the project depends on the continuous training of employees, to ensure the effective application of the tools and to promote a cultural change in the company, fostering efficiency and sustained results in the long term.
120	Díaz-Reza et al. [23]	Integrating the concept of continuous improvement in companies is extremely important for them to be able to more easily achieve social sustainability, serving as an enabler for tools such as TPM and JIT, which are essential components of Lean, as well as philosophies such as TQM.
121	Alberto et al. [142]	The work was carried out based on 87 industries located in Luanda using the Milan maturity model. Through statistical analysis it was possible to observe that the level of Lean maturity in the industry in Luanda is low. Despite the result, this knot can be generalized to all industries in the city.
122	Al-Baldawi et al. [41]	The proposed model allows small and medium-sized companies to focus on the most relevant Lean activities, contributing to improving competitiveness and business sustainability. Companies must implement Lean to eliminate or reduce waste and improve performance and quality. The most significant Lean activities were identified: Kaizen team, efficient manager, relationship with suppliers, customer satisfaction, job rotation and employees with multiple skills.
123	Hasan et al. [56]	Lean practices in construction, by integrating customer needs and continuous improvement, are aligned with sustainable development goals, promoting equitable access to sanitation, economic productivity, and sustainable procurement. Lean resource optimization contributes to economic growth and diversification. Furthermore, continuous improvement acts as a catalyst for innovation and technological progress in the sector. Improving production flows increases efficiency, promotes sustainable production and responsible resource use, and is fundamental for reducing waste, improving costs, and increasing resource efficiency in public procurement processes.

Table A2. Cont.

Item	Author and Year	Key Findings
124	Slavina and Štefanić [28]	For the effective implementation of Lean and TPM methodologies, alignment between senior management and employees is fundamental. It is necessary to overcome barriers and challenges, improve equipment selection, positively engage employees through education and training, and consider Industry 4.0 technologies. Critical factors include lack of recognition of internal audits, inadequate equipment selection, occupational safety, and insufficient rigor in Lean activities. The integration of Lean and TPM should be a daily and continuous process, subject to regular audits, with adequate training at all hierarchical levels. The correct choice of equipment and increased employee motivation through better working conditions and safety are crucial for successful implementation.
125	Antonelli et al. [9]	The study demonstrates that implementing Lean tools can facilitate the inclusion of people with disabilities in dynamic environments, such as the factory floor, promoting equity in the workplace. By identifying and eliminating inefficiencies and waste in production systems, companies can design roles and processes that guarantee equal opportunities for participation and contribution. While Lean tools contribute to inclusive and equitable environments, they are not a universal solution and must be adapted to the specific needs of people with disabilities. The adoption of Lean promotes inclusion and equity in business, as well as contributing to the improvement of the three dimensions of sustainability: economic, social, and environmental.
126	Rodrigues and Alves [143]	In the existing literature, there are not many works that integrate Lean with Information Technology Project Management (ITIM). The model can serve as a guide for practitioners and researchers to see the integration of Lean and GPTI as a new approach that contributes to improving the efficiency of projects. Integrating Lean into projects can contribute to eliminating waste identified in projects, where, on the other hand, it will make it possible to better manage resources and increase project performance.
127	Al-baldawi et al. [144]	Small and medium enterprises (SMEs) these days are increasingly fundamental to the economy of any country. SMEs represent about 90% of companies and contribute about 46% of global gross domestic product (GDP) and can offer 60% of employment opportunities. Although Lean is a widely known and effective philosophy to promote improvements within companies, SMEs, due to their characteristics, face difficulties in adopting all Lean activities due to structural and financial limitations. For SMEs to be able to improve their competitiveness, they must join efforts in continuous improvement, to cope with the volatility of increasingly global markets.
128	Chitiva-Enciso et al. [145]	For companies, the measurement of indicators represents a huge challenge for specialists, managers and top management. The model is an innovative alternative to measuring Lean systems, using a human perspective associated with mathematics, such as dimensional analysis, to efficiently identify key indicators that require action plans to ensure the continuous improvement of Lean systems. The model contributes to the identification of the most important indicators for managers.
129	Kessy et al. [66]	The study identifies the factors that generate waste and analyzes how the application of Lean can reduce them. The main wastes are related to demand management, supplier development, institutional and organizational structure, and incentive culture. Public institutions face more challenges due to institutional complexity and high bureaucracy, while private institutions apply more Lean practices, such as standardization and automation. The most common wastes include excess inventory, operational and transactional costs, rework, and delays. Other influential factors are environmental uncertainty and the quality of digital and internet infrastructure. Supply chains in public institutions tend to be more extensive, complex, and bureaucratic, while those in private institutions are more agile, with less bureaucracy and greater funding.

Table A2. Cont.

Item	Author and Year	Key Findings
130	Contreras Castañeda et al. [86]	The study identified the main sources of waste in the plant, including handling, transportation, and waiting. Implementing 5S tools, visual management, standardized procedures, and the Lean Kaizen concept resulted in a more organized, clean, and safe work environment. This led to improved company image, prevention of product contamination, greater safety and efficiency in activities, and compliance with quality parameters. Furthermore, the application of these practices reduced production time and increased the company's competitiveness in economic, environmental, and social terms.
131	Moso and Olanrewaju [146]	Through the proposed model and case study, it was found that troubleshooting models can serve as a tool for the development of companies, given the characteristic of problem-solving. The development of companies will be all the better the more accurate the problem-solving system is. The model presented combines some Lean tools that allow them to analyze the problems. With the simulation of the model, it was possible to verify that it can contribute to problem-solving and achieve operational improvements.
132	Mandic et al. [147]	The study identified that Lean and quality tools, such as Gemba Walk, 5S, PDCA, Ishikawa Diagram, and the A3 methodology, contribute to increased productivity in civil construction. The implementation of these tools allowed for the identification of process problems and the proposal of changes to improve productivity, reducing installation time per panel. Furthermore, quality improved through standardization and worker training. The 5S methodology made the workspace safer, cleaner, and more organized, reducing the risk of accidents and injuries.

References

- Kovilage, M.P. Influence of Lean–Green Practices on Organizational Sustainable Performance. *J. Asian Bus. Econ. Stud.* **2021**, *28*, 121–142. [CrossRef]
- Henao, R.; Sarache, W.; Gómez, I. Lean Manufacturing and Sustainable Performance: Trends and Future Challenges. *J. Clean. Prod.* **2019**, *208*, 99–116. [CrossRef]
- Dieste, M.; Panizzolo, R. On the relationship between lean practices and environmental performance. *IOP Conf. Ser. Earth Environ. Sci.* **2018**, *151*, 012034. [CrossRef]
- Ince, M.N.; Tasdemir, C.; Gazo, R. Lean and Sustainable Supplier Selection in the Furniture Industry. *Sustainability* **2023**, *15*, 15891. [CrossRef]
- Piercy, N.; Rich, N. The Relationship between Lean Operations and Sustainable Operations. *Int. J. Oper. Prod. Manag.* **2015**, *35*, 282–315. [CrossRef]
- Nassereddine, A.; Wehbe, A. Competition and Resilience: Lean Manufacturing in the Plastic Industry in Lebanon. *Arab Econ. Bus. J.* **2018**, *13*, 179–189. [CrossRef]
- Tenera, A.M.B.R.; Pimentel, C.M.O.; Dias, R.M.F.; Matias, J.C.d.O. Lean Tools Contribution to Sustainability Outcomes: Insights from a Set of Case Studies. In *Lean Engineering for Global Development*; Alves, A.C., Kahlen, F.-J., Flumerfelt, S., Siriban-Manalang, A.B., Eds.; Springer International Publishing: Cham, Switzerland, 2019; pp. 161–190. [CrossRef]
- Ali, Y.; Younus, A.; Khan, A.U.; Pervez, H. Impact of Lean, Six Sigma and Environmental Sustainability on the Performance of SMEs. *Int. J. Prod. Perform. Manag.* **2020**, *70*, 2294–2318. [CrossRef]
- Antonelli, D.; Stadnicka, D.; Litwin, P. Inclusive Manufacturing through the Application of Lean Tools to Sustainability Issues. *Procedia CIRP* **2024**, *122*, 593–598. [CrossRef]
- Varela, L.; Araújo, A.; Ávila, P.; Castro, H.; Putnik, G. Evaluation of the Relation between Lean Manufacturing, Industry 4.0, and Sustainability. *Sustainability* **2019**, *11*, 1439. [CrossRef]
- Farias, L.M.S.; Santos, L.C.; Gohr, C.F.; de Oliveira, L.C.; da Silva Amorim, M.H. Criteria and Practices for Lean and Green Performance Assessment: Systematic Review and Conceptual Framework. *J. Clean. Prod.* **2019**, *218*, 746–762. [CrossRef]
- Garza-Reyes, J.A. Lean and Green—A Systematic Review of the State of the Art Literature. *J. Clean. Prod.* **2015**, *102*, 18–29. [CrossRef]
- Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E. The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews. *BMJ* **2021**, *372*, n71. [CrossRef]

14. Reis, J.; Marques, P.A.; Marques, P.C. Where Are Smart Cities Heading? A Meta-Review and Guidelines for Future Research. *Appl. Sci.* **2022**, *12*, 8328. [[CrossRef](#)]
15. Paterson, C.; Mckie, A.; Turner, M.; Kaak, V. Barriers and Facilitators Associated with the Implementation of Surgical Safety Checklists: A Qualitative Systematic Review. *J. Adv. Nurs.* **2024**, *80*, 465–483. [[CrossRef](#)] [[PubMed](#)]
16. Aromataris, E.; Fernandez, R.; Godfrey, C.M.; Holly, C.; Khalil, H.; Tungpunkom, P. Summarizing Systematic Reviews: Methodological Development, Conduct and Reporting of an Umbrella Review Approach. *JBIEvid. Implement.* **2015**, *13*, 132–140. [[CrossRef](#)] [[PubMed](#)]
17. Ioppolo, G.; Cucurachi, S.; Salomone, R.; Saija, G.; Ciraolo, L. Industrial Ecology and Environmental Lean Management: Lights and Shadows. *Sustainability* **2014**, *6*, 6362–6376. [[CrossRef](#)]
18. Minh, N.D.; Quyen, N.T.H. Human Resources Quality Improvement from the Perspective of Kaizen Practice. *Management* **2022**, *26*, 144–163. [[CrossRef](#)]
19. Mieke, R.; Bogdanov, I.; Schneider, R.; Hirsch, M.; Bauernhansl, T.; Pawlik, E.; Horbal, R. The Eco Lean Method—A Combined Approach for Low Cost Economic and Ecologic Optimization in the Manufacturing Industry. *Procedia CIRP* **2016**, *57*, 613–618. [[CrossRef](#)]
20. Wu, P.; Pienaar, J.; O'Brien, D. Developing a Lean Benchmarking Process to Monitor the Carbon Efficiency in Precast Concrete Factories—A Case Study in Singapore. *J. Green Build.* **2013**, *8*, 133–152. [[CrossRef](#)]
21. De Carvalho, A.C.V.; Granja, A.D.; Da Silva, V.G. A Systematic Literature Review on Integrative Lean and Sustainability Synergies over a Building's Lifecycle. *Sustainability* **2017**, *9*, 1156. [[CrossRef](#)]
22. da Silva, M.G.M.; Bouzon, M.; dos Santos Silva, J. Value Stream Analysis of a Waste Picker Cooperative: An Approach Based on Sustainability and Lean Philosophy. *Braz. J. Oper. Prod. Manag.* **2023**, *20*, 1801. [[CrossRef](#)]
23. Díaz-Reza, J.R.; García-Alcaraz, J.L.; Sánchez-Ramírez, C.; Vargas, A.R. Assessing the Impact of Lean Manufacturing on the Social Sustainability through Structural Equation Modeling and System Dynamics. *Jordan J. Mech. Ind. Eng.* **2024**, *18*, 113–130. [[CrossRef](#)]
24. Liu, Q.; Yang, H. An Improved Value Stream Mapping to Prioritize Lean Optimization Scenarios Using Simulation and Multiple-Attribute Decision-Making Method. *IEEE Access* **2020**, *8*, 204914–204930. [[CrossRef](#)]
25. Solaimani, S.; Sedighi, M. Toward a Holistic View on Lean Sustainable Construction: A Literature Review. *J. Clean. Prod.* **2020**, *248*, 119213. [[CrossRef](#)]
26. Hernandez Marquina, M.V.; Zwolinski, P.; Mangione, F. Application of Value Stream Mapping Tool to Improve Circular Systems. *Clean. Eng. Technol.* **2021**, *5*, 100270. [[CrossRef](#)]
27. Monroe, K.; Fick, F.; Joshi, M. Successful Integration of Ergonomics into Continuous Improvement Initiatives. *Work* **2012**, *41*, 1622–1624. [[CrossRef](#)]
28. Slavina, T.; Štefanić, N. Facing Challenges of Implementing Total Productive Management and Lean Tools in Manufacturing Enterprises. *Systems* **2024**, *12*, 52. [[CrossRef](#)]
29. Niñerola, A.; Ferrer-Rullan, R.; Vidal-Suñé, A. Climate Change Mitigation: Application of Management Production Philosophies for Energy Saving in Industrial Processes. *Sustainability* **2020**, *12*, 717. [[CrossRef](#)]
30. Tasdemir, C.; Gazo, R. A Systematic Literature Review for Better Understanding of Lean Driven Sustainability. *Sustainability* **2018**, *10*, 2544. [[CrossRef](#)]
31. Hammadi, S.; Herrou, B. Lean Integration in Maintenance Logistics Management: A New Sustainable Framework. *Manag. Prod. Eng. Rev.* **2020**, *11*, 99–106. [[CrossRef](#)]
32. Moradi, S.; Sormunen, P. Lean and Sustainable Project Delivery in Building Construction: Development of a Conceptual Framework. *Buildings* **2022**, *12*, 1757. [[CrossRef](#)]
33. Solaimani, S.; Haghighi Talab, A.; van der Rhee, B. An Integrative View on Lean Innovation Management. *J. Bus. Res.* **2019**, *105*, 109–120. [[CrossRef](#)]
34. Craveiro, A.; Lima, V.; Santos, G.; Sá, J.C.; Lopes, M.; Carvalho, J.D. Lean and Six Sigma Philosophies and Organizational Performance: A Study in Portuguese Laboratories. *Qual. Innov. Prosper.* **2023**, *27*, 21–45. [[CrossRef](#)]
35. Ishak, A.; Siregar, K.; Ginting, R.; Gustia, D. A systematic literature review of lean six sigma. *IOP Conf. Ser. Mater. Sci. Eng.* **2020**, *1003*, 012096. [[CrossRef](#)]
36. Liu, G.; Ding, Y.; Wen, C.; Gao, K.; Wang, T.; Sun, R. Understanding the Role of Sustainable-Oriented and Process Innovation with Lean Practices in Achieving Sustainability Paradigm: A Chinese Perspective. *Front. Environ. Sci.* **2022**, *10*, 905112. [[CrossRef](#)]
37. Prasetyawan, Y.; Suef, M.; Rifqy, N.; Kusuma Wardani, I.O. Manufacturing strategy improvement based on lean methodology. *IOP Conf. Ser. Mater. Sci. Eng.* **2019**, *508*, 012095. [[CrossRef](#)]
38. Sá, S.; Pinto Ferreira, L.; Silva, F.J.G.; Sá, J.C.; Pereira, M.T.R.; Santos, G. The Importance of Subcontracting and Its Relationship with Lean Philosophy in Automotive Industry. *Int. J. Ind. Eng. Manag.* **2022**, *13*, 186–193. [[CrossRef](#)]
39. Stadnicka, D.; Ratnayake, R.M.C. Minimization of Service Disturbance: VSM Based Case Study in Telecommunication Industry. *IFAC-PapersOnLine* **2016**, *49*, 255–260. [[CrossRef](#)]

40. Alanya, B.S.; Dextre, K.E.; Nuñez, V.H.; Marcelo, G.E.; Alvarez, J.C.; Hatakeyama, K. Application of Lean Manufacturing to Improve Processes and Increase Productivity in the Textile Industry of Peru: Case Study. *S. Afr. J. Ind. Eng.* **2024**, *35*, 140–153. [[CrossRef](#)]
41. Al-Baldawi, Z.; Kassam, A.H.; Al-Zubaidi, S.S.A. Assessment the Level of Importance of SME Lean Activities Using an Integrated Model Based on Fuzzy Logic. *Manag. Prod. Eng. Rev.* **2024**, *15*, 76–89. [[CrossRef](#)]
42. Sanda, M.-A.; Johansson, J.; Johansson, B. Miners' tacit knowledge: A unique resource for developing human-oriented lean mining culture in deep mines. In *Proceedings of the 2011 IEEE International Conference on Industrial Engineering and Engineering Management, Singapore, 6–9 December 2011*; IEEE: New York, NY, USA, 2011; pp. 399–404. [[CrossRef](#)]
43. Santos, E.; Lima, T.M.; Gaspar, P.D. Optimization of the Production Management of an Upholstery Manufacturing Process Using Lean Tools: A Case Study. *Appl. Sci.* **2023**, *13*, 9974. [[CrossRef](#)]
44. Dombrowski, U.; Mielke, T. Lean Leadership—15 Rules for a Sustainable Lean Implementation. *Procedia CIRP* **2014**, *17*, 565–570. [[CrossRef](#)]
45. Bhasin, S.; Found, P. Sustaining the Lean Ideology. *Manag. Decis.* **2021**, *59*, 568–585. [[CrossRef](#)]
46. AlManei, M.; Salonitis, K.; Xu, Y. Lean Implementation Frameworks: The Challenges for SMEs. *Procedia CIRP* **2017**, *63*, 750–755. [[CrossRef](#)]
47. Bajjou, M.S.; Chafi, A.; Ennadi, A. Development of a Conceptual Framework of Lean Construction Principles: An Input–Output Model. *J. Adv. Manuf. Syst.* **2019**, *18*, 1–34. [[CrossRef](#)]
48. Duran, O.; Capaldo, A.; Duran Acevedo, P.A. Lean Maintenance Applied to Improve Maintenance Efficiency in Thermoelectric Power Plants. *Energies* **2017**, *10*, 1653. [[CrossRef](#)]
49. Hasibul, I.M.; Gustav, B.; Malin, T. Adoption of Lean Philosophy in Car Dismantling Companies in Sweden—A Case Study. *Procedia Manuf.* **2018**, *25*, 620–627. [[CrossRef](#)]
50. Kurilova-Palisaitiene, J.; Sundin, E. Toward Pull Remanufacturing: A Case Study on Material and Information Flow Uncertainties at a German Engine Remanufacturer. *Procedia CIRP* **2015**, *26*, 270–275. [[CrossRef](#)]
51. Tekez, E.K.; Taşdeviren, G. A Model to Assess Leanness Capability of Enterprises. *Procedia Comput. Sci.* **2016**, *100*, 776–781. [[CrossRef](#)]
52. Ngoc Thuy, V.T.; Phuong Thao, H.D.P. Ecotourists' Satisfaction and Dissatisfaction: Asymmetric Effects of Service Attributes. *J. Asian Bus. Econ. Stud.* **2019**, *26*, 189–205. [[CrossRef](#)]
53. Toussaint, J.S.; Berry, L.L. The promise of lean in health care. *Mayo Clin. Proc.* **2013**, *88*, 74–82. [[CrossRef](#)]
54. Van der Merwe, K.R.; Pieterse, J.J.; Lourens, A.S. The Development of a Theoretical Lean Culture Causal Framework to Support the Effective Implementation of Lean in Automotive Component Manufacturers. *S. Afr. J. Ind. Eng.* **2014**, *25*, 131–144. [[CrossRef](#)]
55. Veres, C. Conceptual Model for Introducing Lean Management Instruments. *Procedia Manuf.* **2020**, *46*, 233–237. [[CrossRef](#)]
56. Hasan, S.; Işık, Z.; Demirdöğen, G. Evaluating the Contribution of Lean Construction to Achieving Sustainable Development Goals. *Sustainability* **2024**, *16*, 3502. [[CrossRef](#)]
57. Minh, N.D.; Van Ha, N.T. “Made in Vietnam” Lean Management Model for Sustainable Development of Vietnamese Enterprises. *Procedia CIRP* **2016**, *40*, 602–607. [[CrossRef](#)]
58. Salonitis, K.; Tsinopoulos, C. Drivers and Barriers of Lean Implementation in the Greek Manufacturing Sector. *Procedia CIRP* **2016**, *57*, 189–194. [[CrossRef](#)]
59. Burka, I. How Managers in Poland Use the Principles and Instruments of the Kaizen Philosophy in Their Personal Lives—The Personal Kaizen Approach. *Qual. Innov. Prosper.* **2020**, *24*, 1–21. [[CrossRef](#)]
60. Caretta Teixeira, J.C.; Bernardi, F.A.; Lopes Rijo, R.P.C.; Alves, D. Proposal for a Health Information Management Model Based on Lean Thinking. *Procedia Comput. Sci.* **2021**, *181*, 1097–1104. [[CrossRef](#)]
61. Vijverberg, J.R.G.; Rouppe van der Voort, M.B.V.; van der Nat, P.B.; Mosselman, M.J.; Rigter, S.; Biesma, D.H.; van Merode, F. How to Use Lean Thinking for the Optimization of Clinical Pathways: A Systematic Review and a Proposed Framework to Analyze Pathways on a System Level. *Healthcare* **2023**, *11*, 2488. [[CrossRef](#)]
62. Antosz, K.; Stadnicka, D. Lean Philosophy Implementation in SMEs—Study Results. *Procedia Eng.* **2017**, *182*, 25–32. [[CrossRef](#)]
63. Antonioli, I.; Guariente, P.; Pereira, T.; Ferreira, L.P.; Silva, F.J.G. Standardization and Optimization of an Automotive Components Production Line. *Procedia Manuf.* **2017**, *13*, 1120–1127. [[CrossRef](#)]
64. Agostinho, A.; Guilherme, H.; Marcelino, S.; Lima, T.M.; Gaspar, P.D. Decision Support System for the Application of Lean Healthcare in Stock Management in Health Facilities. In *Proceedings of the 2021 International Conference on Decision Aid Sciences and Application (DASA), Virtual Conference, 7–8 December 2021*; IEEE: New York, NY, USA, 2021; pp. 886–891. [[CrossRef](#)]
65. Dieste, M.; Panizzolo, R.; Garza-Reyes, J.A. Evaluating the Impact of Lean Practices on Environmental Performance: Evidences from Five Manufacturing Companies. *Prod. Plan. Control* **2020**, *31*, 739–756. [[CrossRef](#)]
66. Kessy, S.S.A.; Salema, G.L.; Simwita, Y. Lean Thinking in Medical Commodities Supply Chains: Applicability and Success Factors for Tanzanian Health Supply Chains. *J. Humanit. Logist. Supply Chain Manag.* **2024**, *14*, 105–117. [[CrossRef](#)]

67. Satolo, E.G.; Hiraga, L.E.d.S.; Goes, G.A.; Lourenzani, W.L. Lean Production in Agribusiness Organizations: Multiple Case Studies in a Developing Country. *Int. J. Lean Six Sigma* **2017**, *8*, 335–358. [[CrossRef](#)]
68. Rampasso, I.S.; Anholon, R.; Gonçalves Quelhas, O.L.; Filho, W.L. Primary Problems Associated with the Health and Welfare of Employees Observed When Implementing Lean Manufacturing Projects. *Work* **2017**, *58*, 263–275. [[CrossRef](#)]
69. Dieste, M.; Panizzolo, R.; Garza-Reyes, J.A. A Systematic Literature Review Regarding the Influence of Lean Manufacturing on Firms' Financial Performance. *J. Manuf. Technol. Manag.* **2021**, *32*, 101–121. [[CrossRef](#)]
70. Rauch, E.; Dallasega, P.; Matt, D.T. Synchronization of Engineering, Manufacturing and on-Site Installation in Lean ETO-Enterprises. *Procedia CIRP* **2015**, *37*, 128–133. [[CrossRef](#)]
71. Karam, A.-A.; Liviu, M.; Cristina, V.; Radu, H. The Contribution of Lean Manufacturing Tools to Changeover Time Decrease in the Pharmaceutical Industry. A SMED Project. *Procedia Manuf.* **2018**, *22*, 886–892. [[CrossRef](#)]
72. Pardillo Baez, Y.; Andersson, R.; Bridi, E.; Pacheco Paladini, E. Lean six sigma philosophy improves collaboration to get more integrated supply chains. *Rev. Eletrôn. Estratég. Neg.* **2019**, *12*, 153–176. [[CrossRef](#)]
73. Abu, F.; Gholami, H.; Saman, M.Z.M.; Zakuan, N.; Streimikiene, D.; Kyriakopoulos, G.L. An SEM Approach for the Barrier Analysis in Lean Implementation in Manufacturing Industries. *Sustainability* **2021**, *13*, 1978. [[CrossRef](#)]
74. Mendes, A.; Lima, T.M.; Gaspar, P.D. Lean Tools Selector—A Decision Support System. In *Proceedings of the 2021 International Conference on Decision Aid Sciences and Application (DASA), Virtual Conference, 7–8 December 2021*; IEEE: New York, NY, USA, 2021; pp. 45–50. [[CrossRef](#)]
75. Kanyemba, A.; Dzinomwa, G.; Sony, M. Application of Lean Six Sigma to Improve the Dense Medium Separation Performance at a Diamond Processing Plant in Namibia. *Cogent Eng.* **2023**, *10*, 2165216. [[CrossRef](#)]
76. Murmura, F.; Bravi, L.; Musso, F.; Mosciszko, A. Lean Six Sigma for the Improvement of Company Processes: The Schnell SpA Case Study. *TQM J.* **2021**, *33*, 351–376. [[CrossRef](#)]
77. Vienažindienė, M.; Čiarnienė, R. The Challenges and Solutions to Implementing the Lean Concept: The Case of Lithuanian Companies. *Pol. J. Manag. Stud.* **2023**, *28*, 423–440. [[CrossRef](#)]
78. Bamford, D.; Forrester, P.; Dehe, B.; Leese, R.G. Partial and Iterative Lean Implementation: Two Case Studies. *Int. J. Oper. Prod. Manag.* **2015**, *35*, 702–727. [[CrossRef](#)]
79. Čiarnienė, R.; Vienažindienė, M. An Empirical Study of Lean Concept Manifestation. *Procedia Soc. Behav. Sci.* **2015**, *207*, 225–233. [[CrossRef](#)]
80. Elkhairi, A.; Fedouaki, F.; El Alami, S. Barriers and Critical Success Factors for Implementing Lean Manufacturing in SMEs. *IFAC-PapersOnLine* **2019**, *52*, 565–570. [[CrossRef](#)]
81. Bayhan, H.G.; Demirkesen, S.; Jayamanne, E. Enablers and barriers of lean implementation in construction projects. *IOP Conf. Ser. Mater. Sci. Eng.* **2019**, *471*, 022002. [[CrossRef](#)]
82. Aslam, M.; Gao, Z.; Smith, G. Development of Lean Approaching Sustainability Tools (LAST) Matrix for Achieving Integrated Lean and Sustainable Construction. *Constr. Econ. Build.* **2021**, *21*, 176–197. [[CrossRef](#)]
83. Maware, C.; Parsley, D.M. The Challenges of Lean Transformation and Implementation in the Manufacturing Sector. *Sustainability* **2022**, *14*, 6287. [[CrossRef](#)]
84. Ainul Azyan, Z.H.; Pulakanam, V.; Pons, D. Success Factors and Barriers to Implementing Lean in the Printing Industry: A Case Study and Theoretical Framework. *J. Manuf. Technol. Manag.* **2017**, *28*, 458–484. [[CrossRef](#)]
85. Zaporowska, Z.; Szczepański, M. Exploration of Lean Management Methods Used in Shared Services Centers, Drivers and Barriers to Process Selection for Improvements in the Light of Risk Management and ESG Reporting. *Sustainability* **2022**, *14*, 4695. [[CrossRef](#)]
86. Contreras Castañeda, E.D.; Gordillo Galeano, J.J.; Olaya Rodríguez, K.J. Lean-Kaizen Startup in Panela Production Processes: The Case of a Trapiche. *Cogent Eng.* **2024**, *11*, 2322834. [[CrossRef](#)]
87. Antosz, K.; Pacana, A. Comparative Analysis of the Implementation of the SMED Method on Selected Production Stands. *Teh. Vjesn.* **2018**, *25*, 276–282. [[CrossRef](#)]
88. Becker, S.D.; Enderich, C. Entrepreneurial Ecosystems as Amplifiers of the Lean Startup Philosophy: Management Control Practices in Earliest-Stage Startups. *Contemp. Account. Res.* **2023**, *40*, 624–667. [[CrossRef](#)]
89. Diaz, I.C.; Jin, Y.; Ares, E. Cycle Time Study of Wing Spar Assembly on Aircraft Factory. *Procedia Manuf.* **2017**, *13*, 1019–1025. [[CrossRef](#)]
90. Gonçalves, T.I.G.; Sousa, P.S.A.; Moreira, M.R.A. Does Lean Practices Implementation Impact on Company Performance? A Meta-Analytical Research. *Manag. Prod. Eng. Rev.* **2019**, *10*, 11–24. [[CrossRef](#)]
91. Simonsen, E.M.; Herrera, R.F.; Atencio, E. Benefits and Difficulties of the Implementation of Lean Construction in the Public Sector: A Systematic Review. *Sustainability* **2023**, *15*, 6161. [[CrossRef](#)]
92. Jebbor, I.; Benmamoun, Z.; Hachimi, H. Leveraging Digital Twins and Metaverse Technologies for Sustainable Circular Operations: A Comprehensive Literature Review. *Circ. Econ. Sustain.* **2025**, *5*, 5795–5848. [[CrossRef](#)]

93. Siqueira, C.L.; Siqueira, F.F.; Lopes, G.C.; Gonçalves, M.d.C.; Sarantopoulos, A. Enteral Diet Therapy: Use of the Lean Healthcare Philosophy in Process Improvement. *Rev. Bras. Enferm.* **2019**, *72*, 235–242. [[CrossRef](#)]
94. Mirali, F.; Jebbor, I.; Raouf, Y.; Benmamoun, Z.; Jizat, J.E.M.; Hachimi, H. Driving Manufacturing Excellence: The Role of Lean Strategies and Mediating Factors in Performance Improvement. *Manag. Prod. Eng. Rev.* **2025**, *16*, 1–11. [[CrossRef](#)]
95. Sá, J.C.; Soares, L.; Dinis-Carvalho, J.; Silva, F.J.G.; Santos, G. Assessment of the Impact of Lean Tools on the Safety of the Shoemaking Industry. *Safety* **2023**, *9*, 70. [[CrossRef](#)]
96. Basulo-Ribeiro, J.; Amorim, M.; Teixeira, L. How to Accelerate Digital Transformation in Companies with Lean Philosophy? Contributions Based on a Practical Case. *Int. J. Ind. Eng. Manag.* **2023**, *14*, 94–104. [[CrossRef](#)]
97. Bakri, A.H.; Rahim, A.R.A.; Yusof, N.M.; Ahmad, R. Boosting Lean Production via TPM. *Procedia Soc. Behav. Sci.* **2012**, *65*, 485–491. [[CrossRef](#)]
98. Krogstie, L.; Martinsen, K. Beyond Lean and Six Sigma; Cross-Collaborative Improvement of Tolerances and Process Variations—A Case Study. *Procedia CIRP* **2013**, *7*, 610–615. [[CrossRef](#)]
99. Ramnath, B.V.; Kumar, C.S.; Mohamed, G.R.; Venkataraman, K.; Elanchezian, C.; Sathish, S. Analysis of Occupational Safety and Health of Workers by Implementing Ergonomic Based Kitting Assembly System. *Procedia Eng.* **2014**, *97*, 1788–1797. [[CrossRef](#)]
100. Wu, P. Monitoring Carbon Emissions in Precast Concrete Installation through Lean Production—A Case Study in Singapore. *J. Green Build.* **2014**, *9*, 191–211. [[CrossRef](#)]
101. McCann, L.; Hassard, J.S.; Granter, E.; Hyde, P.J. Casting the Lean Spell: The Promotion, Dilution and Erosion of Lean Management in the NHS. *Hum. Relat.* **2015**, *68*, 1557–1577. [[CrossRef](#)]
102. Goerke, M.; Schmidt, M.; Busch, J.; Nyhuis, P. Holistic Approach of Lean Thinking in Learning Factories. *Procedia CIRP* **2015**, *32*, 138–143. [[CrossRef](#)]
103. Mardani, A.; Jusoh, A.; Nor, K.M.D.; Khalifah, Z.; Zakwan, N.; Valipour, A. Multiple Criteria Decision-Making Techniques and Their Applications—A Review of the Literature from 2000 to 2014. *Econ. Res.-Ekonom. Istraz.* **2015**, *28*, 516–571. [[CrossRef](#)]
104. Rohac, T.; Januska, M. Value Stream Mapping Demonstration on Real Case Study. *Procedia Eng.* **2015**, *100*, 520–529. [[CrossRef](#)]
105. Elizondo, R.L.; Grabot, B.; Ngouna, R.H. Beyond Productivity and Continuous Improvement: Fundamentals Required for Lean Complex Transformation Unpublished. *IFAC-PapersOnLine* **2016**, *49*, 467–472. [[CrossRef](#)]
106. Vavrušová, V.; Vitásková, E. Lean healthcare: Results of multicenter survey of Czech medical staff. In *Proceedings of the 12th Annual International Bata Conference for Ph.D. Students and Young Researchers (DOKBAT)*, Zlín, Czech Republic, 26 May 2016; Tomas Bata University in Zlín: Zlín, Czech Republic, 2016. [[CrossRef](#)]
107. Coetzee, R.; Van Dyk, L.; Van der Merwe, K. Lean Implementation Strategies: How Are the Toyota Way Principles Addressed? *S. Afr. J. Ind. Eng.* **2016**, *27*, 79–91. [[CrossRef](#)]
108. Laureani, A.; Antony, J. Leadership Characteristics for Lean Six Sigma. *Total Qual. Manag. Bus. Excell.* **2015**, *28*, 405–426. [[CrossRef](#)]
109. Aij, K.H.; Teunissen, M. Lean Leadership Attributes: A Systematic Review of the Literature. *J. Health Organ. Manag.* **2017**, *31*, 713–729. [[CrossRef](#)] [[PubMed](#)]
110. Nowotarski, P.; Paslawski, J.; Wysocki, B. Quality Improvement of Ground Works Process with the Use of Chosen Lean Management Tools—Case Study. *IOP Conf. Ser. Earth Environ. Sci.* **2017**, *95*, 022032. [[CrossRef](#)]
111. Filser, L.D.; da Silva, F.F.; de Oliveira, O.J. State of Research and Future Research Tendencies in Lean Healthcare: A Bibliometric Analysis. *Scientometrics* **2017**, *112*, 799–816. [[CrossRef](#)]
112. Van Dun, D.H.; Hicks, J.N.; Wilderom, C.P.M. Values and Behaviors of Effective Lean Managers: Mixed-Methods Exploratory Research. *Eur. Manag. J.* **2017**, *35*, 174–186. [[CrossRef](#)]
113. Rocha, H.T.; Ferreira, L.P.; Silva, F.J.G. Analysis and Improvement of Processes in the Jewelry Industry. *Procedia Manuf.* **2018**, *17*, 640–646. [[CrossRef](#)]
114. Sousa, E.; Silva, F.J.G.; Ferreira, L.P.; Pereira, M.T.; Gouveia, R.; Silva, R.P. Applying SMED Methodology in Cork Stoppers Production. *Procedia Manuf.* **2018**, *17*, 611–622. [[CrossRef](#)]
115. Makumbe, S.; Hattingh, T.; Plint, N.; Esterhuizen, D. Effectiveness of Using Learning Factories to Impart Lean Principles in Mining Employees. *Procedia Manuf.* **2018**, *23*, 69–74. [[CrossRef](#)]
116. Rosa, C.; Silva, F.J.G.; Ferreira, L.P.; Pereira, T.; Gouveia, R. Establishing Standard Methodologies To Improve The Production Rate Of Assembly Lines Used For Low Added-Value Products. *Procedia Manuf.* **2018**, *17*, 555–562. [[CrossRef](#)]
117. Singh, S.; Dixit, S.; Sahai, S.; Sao, A.; Kalonia, Y.; Kumar, R.S. Key benefits of adopting lean manufacturing principles in Indian construction industry. In *Proceedings of the MATEC Web of Conferences, Chennai, India, 6–7 April 2018*; EDP Sciences: Les Ulis, France; Volume 172, p. 05002. [[CrossRef](#)]
118. Pereira, J.; Silva, F.J.G.; Bastos, J.A.; Ferreira, L.P.; Matias, J.C.O. Application of the A3 Methodology for the Improvement of an Assembly Line. *Procedia Manuf.* **2019**, *38*, 745–754. [[CrossRef](#)]
119. Khan, Z.A.; Ahmad, M.; Butt, S. Implementation of Lean Practices in Banks: A Qualitative Research. *Ind. J. Manag. Prod.* **2019**, *10*, 489–498. [[CrossRef](#)]

120. Azevedo, J.; Sá, J.C.; Ferreira, L.P.; Santos, G.; Cruz, F.M.; Jimenez, G.; Silva, F.J.G. Improvement of Production Line in the Automotive Industry Through Lean Philosophy. *Procedia Manuf.* **2019**, *41*, 1023–1030. [[CrossRef](#)]
121. Morgado, T.L.M.; Sandiães, J.; Navas, H.V.G. TRIZ and Lean Philosophies Applied Together in Management Activities. *Qual. Innov. Prosper.* **2019**, *23*, 90–102. [[CrossRef](#)]
122. Nowotarski, P.; Paslawski, J.; Skwarek, J. Waste Reduction by Lean Construction-Office Building Case Study. *IOP Conf. Ser. Mater. Sci. Eng.* **2019**, *603*, 042061. [[CrossRef](#)]
123. Rotter, T.; Plishka, C.; Lawal, A.; Harrison, L.; Sari, N.; Goodridge, D.; Flynn, R.; Chan, J.; Fiander, M.; Poksinska, B. What Is Lean Management in Health Care? Development of an Operational Definition for a Cochrane Systematic Review. *Eval. Health Prof.* **2019**, *42*, 366–390. [[CrossRef](#)]
124. Issa, U.H.; Alqurashi, M. A Model for Evaluating Causes of Wastes and Lean Implementation in Construction Projects. *J. Civ. Eng. Manag.* **2020**, *26*, 331–342. [[CrossRef](#)]
125. Ömürgönülşen, M.; Eryiğit, C.; Tektaş, Ö.Ö.; Soysal, M. Enhancing the Quality of a Higher Education Course: Quality Function Deployment and Kano Model Integration. *Yükseköğretim Derg.* **2020**, *10*, 312–327. [[CrossRef](#)]
126. Zhiwen, Z.; Xiaoying, Y.; Yujun, X.; Limin, G.; Junxing, L. Supply Chain Logistics Information Quality Evaluation from Just-in-Time Perspective. *IEEE Access* **2020**, *8*, 105728–105743. [[CrossRef](#)]
127. Nedeliakova, E.; Hudakova, M.; Masar, M.; Lizbetinova, L.; Stasiak-Betlejewska, R.; Śulko, P. Sustainability of Railway Undertaking Services with Lean Philosophy in Risk Management—Case Study. *Sustainability* **2020**, *12*, 5298. [[CrossRef](#)]
128. Kowalski, A.; Waszkowski, R.; Ratushnyi, V. The Use of Lean Manufacturing Principles to Improve Production Processes by Better Designing of Assembly Cells. *IOP Conf. Ser. Mater. Sci. Eng.* **2020**, *916*, 012053. [[CrossRef](#)]
129. Martins, R.; Pereira, M.T.; Ferreira, L.P.; Sá, J.C.; Silva, F.J.G. Warehouse Operations Logistics Improvement in a Cork Stopper Factory. *Procedia Manuf.* **2020**, *51*, 1723–1729. [[CrossRef](#)]
130. Morell-Santandreu, O.; Santandreu-Mascarell, C.; Garcia-Sabater, J.J. A Model for the Implementation of Lean Improvements in Healthcare Environments as Applied in a Primary Care Center. *Int. J. Environ Res. Public Health* **2021**, *18*, 2876. [[CrossRef](#)]
131. Gaudenzi, B.; Qazi, A. Assessing Project Risks from a Supply Chain Quality Management (SCQM) Perspective. *Int. J. Qual. Reliab. Manag.* **2021**, *38*, 908–931. [[CrossRef](#)]
132. Ulewicz, R.; Kleszcz, D.; Ulewicz, M. Implementation of Lean Instruments in Ceramics Industries. *Manag. Syst. Prod. Eng.* **2021**, *29*, 203–207. [[CrossRef](#)]
133. Mangaroo-Pillay, M.; Coetzee, R. A Systematic Literature Review (SLR) Comparing Japanese Lean Philosophy and the South African Ubuntu Philosophy. *Int. J. Lean Six Sigma* **2022**, *13*, 118–135. [[CrossRef](#)]
134. Velásquez, M.; Zabala, N.; Neira-Rodado, D.; Baldovino, T.O.; Mercado-Caruso, N. Design of Lean-Based Strategies to Improve the Flow of Materials in the Value Chain of a Furniture Company in Colombia. *Procedia Comput. Sci.* **2022**, *203*, 502–507. [[CrossRef](#)]
135. Keleş, A.E.; Yılmaz, H.K. Investigation of Lean Production Knowledge among Employees in Building Inspection Organizations. *Sustainability* **2022**, *14*, 15142. [[CrossRef](#)]
136. Mangaroo-Pillay, M.; Coetzee, R. Lean Frameworks: A Systematic Literature Review (SLR) Investigating Methods and Design Elements. *J. Ind. Eng. Manag.* **2022**, *15*, 202–214. [[CrossRef](#)]
137. Pawlak, S.; Nowacki, K.; Kania, H. Analysis of the Impact of the 5S Tool and Standardization on the Duration of the Production Process—Case Study. *Prod. Eng. Arch.* **2023**, *29*, 421–427. [[CrossRef](#)]
138. Fuentes, L.B.E.H.; Gardim, L.; da Silva, T.O.; de Moura, A.A.; Bernardes, A. Applying Lean Healthcare in the Hospitalization and Patient Discharge Process: An Integrative Review. *Rev. Bras. Enferm.* **2023**, *76*, e20220751. [[CrossRef](#)]
139. Baskiewicz, N.; Daroń, M.; Pachura, A. Directions of Changes in Healthcare Unit Management from the Patient’s Perspective. *Pol. J. Manag. Stud.* **2023**, *28*, 82–100. [[CrossRef](#)]
140. Vaz, E.; Vieira De Sá, J.C.; Santos, G.; Correia, F.; Ávila, P. The Value of TPM for Portuguese Companies. *J. Qual. Maint. Eng.* **2023**, *29*, 286–312. [[CrossRef](#)]
141. Moso, M.; Olanrewaju, O.A. An Application of Lean Techniques to Construct an Integrated Management Systems Preventive Action Model and Evaluation: Kaizen Projects. *Processes* **2024**, *12*, 1069. [[CrossRef](#)]
142. Alberto, A.; Lima, T.M.; Charrua-Santos, F.; Gaspar, P.D. Assessment of Lean Maturity Levels in Industries of the Luanda Region, Angola. *Appl. Sci.* **2024**, *14*, 6949. [[CrossRef](#)]
143. Rodrigues, I.; Alves, W. Integrating Lean Thinking into Project Management: A Conceptual Model for the IT Sector. *Procedia Comput. Sci.* **2024**, *239*, 1604–1611. [[CrossRef](#)]
144. Al-baldawi, Z.; Kassam, A.H.; Al-Zubaidi, S.S.A. Investigation and Assessment the Level of Adoption Lean Philosophy in SMES Under Uncertainty by EFA/FAHP/FTOPSIS Integrated Model. *Manag. Syst. Prod. Eng.* **2024**, *32*, 280–293. [[CrossRef](#)]
145. Chitiva-Enciso, W.A.; Pérez-Domínguez, L.A.; Romero-López, R.; Luviano-Cruz, D.; Pérez-Olguín, I.J.C.; Méndez-González, L.C. Lean Manufacturing Assessment: Dimensional Analysis with Hesitant Fuzzy Linguistic Term Sets. *Appl. Sci.* **2024**, *14*, 1475. [[CrossRef](#)]

146. Moso, M.; Olanrewaju, O.A. Review of Integrated Management Systems to Re-Engineer Existing Nonconformances Troubleshooting System. *Safety* **2024**, *10*, 58. [[CrossRef](#)]
147. Mandic, J.; Sremcevic, N.; Piaux, J.; Vrhovac, V.; Kucevic, D.; Stankovski, S. Streamlining Construction Operations: A Holistic Approach with A3 Methodology and Lean Principles. *Buildings* **2024**, *14*, 2260. [[CrossRef](#)]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.