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*Review Article*

# Implementation of the Lean Construction Methodology in the Management of the Material Transportation Process- A Review

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***Abstract*** *- One of the biggest problems in the construction industry that often generates delays and loss of value in the construction site are the processes related to the management of material transportation. These processes are decisive in collaborating in the search for greater productivity. Lean Construction (LC), together with its tools and techniques, is a methodology that is being implemented in the sector and whose objective is the identification and elimination of waste on-site. The objective of this work is to analyze the impact of implementing the LC methodology in the construction sector focused on the transportation of materials, as well as to verify the other benefits of the methodology. In this systematic literature review (SLR) work, seven online databases were used to search for scientific manuscripts related to the LC methodology and the materials transportation process; after being analyzed and systematized using the prism methodology and the inclusion and exclusion criteria, 54 manuscripts were selected, seeking to answer the research questions. The results indicate that 21 manuscripts state that the benefits provided by the application and execution of LC are fundamental to ensure the execution and success of the project. Also, LC tools and techniques are essential to improve productivity. Also, the analysis shows that the main challenges are lack of management commitment, lack of willingness to change the culture, lack of skills and lack of training. Finally, the importance of management in the building materials supply chain is demonstrated by identifying the drivers and enablers.*

***Keywords*** *- Lean construction, Lean tools and techniques, Barriers, Productivity, Supply chain.*

## 1. Introduction

The LC Methodology seeks the identification and elimination of waste found on site; all activities that generate high variability and do not generate value to the work should be eliminated from the process; in addition, it should be noted that the LC methodology is increasing in popularity and more and more companies are implementing it; although, in a slower way compared to its impact on other industries [1]–[4]. Countries always looking for innovation in the construction sector, such as China, the United States, Singapore, and Japan, are some of the countries that are at the forefront of using methodologies that improve the productivity and quality of their final products [5]. LC continues to provide evidence of the benefits of its implementation: increased productivity, improved lead times, improved quality, lower costs, and increased customer satisfaction. However, there are barriers that do not allow implementation on a larger scale [6]. A large percentage of construction companies in different countries do not implement it because of the number of resources it demands; there are others that have no real interest in abandoning traditional management processes instead of wanting to adopt the LC methodology [7], [8]. Site productivity is defined as the ratio of a measure of output volume to a measure of the volume of input use [9]. Productivity can be measured at three levels: industry or sector level, project level and activity or process level measurement [10]. Moreover, productivity being a point of critical importance for the construction sector, there are different methodologies for its measurement and analysis; both average labor productivity and average labor productivity consider various problems to evaluate the efficiency of contracting operations [10].

The purpose of this paper is to analyze the impact of the implementation of the LC methodology in the construction sector focused on the transportation of materials, some of its implementation barriers, the verification of its benefits and its impact on productivity. In this work, different SLR articles are analyzed to make comparisons at the productivity level based on the activities related to material transportation and to check the impact that the implementation of the LC methodology generates on the organization, which can be beneficial or challenging to be faced depending on the condition of each project.

Nowadays, there is a notorious change in the typical types of management that positively improves, specifically, the productivity on site. However, the speed of change in traditional management is not as fast as in other industries; it is expected that, based on research and information sharing, a much greater impact can be achieved on a global scale [11], [12]. In [11], LC is defined as an innovative, systematic, and collaborative approach that seeks to maximize waste by reducing waste, continuously improving, and maintaining the production rate as requested or coordinated with the customer. LC is the practical application of Lean Manufacturing to the construction industry to improve production and quality indicators. In addition, the implementation of the combination of LC and BIM methodology for green and sustainable construction in the Architecture, Engineering and Construction, or AEC, industry is studied. The same is studied in the articles [13], [14]. In addition, the role of Lean tools in achieving the objectives of the LC methodology is important. Thus, in [11], some Lean tools found in the systematic literature review are detailed and organized according to the benefits of their use; for example, 5S, LPS, Poke Yoke, and VM have as common benefit waste reduction, error correction and inventory management; color coding, standard signs, visualization boards and BIM, are used for on-site management, timely project completion and variation reduction; Collaborative process mapping, Heijunka and Andon are used for minimal rework, standardized schedules and job site cleanliness; and finally, large rooms, the value-added system and continuous improvement are used to stimulate the workforce to achieve common goals, and the labor force to fully achieve on-time project completion and rework. Among other tools detailed by the author are: A3, off-site manufacturing, JIT, estimation chain mapping, Visual Site, and day-by-day team groups.

Similarly, in [12], additional Lean techniques that are the result of a systematic literature review are detailed, such as recurrent engineering, teamwork, value-based management/transmission mapping, total quality management, VDC, kaizen, 6 sigma, kanban, standardization, Walk to Gemba, among others. They also detail the benefits that are categorized according to the objectives, which can be: economic, in terms of cost, quality and time; social, in terms of relationships and people satisfaction; and environmental. In [15], they classify Lean-type tools into two groups: (1) LC basic technologies, in which we find VSM, TQM, standardization, error checking, JIT, PR (process reengineering, concurrent engineering, visualization, and Lean Six Sigma; and (2) LC key technologies, where we find LPS, LPDS, value and process management techniques, etc.).

In [16], it is identified that the recovery of infrastructure affected by natural disasters is of a complex and dynamic nature, which generates that contractor companies report low returns during its development; therefore, it is proposed to use the LC approach and develop a framework to influence their organizational resilience and; in addition, identify the components that contribute to the effective implementation of Lean recovery and its philosophy in order to justify the proposed conceptual framework. Similarly, in [17], an integrative view of Lean innovation management is conceptualized through a systematic literature review, in which key Lean principles and practices are identified and synthesized within an integrative framework. The research identifies 34 Lean principles and practices relevant to innovation management.

Several researchers have shown important advances in supply chain coordination in construction. It is important to recognize the value of good supply chain logistics for industries; thus, [18] identifies the enablers of supply chain logistics coordination by classifying them into three categories that confirm that the different functions need some level of integration among the stakeholders to accelerate the response and feedback processes. Finally, in [18], additional perspectives are offered to improve supply chain performance. In article [19], Lean principles are applied with a focus on supply chains for the construction sector through a bibliometric analysis showing the current state of research on Lean concepts and the successful development of the LC philosophy. In the article [20], prefabricated housing companies seeking industrialization are at the same time seeking to implement innovative principles and practices with a well-established and validated conceptual basis with a focus on the supply chain.

In [21], 83 possible barriers to LC are identified. Their criticality is assessed through a systematic investigation of scientific manuscripts that allows a more accurate understanding of the challenges to be overcome for a successful LC implementation and helps companies and their professionals to focus their efforts on those obstacles; furthermore, it provides information to project managers, such as managers and personnel managers, to get on the right track towards the successful implementation of the LC framework. The most difficult LC challenges are those related to corporate culture, leadership, employee resilience, ignorance about implementing a new system, and obstacles related to measuring project performance. The barriers that generate a higher probability of failure in the implementation of LC in the sector are also identified: (1) teamwork by obligation and not by commitment. (2) Lack of support from the project management, (3) Immobility of the leaders, (4) Complications to concentrating the client's business ideas, (5) Immobility of the employees, (6) Incompetence to calculate the progress of the Lean project, (7) centralization of decisions, and (8) lack of preparation of the managers to lead the change; six of these barriers are linked to leadership and several of them can be eliminated or reduced through a solid knowledge base construction among those who lead the company. To overcome these barriers, it is essential to modify the culture within the organization. Similarly, in [22], it is determined that the three most important challenges to consider for the implementation of LC are ignorance and lack of understanding of LC, immobility and lack of involvement in project management; the same can be overcome with the enablers identified in the research, within which the three main ones were: the development of the Lean culture, the use of Lean-type tools and techniques, and the active involvement of top management.

## 2. Materials and Methods

The PRISMA methodology is used for the development of this article. This is a statement that benefits authors, editors, and peer reviewers of systematic reviews. It helps researchers to concisely document the information found in the articles or research sources that are related to our developing topic and seeks to make the presentation of publications more transparent, complete, and accurate, to facilitate evidence-based decision-making [23].

The Prisma statement provides a structure that serves as a guide for a more orderly and clear development. It details the steps of the Prisma method:

- Related documents important to our topic are identified.
- Exclude duplicative documents.
- Eligibility analysis is developed.

### *2.1. Research Questions*

At this point, we analyze the current state of the articles and works that investigate the implementation of the Lean Construction methodology to the transportation processes of materials in construction and its impact on the productivity of the work. Based on the above, the research questions (RQ) are made.

The questions for the present research in the systematic review are:

RQ1: What are the benefits of implementing the LC framework?

RQ2: What Lean-type tools or techniques can be used for the improvement of site productivity and material transport process management within an LC framework?

RQ3: What are the challenges or barriers to implementing the LC framework and its tools?

### *2.2. Search Strategy*

The search string used to search for manuscripts that respond to the research variables is presented in Figure 1.

((lean construction methodology) AND (material transportation processes))

**Fig. 1 Search chain of documents related to the research topic**

**Table 1. Inclusion, exclusion, and justification criteria.**

| **Inclusion criteria** | **Justification** |
|---|---|
| Include studies related to the Lean Construction philosophy. | To analyze the contribution it provides to the construction sector and its productivity improvement and to fulfill the objective of this article. |
| Include studies related to the process of transportation and supply of materials for the construction sector | With the purpose of analyzing possible proposals for improving the logistics of construction materials and their impact on the productivity of construction projects. |
| Include studies investigating the challenges of LC application and/or its tools. | To investigate the possible reasons why companies do not implement the methodology. |
| Include studies published in the last 5 years (2019-2023). | Recent research, as up-to-date as possible, the result will be effective and up to date. |
| Articles in a reliable database. | Articles from reliable sources, which will allow an investigation with a truthful result. |
| **Exclusion Criteria** | **Justification** |
| Short documents. | No books, manuals, or similar research will be available. |
| Articles older than 5 years. | Use only recent articles |
| Studies that are not related to the subject matter. | They do not provide arguments to achieve the objective. |
| Very general articles. | They do not provide precise arguments to achieve the objective. |
| Articles in Spanish | Articles in another language are more reliable for research. |

The search string has been used in scientific article databases such as EBSCO Host, Google Scholar, IEEE Xplore, Science Direct, Scopus and Taylor & Francis Online, with the intention of identifying relevant documents through a systematic review matrix in which the necessary filters are used to be able to determine the final documents that will be used for the research.

After obtaining the results with the search string, we went on to validate the scientific documents that do not have direct correspondence with the objective of the research. Therefore, according to the Prisma statement, we applied the inclusion and exclusion criteria to select the relevant documents for the research, as presented in Table 1.

The PRISMA procedure is then applied, as shown in Figure 2, which shows the four phases of the scientific article selection process used to develop this work. In the first phase, duplicate articles found in the search of the seven databases were eliminated. The reduction was of two articles, leaving 309 articles. In the second phase, all the articles were analyzed, and those that did not meet the inclusion criteria were eliminated by reviewing their abstracts, resulting in 220 articles that were not included in the research and 89 articles that remained to be evaluated. In the third phase, eligibility or suitability, 35 articles were excluded for not being directly related to the research questions or for being very general in their topic of development. Finally, in phase 4, the inclusion stage, we have, as a result, the 54 articles that will be considered in the research.

## 3. Results

This section develops the bibliometric analysis and a more in-depth analysis of the works detailed above. First, Figure 3 shows the relationships between the most common terms with respect to the management of occurrences and the visualization of density. It also analyzes some of the Lean-type methodological frameworks, researched and proposed by different scholars and experts on the subject, which have been proposed for implementing the LC philosophy and its tools in various conditions and locations with the aim of increasing production in the projects being executed.

### 3.1. Bibliometric Analysis

The VOSviewer application is used, which according to [24], is a software that allows the construction and visualization of bibliometric networks between journals, researchers, or individual publications and from a base of information such as citations, bibliographic linkage, co-citation, or co-authorship. This tool provided valuable visual information that allows us to see the relationship between the keywords associated with the management of occurrences on implementing the Lean methodology for materials management processes in construction. In the same way, it helps to identify the benefits, Lean-type techniques or tools and implementation barriers and organizes them according to their relevance by clusters. Figure 3 shows the bibliometric map that shows the network of relationships between the most used terms and how they are linked to each other. The largest point or node indicates the most used terminology among the articles reviewed; in addition, the t-size represents the number of times these words appear in the review articles. The analysis was performed on the title and abstract using a binary re-counting method of 180 keywords examined with a minimum threshold of 1 occurrence, resulting in 180 terminologies.

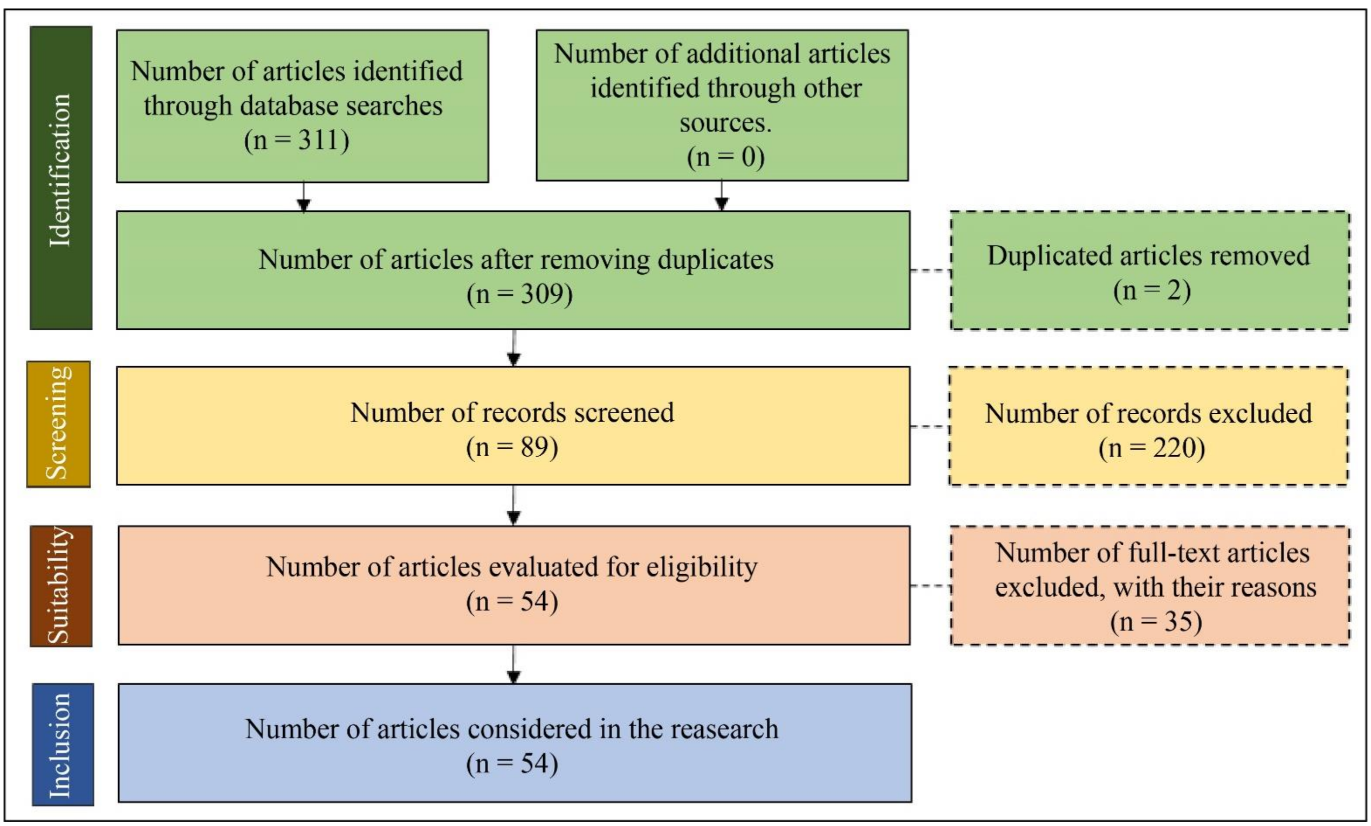


**Fig. 2 Scientific article selection process according to PRISMA methodology**

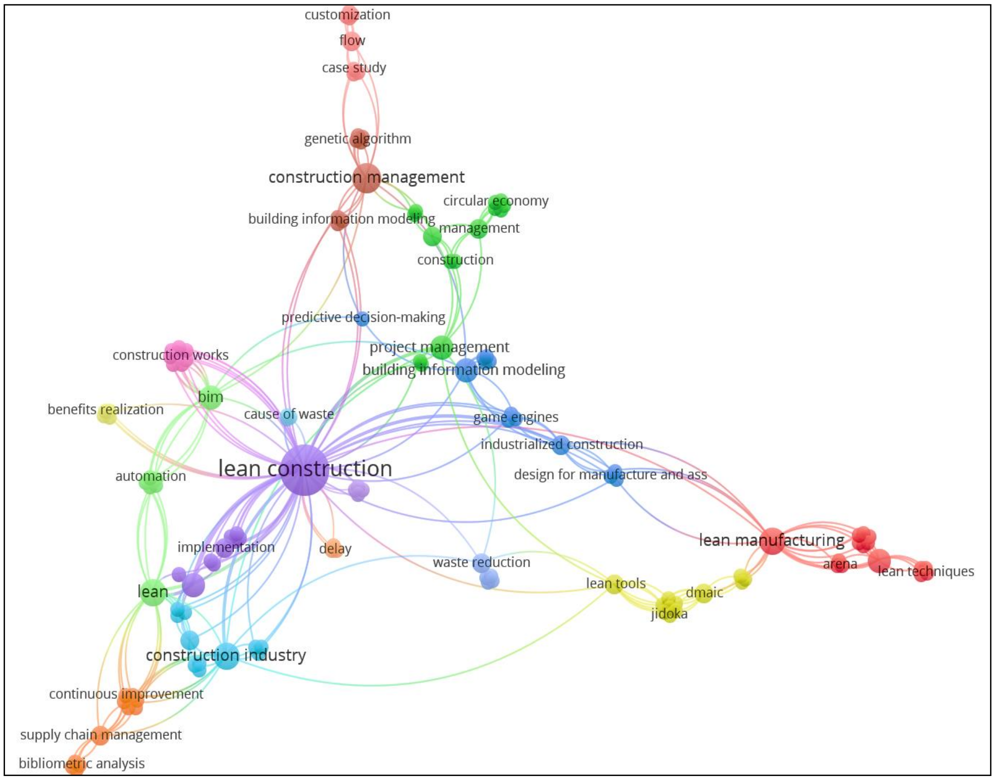


**Fig. 3 Bibliometric map of relationships among common terms**

The colors represent each cluster in the network map and bring together certain common terms, which are evidenced by their number of occurrences; thus, for this particular case, we have (1) the purple cluster, which contains the term "LC", among other terms and with 16 occurrences within the 16 clusters, which identifies the program; (2) the brown cluster, which contains the term "Construction management", among other terms and with 5 occurrences. With 4 occurrences, we have the terms "Lean manufacturing", "Construction Industry", and "Lean" in clusters (3) red, (4) light blue and (5) light green, respectively and among other terms. With 3 occurrences, we have the terms "Project management" and "Building Information Modeling", among other terms and from clusters (6) dark green and (7) blue. With 2 occurrences, we have the terms: "Lean tools", "Supply chain management", "Flow", and "waste reduction", among other terms, in clusters (8) lime green, (9) orange, (10) light red and (11) light blue. With 1 occurrence, we have "Construction work", "Benefits realization", "Collaboration", "Cause of waste", and "Delay", among other terms and in clusters (12) pink, (13) light lime green, (14) light purple, (15) light blue and (16) light brown respectively. It is possible to appreciate all the relationships between the most used terms found in the review articles.

Also, we observe in Figure 4 the density map of the documents to identify the keywords in the articles reviewed which have a recurrence and which, in addition, are related to the bibliometric analysis database.

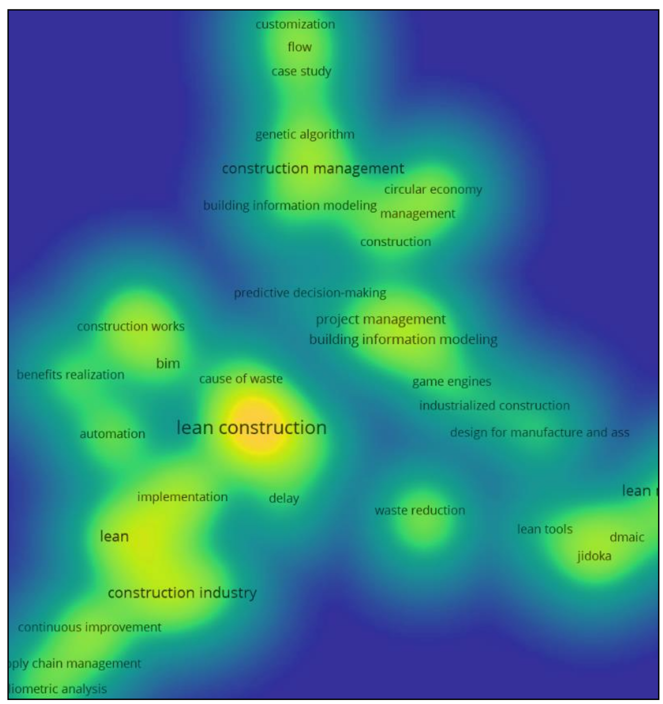


**Fig. 4 Density map of the relationships between common terms**

From the analysis of Figures 3 and 4, each cluster's key terms and their occurrence levels are identified. Figure 5 shows each of the terms with the number of occurrences according to this analysis.

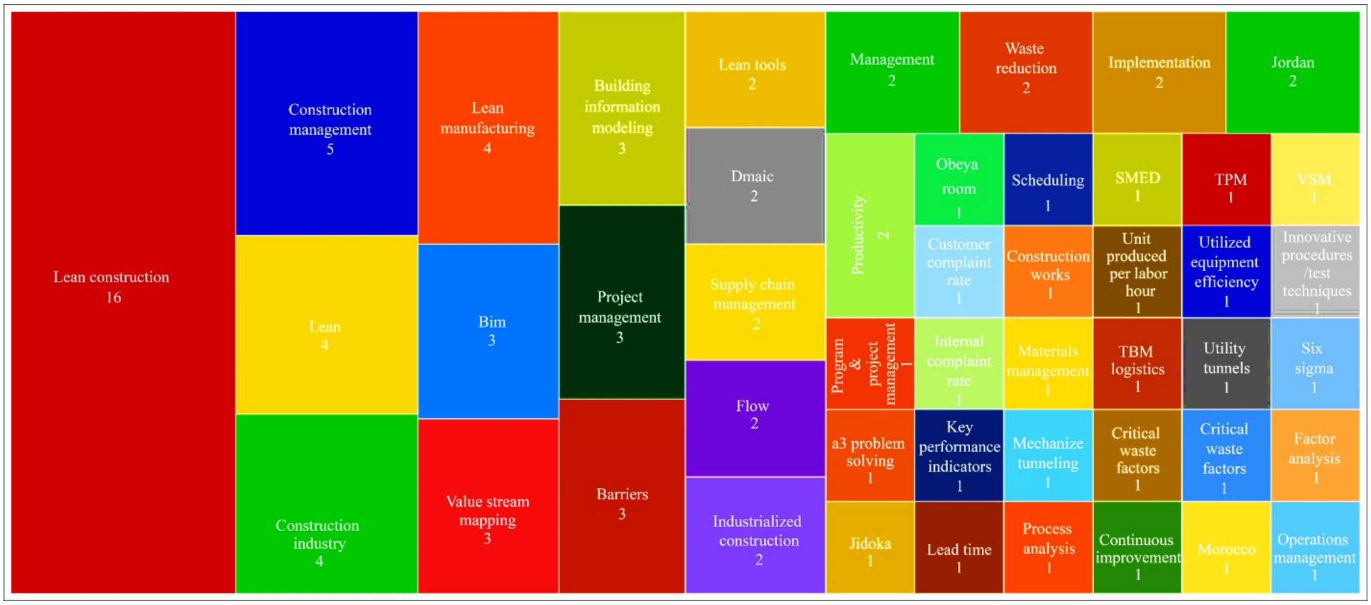

**Fig. 5 Number of occurrences per keyword**

### 3.2. Manuscript Analysis

Seven databases were used to obtain the manuscripts of the results. The initial number of articles found was 311, and after applying certain exclusion and purification criteria, 56 articles were found. Then, 2 duplicate articles were eliminated. Finally, we have, as a result, 54 articles, as shown in Figure 6.

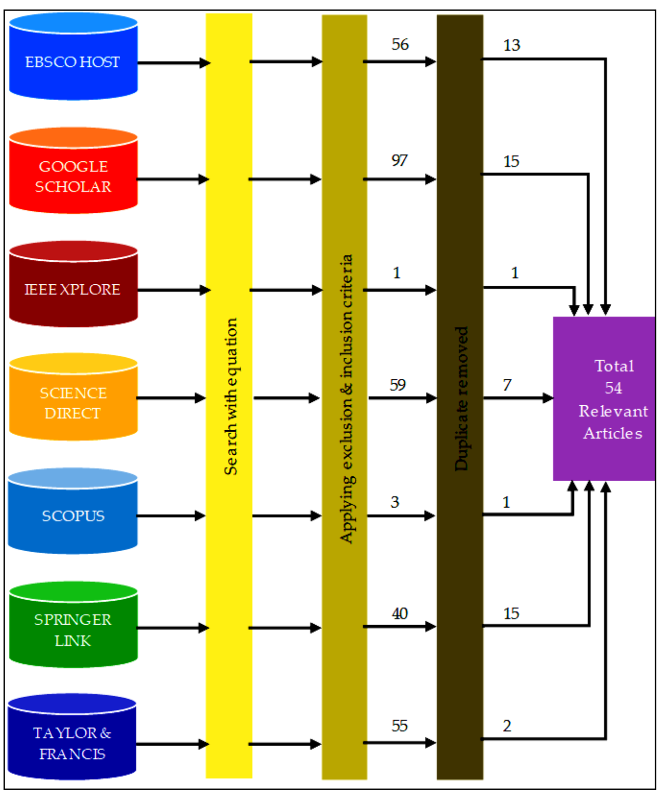

**Fig. 6 Graph of results obtained in the search.**

Figure 7 identifies the percentage of information contribution by each of the databases. The three databases with the highest contribution are Springer Link, Google Scholar, and EBSCO Host, with a contribution of 28%, 28% and 24%, respectively. They are followed by Science Direct, Taylor & Francis, Scopus and IEEE Xplore with 13%, 3%, 2% and 2%, respectively.

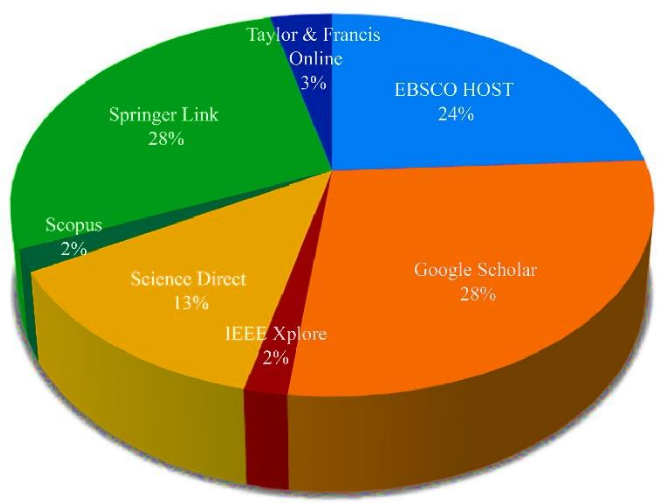

**Fig. 7 Graph of results obtained in the search**

Figure 8 shows the 3 phases of the Prisma methodology for each of the databases and the number of relevant articles selected for each of the databases. Phase 1, in light blue, represents the results of the initial search. Phase 2, in orange, after applying the inclusion and exclusion criteria, shows the resulting articles. Finally, phase 3, in fuchsia, eliminates duplicates and provides the 54 final relevant articles.

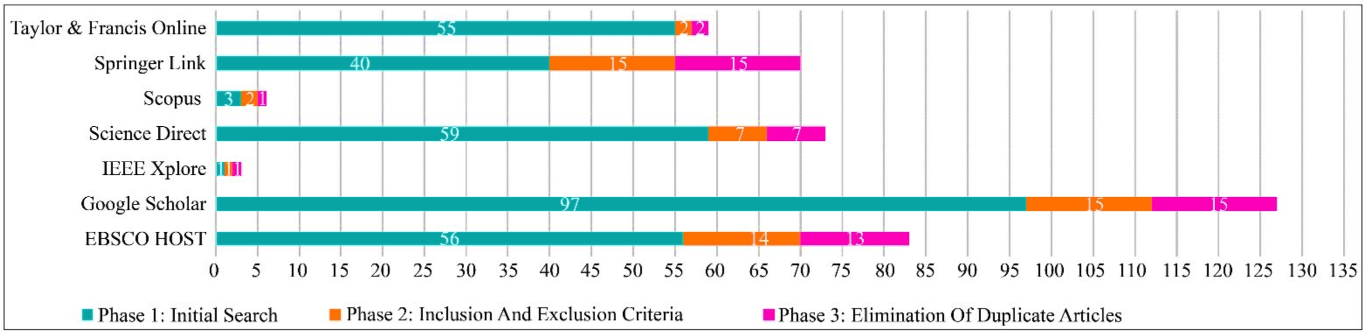


**Fig. 8 Manuscripts in the stages of the prisma methodology**

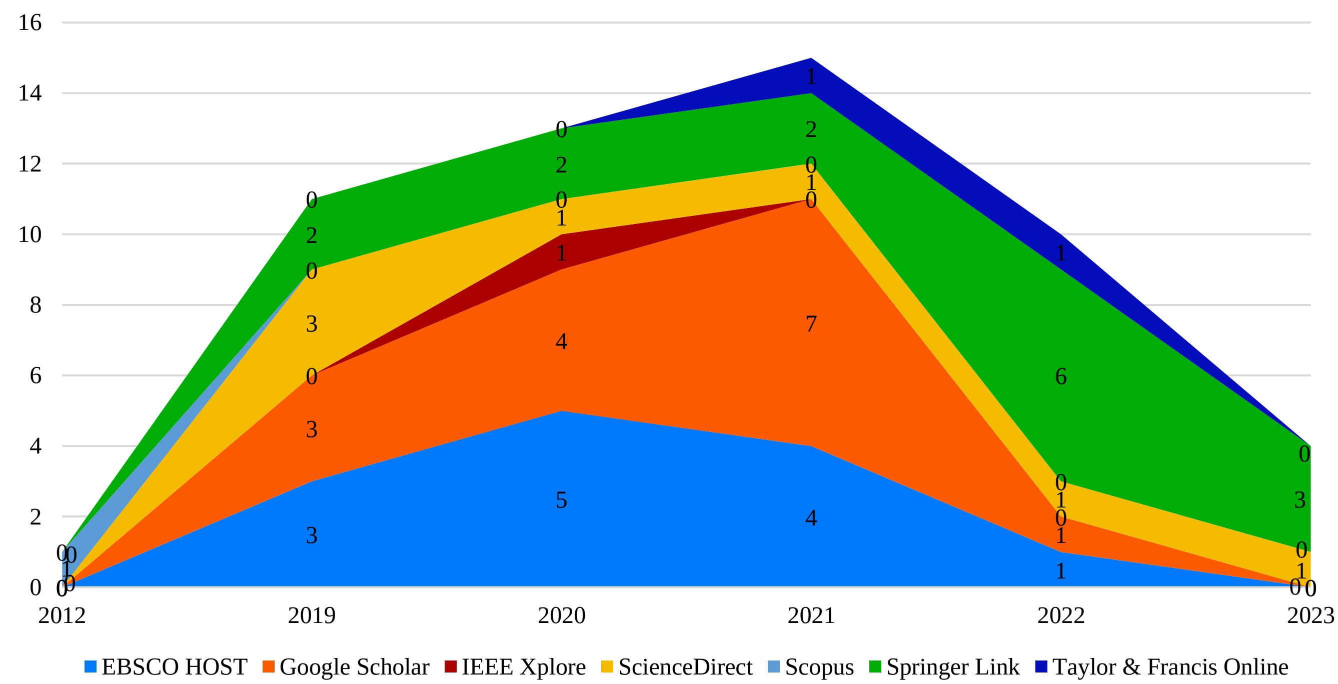


**Fig. 9 Manuscripts Published Year and its Database**

Figure 9 shows the graph on the publication of manuscripts by year of publication and by the database to which it belongs. The largest number of manuscripts were published between 2019 and 2022 and were from EBSCO HOST and Google Scholar.

## 4. Discussion

### *4.1. RQ1: What are the Benefits of Implementing the LC Framework?*

In the present research, it is determined that the implementation of LC and its tools generate remarkable benefits against those problems that affect productivity in construction. Furthermore, it is necessary to develop a scientific methodology in which all those involved with some interest in the project intervene, thus seeking a collaborative development of the work to achieve the benefits of LC, as the authors in the works [12], [13], [16], [17] concluded in the same sense with respect to the benefits and opportunities generated by the LC framework. It is also proven that implementing the LC framework together with using different tools helps achieve the objectives more effectively and thus achieve the benefits of its implementation; this is also agreed in [13], [14]. In this SLR, a dominant pattern is found for implementing the LC framework: it starts with reviewing existing literature.

It continues with the formulation and implementation of some surveys, questionnaires, or interviews with experts in the field to accumulate information on the state of awareness of the LC framework in the area to be implemented. The results obtained are then analyzed, and finally, conclusions and recommendations are issued for implementing LC in the organization. Table 2 presents a categorization of the benefits of implementing the LC framework in the construction sector found in this review.

### *4.2. RQ2: What Lean-type Tools or Techniques can be used for the Improvement of Site Productivity and Material Transport Process Management within an LC Framework?*

This article identifies that Lean tools improve quality, increase safety, reduce project time, and make efficient use of resources. It is also concluded that the trend of applying the LC framework together with applying different Lean techniques and tools for the construction sector improves the competitiveness and productivity of buildings. Trends such as technological support through the Six Sigma methodology also need as requirements for developing LPS and LPSD technologies because they allow the integration of new tools. In the same way, integrating different methodologies or tools is presented; for example, developing a BIM methodology within an LC framework, similarly agreed in [11] and [15]. In addition, it is identified that some coordination enablers allow the good development of supply chain logistics to achieve better performance within the construction sector, in the same way, researchers study them in articles [18]–[20]. The implementation and utilization of LC techniques and tools collaborate for the improvement of the management of material transportation processes, supply chain management and as well as, the processes in the design, construction, and operability stage of the building; in the same way, it is concluded in [15]. Table 3 presents the Lean techniques and tools found in this systematic literature review.

**Table 2. Benefits of implementing the LC methodology**

| # | Lean Construction Benefits | Quantity | Reference |
|---|---|---|---|
| 1 | Improved Quality | 2 | [25]– [30] |
| 2 | Improved Safety | 2 | [25]– [29] |
| 3 | Increases productivity and improves customer satisfaction | 2 | [25]– [32] |
| 4 | Reduces construction costs | 3 | [27]– [31], [33] |
| 5 | Reduces construction time | 4 | [26]– [29], [31], [34] |
| 6 | Reduces environmental impacts | 4 | [27]– [29], [35], [36] |
| 7 | Improves sustainability | 4 | [27], [28], [36], [37],[83] |

**Table 3. Lean-type techniques or tools that improve the management of material transport processes**

| # | LC Techniques / Tools | Brief Description | Quantity | Reference |
|---|---|---|---|---|
| 1 | 5S | It refers to Seiri, Seiso, seiton, Seiketsu and Shitsuke; which means Order, Straighten, Shine, Standardize and Sustain. | 5 | [25], [28], [29], [39]–[41] |
| 2 | Just in time | It helps to reduce production flow time. In addition, it reduces the response time of suppliers. | 8 | [25], [28], [29], [36], [39], [40], [42]–[46] |
| 3 | PDCA | It is a process that helps to improve production methods and designs. Its acronym stands for; Plan, Do, Check, and Act. | 1 | [25] |
| 4 | Six Sigma | It is a method that contains techniques that help to improve quality, seeking to eliminate defects and minimizing changes in the construction process. | 3 | [28], [31], [39] |
| 5 | Pareto analysis | It consists of using the bar chart to identify the level of a process or situation visually. | 2 | [28], [29] |
| 6 | Last Planner System | The LPS seeks to carry out processes in a collaborative manner in order to control the flow and reduce errors in projects. | 9 | [25], [27]–[29], [31], [36], [40], [41], [44],[47] |
| 7 | Kaizen | It is a continuous improvement process used to improve quality and efficiency. | 5 | [28], [29], [36], [39], [51] |
| 8 | Kanban | It is a system that helps to regulate and control the output of materials in an orderly manner. | 6 | [29], [32], [36], [44], [51], [52] |
| 9 | FMEA | It is a process that helps to identify potential flaws in a product or design and manufacture. | 11 | [29] |
| 10 | Ishikawa diagram | The Ishikawa diagram is a tool that helps to identify the root cause and solve the real problem quickly. | 3 | [29], [36], [41] |

| | | | | |
|---|---|---|---|---|
| 11 | Value stream mapping | It is a method that helps to improve any process flow, analyzing and documenting. | 6 | [25], [28], [29], [44], [53], [54] |
| 12 | Poka-yoke | It is a technique used for quality management, and it consists of detecting errors and defects to obtain a good process. | 4 | [28], [29], [36], [41] |
| 13 | First run studies | A tool that helps to test a process with a stated objective. | 1 | [40] |
| 14 | Visual management | Helps improve communication by means of visual information panels. | 5 | [25], [28], [36], [39], [41] |
| 15 | Total Quality Management | The methodology integrates all the functions of the organization to guarantee the fulfillment of objectives. | 2 | [41], [45] |
| 16 | 5 Whys | It is a technique that seeks to eliminate a problem or risk by finding the root cause to avoid its recurrence. | 6 | [28], [29], [32], [36], [41], [46] |
| 17 | Work standardization | It is a technique for producing documents that help capture best practices. | 7 | [28], [29], [31], [36], [39], [48], [82] |
| 18 | Waste elimination | Seeks to raise employee awareness to eliminate all types of waste, such as overproduction, quality defects, unnecessary transportation, etc. | 10 | [25], [27], [29], [31], [39], [41], [45], [51], [56]–[60] |
| 19 | Fail-safe for quality | It is like Poka-Yoke but also looks at security management. | 1 | [40] |
| 20 | Continuous improvement | It allows to improve the process, quality, supply-demand, equipment performance, etc. | 1 | [61] |
| 21 | Prefabrication | Helps eliminate the problems of waste, low quality, low productivity, high variability, and poor safety. | 6 | [25], [28], [29], [46], [62],[63],[65],[66],[81] |
| 22 | Daily huddle meetings | Daily meetings are important for greater worker participation by gaining awareness and contributing to solving problems. | 2 | [29], [40] |
| 23 | Go To Gemba | It allows us to know the current condition of the organization and identifies the problems with the people involved in order to provide an improved solution proposal. | 2 | [39], [51] |
| 24 | Simulation of discrete events | Tool that allows us to simulate the behavior and performance of real-world processes. | 4 | [50], [65], [67], [68] |
| 25 | Takt Production | Stabilizes the pace of work and standardizes processes. | 3 | [36], [48], [69] |
| 26 | reengineered of processes | Develops a model for measuring workflow reliability | 1 | [45] |
| 27 | DMAIC | "Define, measure, analyze, improve, control". Methodology that improves processes | 1 | [39] |
| 28 | Yokoten | Japanese word meaning: "Share the best practice". | 2 | [28], [39] |
| 29 | SMED | "Single Minute Exchange of Dies. It is a tool to implement changes in a fast way. | 3 | [28], [32], [39] |
| 30 | Heijunka | Mixed production system - production level. | 1 | [39] |
| 31 | Chalk circle exercise | 7 principles with Lean fundamentals that minimize the waste process. | 1 | [70] |
| 32 | Total Productive Maintenance | Increases operating time. | 2 | [28], [29] |
| 33 | Target Value Design | Increase in value | 2 | [25], [27]–[29] |
| 34 | BIM – Building Information Modeling | Lean design tool for construction that is based on information-based design. | 11 | [25], [28], [31], [36], [44], [45], [48]–[51], [62], [71]–[74] |
| 35 | Increased Visualization | Tool that conveys key information to stakeholders improving workflow. | 2 | [36], [40] |
| 36 | Working environment in the construction industry | A tool that ensures the management of occupational safety and health. | 1 | [29] |

### *4.3. RQ3: What are the Challenges or Barriers to Implementing the LC Framework and its Tools?*

During the SLR, the challenges and barriers to the implementation of the LC framework in the construction sector were identified; some challenges and barriers are presented in Table 4. In addition, in this work, it is concluded that the most important challenges, and in reference to Table 4, are: 4) Lack of management commitment; 8) Lack of clarity in client requests; 20) Insufficient financial resources; 28) Lack of technical knowledge of Lean techniques; 30) Inherently knowledge-intensive; 33) Lack of incentives, motivation, and low professional salaries, in equal magnitude is concluded and determined in [21], [22]. Within the research, we found different reasons, in different geographical locations, in developed, developing and underdeveloped countries; for which the companies specialized in the field do not achieve or, in some cases, do not initiate the implementation of the Lean methodology. Table 4 presents the challenges or barriers to the implementation of the LC framework that have been encountered in this SLR.

**Table 4. Challenges for the implementation of the lean construction methodology**

| # | Challenges to the Implementation of Lean Construction | Quantity | Reference |
|---|---|---|---|
| 1 | Slow decisions in the manufacturing process by the executive. | 1 | [75] |
| 2 | Problems with human attitude in the organization | 2 | [40], [75] |
| 3 | Inadequate pre-planning | 3 | [41], [75], [76] |
| 4 | Lack of management commitment | 4 | [40], [75]–[78] |
| 5 | Lack of standardization; Individual responsibilities not clearly assigned; Lack of teamwork; Lack of commitment of execution specialists during the design process; Uncertainty in production processes; Lack of individual development measure and reward and motivation system; Lack of willingness to change the existing culture; Lack of technological adaptation; Labor shortage; End-user preference; No customer and supplier involvement; Lack of agreement for LC methodology application; Low bid prices; Lack of durability in performance measurement system; Long implementation period of Lean principles. Lack of customer satisfaction measurement system; Use of non-standardized components; Predominance of traditional management. | 1 | [75] |
| 6 | Ineffective communication among project stakeholders | 3 | [33], [41], [75] |
| 7 | Lack of government support | 3 | [75], [76], [78] |
| 8 | Lack of clarity in client requests | 2 | [75], [76] |
| 9 | Unfavorable culture within the organization | 2 | [33], [75] |
| 10 | Additional costs and high inflation rates | 2 | [75], [76] |
| 11 | Traditional design approach | 3 | [33], [75], [76] |
| 12 | Unclear project definition and work specification | 2 | [75], [76] |
| 13 | Poor resource management | 2 | [28], [75] |
| 14 | Lack of strategy and long-term relationship with the supplier | 3 | [33], [75], [76] |
| 15 | Supply chain uncertainty (delays and shortages) | 3 | [34], [75], [76] |
| 15 | Lack of Lean skills, training, and techniques | 3 | [33], [34], [75] |
| 17 | Extensive use of subcontractors | 2 | [33], [75] |
| 18 | Natural and fragmented construction project cycle | 2 | [75], [76] |
| 19 | Deficiency in skills and advanced technical knowledge | 3 | [30], [33], [75] |
| 20 | Insufficient financial resources | 2 | [30], [75] |
| 21 | Lack of awareness of Lean construction | 3 | [33], [75], [79] |
| 22 | Incomplete and complex designs | 2 | [75], [76] |
| 23 | Ineffective waste management | 2 | [41], [75] |

| | | | |
|---|---|---|---|
| 24 | Insufficient training for workers | 2 | [76], [77] |
| 25 | Insufficient management skills | 2 | [33], [76] |
| 26 | Difficulty in understanding LC concepts | 2 | [33], [76] |
| 27 | Lack of knowledge of LC | 3 | [33], [77]–[79] |
| 28 | Lack of technical knowledge of Lean techniques | 2 | [33], [76] |
| 29 | Lack of understanding of LC approaches | 2 | [33], [77] |
| 30 | Inherently knowledge-intensive; Takes time to adopt LC; Poor organizational knowledge; Difficulty of processes within an LC framework; Lack of appropriate policies; Poor culture among project partners; Acceptance of waste as inevitable. An organization without Lean culture. Little use of Design and Build. Lack of adequate training. Lack of awareness of the need for LC application. | 2 | [33] |
| 31 | Lack of involvement and transparency among stakeholders; Management resistance to change. Results are not rapid and may not meet management's high expectations. The reluctance of project participants to share risks. Centralized decision-making, avoidance of decision making and assumption of responsibility by those not in top management. Hierarchies in organizational structures. Inadequate organizational structure. | 2 | [76], [77] |
| 32 | Lack of a long-term philosophy and planning. | 2 | [76], [77] |
| 33 | Lack of incentives, motivation, and low professional salaries. | 2 | [76], [77] |
| 34 | Inadequate management of the information necessary to generate a learning cycle and take corrective actions. Lack of waste identification and control. Unskilled labor and low educational level of the site foreman. High labor turnover. Limited use of off-site construction techniques and lack of prefabrication. Lack of integrated procurement. Strict requirements and approvals during contracting. | 2 | [76], [77] |

## 5. Conclusion

The different articles studied in this SLR work present a positive scenario in favor of implementing a framework particularly based on the LC philosophy and which, moreover, is developed in the construction industry sector. The different manuscripts present in their research similar benefits because of the implementation of LC, its techniques and tools. It is important to develop and implement Lean techniques to ensure the planned and planned objectives. Those tools are the best means we can use in our management based on LC. The importance of Lean management with a focus on the supply chain of construction materials for the industry is demonstrated by identifying the facilitators of coordination to achieve the most appropriate logistics and those positive impacts that achieve an improvement in the performance of the supply chain while improving productivity on site.

Similarly, this research highlights the barriers or challenges faced by companies in the industry in implementing LC and its techniques. The success of implementing the LC framework is directly related to the knowledge of the barriers to its implementation for professionals or entrepreneurs who seek it. Finally, in conclusion, it is determined that implementing an LC framework and supply chain approach to improve material transportation processes yields positive results for improved performance, productivity, resource utilisation, time, construction costs, and customer satisfaction. Asia, as a continent, leads the research list with 23 articles, showing the highest research interest and development, followed by Europe with 13 articles. India leads the list at the country level with 8 articles, followed by China with 4 articles. The level of research developed in America and Africa with respect to the subject of this research is still low. In addition, the present work seeks to continue with the development of research that will allow us to explore and experiment more with the principles of the Lean philosophy and the implementation of LC and its techniques within the context of the supply chain. In the same way, it contributes to the continuation of the advances in the studies of the implementation of the LC framework with a focus on the supply chain in construction.

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