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SUSTAINABLE SUPPLY CHAIN MANAGEMENT IN CONSTRUCTION: AN EXPLORATORY REVIEW FOR FUTURE RESEARCH

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Abstract. Although the importance of supply chain management in the construction sector has been recognized in recent years, its implementation still faces significant challenges. For the long-term evaluation of this creative sector, numerous intricate sustainability components, such as environmental, social, and financial, are necessary. The study focuses on long-term sustainability considerations in the supply chain in the construction sector. This work aims to address this information and examine sustainable supply chain management (SSCM) research in the construction sector in this manner. More than 95 publications were studied from the beginning of 2017 to the end of 2021 using both in-depth content analysis and bibliometric methodologies. Several issues of SSCM in construction have been found including environmental, economic and social patterns which are most commonly known as the triple bottom line, typically enhanced by artificial intelligence. Many challenges were discovered including inefficiencies in the logistics system and a shortage of funding, environmental issues in demolition procedures and difficulties in applying sustainability measures due to high skill, data, and time requirements. The article offers a broad list of potentials for improving the current situation in the construction sector by using various types of supply chains such as increasing investment in energy conservation and emission reduction technologies to drive sustainable development, establishing strong green supply chain relationships, and forming a Covid-19 financial support group for small construction companies among other things. The study's findings suggested that due to the significance of long-term relationships between construction companies, suppliers and customers, smart technology could make it simpler to reach every supply chain link. After an exhaustive literature review 59 research questions were formulated for the future research. In the future, the importance of these questions could be determined using expert questionnaires and multi-criteria evaluation.

Keywords: construction industry, supply chain management, construction supply chain, research questions, logistics, sustainable construction, systematic review.

Introduction

The relevance of supply chain management (SCM) is increasingly recognized in the construction industry. However, its implementation has been limited and remains a challenge for researchers and practitioners (Studer & De Brito Mello, 2021). Advancements within the construction industry are slowly acknowledged (Masood et al., 2022), although sustainability is commonly used. Analysts considering supply chain (SC) and management state that the execution of local and holistic supply chains could be better if the conjuncture relations and forms between companies are effectively managed (Chandra & Kumar, 2000; Mentzer et al., 2001; Amiri et al., 2021).

SSCM can be defined as an effective and efficient management of linked social, economic and environmental aspects in the construction and maintenance of global supply chains. SSCM promotes governance techniques which decrease waste and assure long-term maintainability. It provides economic value of social and environmen-

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tal well-being for all stakeholders involved in the creation and delivery of products and services at all levels of their lifecycles. The application of sustainable supply chain management (SSCM) in construction companies decreases the environmental effect, decreases the hazard of failure and increases the competitiveness of construction companies (Suhi et al., 2019). The management perspective and its significance are often ignored; it determines a construction project's included value (Kivilä et al., 2017).

The construction supply chain includes contractors, producers, building materials providers, builders and engineers, the client (customer), as well as individuals, carriers, and other intermediaries who provide warehouse administration. All of the entities of SC in the construction are interconnected by joins of finance, data and materials, but not all are required in each part of the chain (Brix-Asala et al., 2018; Blengini & Shields, 2010).

Due to the activities of the entity, the clients are required to decide the structure of the construction supply chain (Goyal et al., 2018). The supply chain is treated as a chain of events and cannot be observed for a single step or stage; the SC must be treated as a network (Carter & Rogers, 2008; Moktadir et al., 2021; Heidary Dahooie et al., 2020; Zhang & Yu, 2021). A builder can get materials from different providers and exchange his items with numerous affiliates and intermediaries. SSCM emphasises a more extensive range of activities for SC directors and companies as this requires the improvement and execution of the arrangements to make strides in the environmental, financial and social administration of the accomplices (Goel et al., 2020). In common, the SSCM covers four areas: (1) data, items, and money-related administration; (2) administration of financial and social variables; (3) innovation and new project management (Iqbal et al., 2020); and (4) partner governance (Bastas & Liyanage, 2018a).

To satisfy the growing demands of construction clients, some actions must be taken to optimise logistics and building processes as current methodologies and tools are inefficient, not secure enough and unreliable (Yan et al., 2019). To remain competitive, construction companies must investigate the noteworthy potential of integrated computer innovations, artificial intelligence (AI), such as the Internet of Things (IoT), blockchain technology, etc. to address the challenge of consumer requests and administrative standards and realize trade openings through the operational efficiency (Rejeb et al., 2020; Sindhwani et al., 2022; Bakhtiarizadeh et al., 2021).

Tiwari et al. (2014) conducted a literature review to assess the current level of SCM research in the construction industry. The review showed that researchers were interested in building and studying diverse decision-making approaches and issues including supply chain coordination and collaboration. Scholars have also examined the importance of material and information flows and the applicability of SCM in some geographic regions. Notwithstanding such accomplishments, it was found that most studies emphasise analyzing certain sections and fall short of establishing a holistic solution.

In this manner, this article aims to fulfil an in-depth survey of the possibilities and challenges of SSCM in the construction field, give a comprehensive picture of what has been scholastically achieved within the sphere to date, and distinguish ranges for further investigation. Furthermore, the Research Questions will be formulated and provided according to the potentials and challenges found in the SSCM in the construction sector within 2017 and 2021. This article will provide an in-depth review that is very needed in the scientific literature for other members of the construction industry related to sustainability and supply chain clusters. The scope of this research is to broaden current conceptual knowledge and theoretical boundaries as scholarly and practical interest in SSCM in the construction sector grows. Some prospective innovative concepts are investigated in this research which may give additional theoretical perspectives for SSCM in the construction industry. This research develops a continuous SSCM framework as conceptual questions for the future research with theoretical limits from existing and emerging theories added. In the future, this review article could be expanded as more research is needed to assess the importance of the Research Questions assuming that their importance is not equal.

First, a description of the methodology is given for the collection and review of references. To examine the content of the connection between the scientific articles, bibliometric indicators were used to link author-supplied keywords. The first section contains a descriptive analysis of the selected papers and conclusions, organised by the framework's subject categories. The findings section gives a broad interpretation of the results taking into the account the additional information, also, justifying information using 3 different forms of classification of SSCM: the 4-area classification, the Triple Bottom Line (of social, environmental and economic) and the different coloured clusters identified using VOSviewer. The discussion section highlights the challenges and potential of SSCM in the construction sector with a research agenda. Also, 59 research questions are presented for each challenge and potential found in the scientific papers. Finally, conclusions and limitations of the study are offered.

1. Materials and methods

A systematic literature review (SLR) can develop a reliable knowledge base. Implementing an SLR involves following a complex process to ensure a more thorough and unbiased search with more transparent, trustworthy and reproducible results. The protocol's implementation is outlined below. In this case, in order to find the main SSCM clusters in the construction, PRISMA flow method (Page et al., 2021) based on the rules, proposed by Amirkhani et al. (2021), was performed. According to the researchers, five main development stages can be defined (Figure 1): to design the study (stage one); to collect the data (stage two), to analyse and disseminate the data using meta-search (stage three), elimination of the duplications, an analysis of abstracts and a full paper analysis, a visualisa-

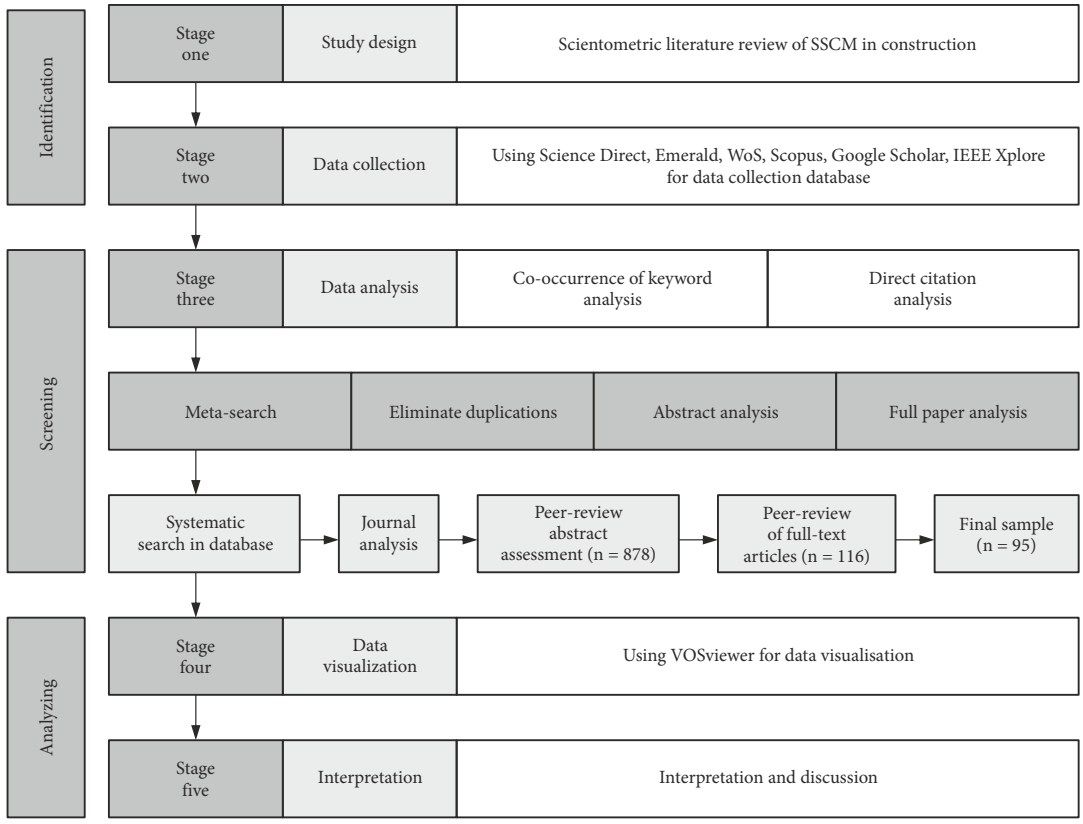

Figure 1. Stages of systematic literature of SSCM in construction industry (compiled by the author using PRISMA method)

tion of the collected data (stage four), the interpretation of the data and the summarisation the discussion (stage five). The objective of PRISMA is to gather significant thoughts, synthesize findings and survey the state of scholastic information regarding a specific research address or a theme (Amirkhani et al., 2021).

The orderly approach to determination is ruled by processes which reduce bias, minimise mistakes which could occur during the research and guarantee scientific thoroughness (Tranfield et al., 2003; Petticrew & Roberts, 2006). To better understand the innovations related to SSCM in construction, this article undertakes a SLR that identifies problems, compares the content and proposals of relevant scientific articles and examines how these approaches benefit the construction sector. Different search phrases were evaluated before settling on the final one for screening articles based on content. To begin, brainstorming was used to develop keywords relevant to theory and strategy. Then, using the snowball technique, new keywords were added to the preliminary review of records, yielding the following list of keywords: "supply chain", "logistics", "triple bottom line", "sustainability", "potentials" and "challenges". Finally, the search phrase included the terms 'supply chain management" and "construction" in addition to the keywords listed above. The data was evaluated using several categorisation parameters, as shown of Figure 1 in the PRISMA flow diagram (Page et al., 2021). The initial categorisation criteria confined the search to peer-reviewed journal articles written in English that were published by the end of 2021.

1.1. Planning the review

One of the main goals of this article was to summarise all creative approaches which have been published and to identify the key clusters of SC sustainability (or shorter, SSC) in the construction sector with a focus on current policies in use around the world. In this way, this article included all of the researches in the construction field which dealt with sustainable supply chain management or related to sustainability in building supply chains, meaning that the review relates to all SCM research in construction sector, including SSCM in the years between the beginning of 2017 and the end of 2021. Previous studies which did not discuss SC from the perspective of sustainable construction were not included in the analysis and were considered beyond the scope.

1.2. Conducting the review

For this study, the information from research publications was gathered from several online databases, including Science Direct (Elsevier), Emerald, Google Scholar, Web of Science (WoS) and IEEE Xplore. Given that SSCM in the construction industry is a quickly evolving and a relatively new research subject, it is critical to cover as many prospective studies as possible in this publication. The research topic was divided into two groups, the first of which focused on terms like "sustainable supply chain management", "supply chain", "sustainability indicators", "big data", and "smart risk management". The second

group contained the strings "construction" and "construction industry".

The key objective was to conduct a study of the scientific literature on SSCM in the construction industry by combining the main strings of the introductions, titles, keywords and abstracts of works. Google Scholar addressed the databases' limited output. Nonetheless, it was used to enable a full-text search of a number of reports that aren't commonly discovered in established scientific databases like Scopus. Google Scholar is more than just an article citation index; it also lists papers from a variety of commercial publisher websites, institutional repositories and databases, as well as reporting citation checks based on its ordered publications (Kousha & Therwall, 2019). The keyword searches in IEEE Explorer were also not permitted.

All in all, the study of the chosen scientific databases brought about 878 papers, including 67 publications in Science Direct (there were 11 review articles, 49 research articles, 4 encyclopaedias and 3 book chapters), 573 articles in Google Scholar, 19 scientific papers in IEEE Xplore, 72 in Emerald and 147 in WoS using the keywords: "sustainable supply chain management", "construction", "sustainability indicators", appropriate for a starting screening analysis. Books, conference proceedings, and papers were examined in order to refine the findings of prior investigations. The scientific papers written in English and met searching keywords and criteria such as accessibility to the authors of this article. With the goal of this study, the significance of scientific publications published between early 2017 and the end of 2021 was analyzed and discussed.

116 different scientific papers passed the initial screening (Table 1). The reduction in publications fulfilling the criterion, relevance to this study, article release time and duplication to other databases may all be explained by using full-text keyword searches. Following that, the articles were scanned from the beginning to end and those that did not meet the requirements were deleted. Finally, 95 scientific publications suitable for this study's examination were left for the final evaluation.

1.3. Reporting findings and knowledge dissemination

The description of the review process, precise results and further methodologies are in the segments of this paper below. The following is a list of the countries that contributed to the papers, as well as the number of publications per year and the methods used in relevant studies. The review is accompanied by a discussion of appropriate articles that demonstrate the construction sector's peculiarity in SSCM.

2. Findings

2.1. Methodologies found in the scientific articles selected for the review

Six methodological approaches were found in the research of scientific papers about the implementation of SSCM in the construction sector, which were chosen for this literature review. The most common methodological approaches used in the scientific articles were case study (29 articles examined), review (25 articles), conceptual (18 articles), survey (12 articles), prototype (9 articles) and interview (2 articles).

According to the findings of the published studies, empirical research is quite widespread. Primary data acquired through surveys, interviews and case studies is widely used in the scientific investigations. Surveys and interviews were used to examine the perspectives of the deployment of sustainable technologies and system attributes such as usability, efficiency, cost and simplicity of use. Theoretical investigations in this review article comprise several literature evaluations as well as conceptual recommendations. These studies largely focused on the core ideas of the supply chain management and technical implementation in the construction industry. Some studies examined the possibilities of new technologies, AI implementations such as IoT and blockchain (Park & Li, 2021), in tracing and tracking supply chains in the construction and logistics industries. The scientific papers picked for this research (95) were examined in three different forms of classification of SSCM: 1) the 4-area classification (Figure 1), 2) the Triple Bottom Line of social, environmental and economic indicators and, finally, 3) the different coloured clusters identified using VOSviewer.

2.2. Publications by year

The study was carried out in late December of 2021. Despite the fact that the number of scientific papers on SSCM has continuously and rapidly increased and devel-

Table 1. Databases and number of scientific papers, selected for the review

Database	Number of publications	Number of selected publications in each database	Results of subsequent screening
Science Direct	67	26	Full text reading of the introduction & conclusion; discussion sections; quality assessment; full text reading of the publication
Emerald	72	32	
Google Scholar	573	25	
IEEE Xplore	19	9	
WoS	147	24	
Total number of studies	878	116	95

oped until now, the Figure 2 below shows that the research on SSCM applications in the construction sector has decreased in 2019 and since then the amount is growing rapidly until the end of 2021. As shown in the graph, the number of research chosen for the review includes a significant number of research on SSCM use in construction in 2020. The amount of the published studies peaked in 2021. It should be mentioned that SSCM in the construction industry released the fewest research in 2019. In 2020, there was a considerable increase in the adoption of sustainable supply chain management towards building (20 scientific articles), which increased noticeably in the first and second quarter of 2021. This interest can be related to sustainability (Berardi, 2013), life cycle assessment (Wu et al., 2020), green construction waste disposal (Aslam et al., 2020), logistics (Dubois et al., 2019), collaborative project delivery (Engebø et al., 2020), new building rules and supply chain management domains (Pero et al., 2017).

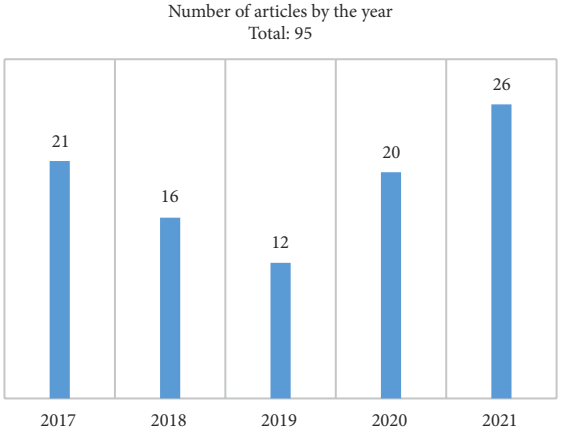

Figure 2. Year-wise distribution of research on SSCM in construction

Implementation of smart technologies and automating sustainable supply chains is critical to optimise construction processes and logistics and increase operational efficiency, allowing for more sustainable building processes to be in use. Efficient uses of SSCM in other industries such as logistics and food, present significant prospects for the construction industry. While SSCM is a well-studied field, terminology and conclusions are continually evolving. As a result, there is a non-negotiable gap between SSCM and its application in the construction business, necessitating more investigation.

2.3. Publications by country

Figure 3 shows a summary of scientific publications by country and the number of articles published in each region. Furthermore, analysing the distribution of publications depending on the geographical location of the initial author's research institution demonstrates the diversity of nations. Asia and Europe, according to the research, were the key sources of information on the issue, accounting for 62% of the total number of papers gathered. India is the global leader in the SSCM research in building business (13 articles selected for further examination). USA and China are ranked second and third in terms of the number of articles (8) that implement SSCM in construction. The UK came in the fourth place with six articles. It appears that these three mega-countries were particularly interested in adopting sustainability, optimising supply chains and using them in the building industry.

Investigating scientific papers by continent (Figure 4), Asian researchers contributed the most to the research and did 46% of the examined publications, European researchers contributed to 26%, North American 13% of the examined scientific papers. The continental dispersion of scientific research indicates that the concentration of SSCM in the construction sector was the most examined by Asian scientists.

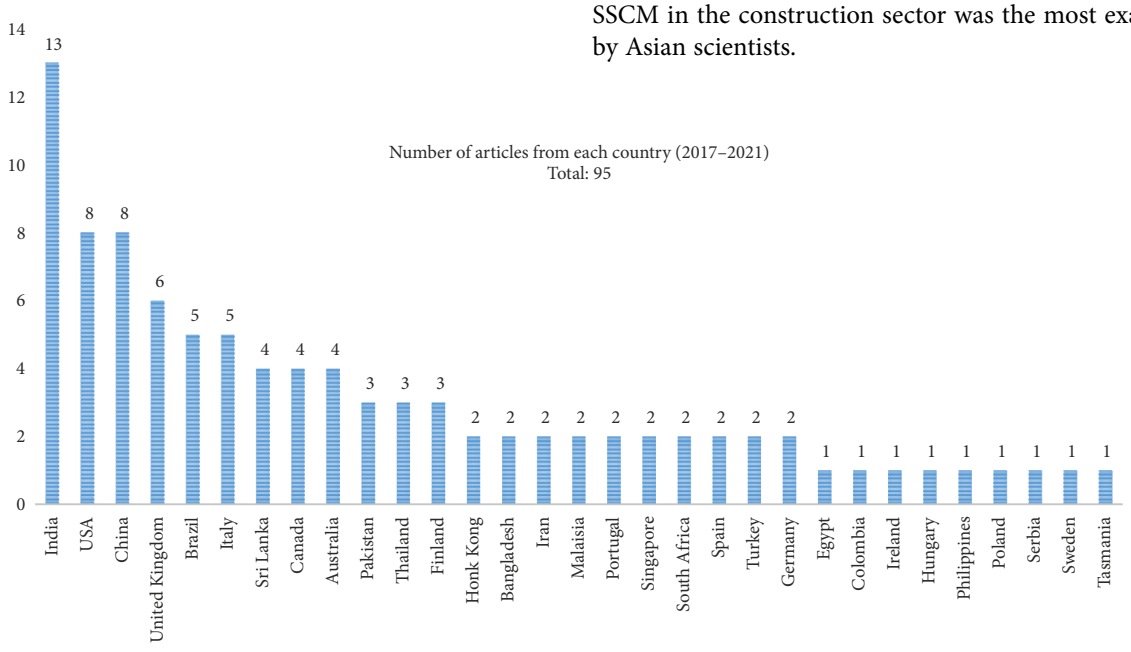

Figure 3. Country-wise distribution of research of SSCM in construction

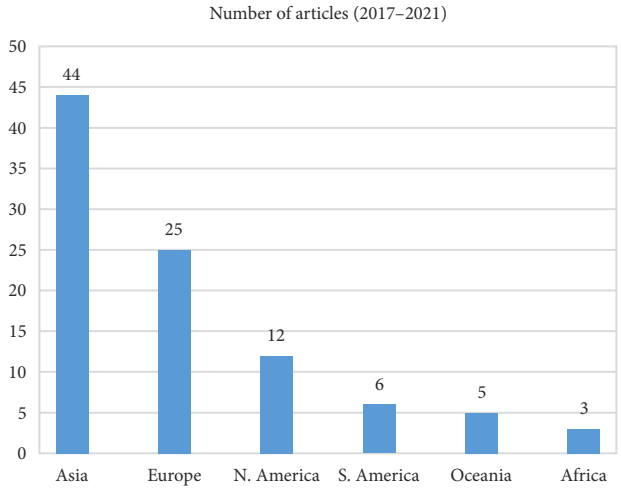

Figure 4. Number of articles from each continent

2.4. Bibliometric analysis of SSCM in construction

A total of 95 scientific papers were analysed utilising bibliometric approaches and data analysis technology known as keyword co-occurrence and co-citation analysis of publications (Wang et al., 2013). Many scientific publications employ a scientific data mining approach of keyword co-occurrence to indicate current research topics or fields of study. The term "co-occurrence method" is used to show a strong link between several publications on comparable topics. It investigates and identifies the intellectual structure, dynamics, and societal changes linked to a specific issue (Lu et al., 2015). In this study, an open-source software tool called VOSviewer was used to visualise the bibliometric data of scientific papers selected from various journals and scientific databases on the topic of sustainable supply chain management in construction. VOSviewer provides a rigorous functional framework for co-occurrence and co-citation analysis and assists in interpreting bibliometric network schematic representations. In this study's bibliometric analysis, a node was represented by a term or an academic publication.

The authors used a keyword co-occurrence network analysis (KCN) to map future investigations. Whereas a co-citation network examines the structure of logical communication by analysing joins between citations in articles, a keyword co-occurrence network (KCN) examines the information components and structure of a scientific/technical field by analysing links between links catchphrases in writing (Radhakrishnan et al., 2017).

The VOSviewer tool was utilised to generate a comprehensive term co-occurrence network in this work's descriptive analysis. Keywords are a quick and easy way to describe the subject of a research paper. A network map of keywords aids in visualising the knowledge structure of a certain study topic, revealing emergent elements, and displaying the dynamics of the knowledge structure. Consequently, a keyword co-occurrence network with at least five occurrences was generated, as shown in Figure 5. Figure 5 shows a network made up of nodes and edges,

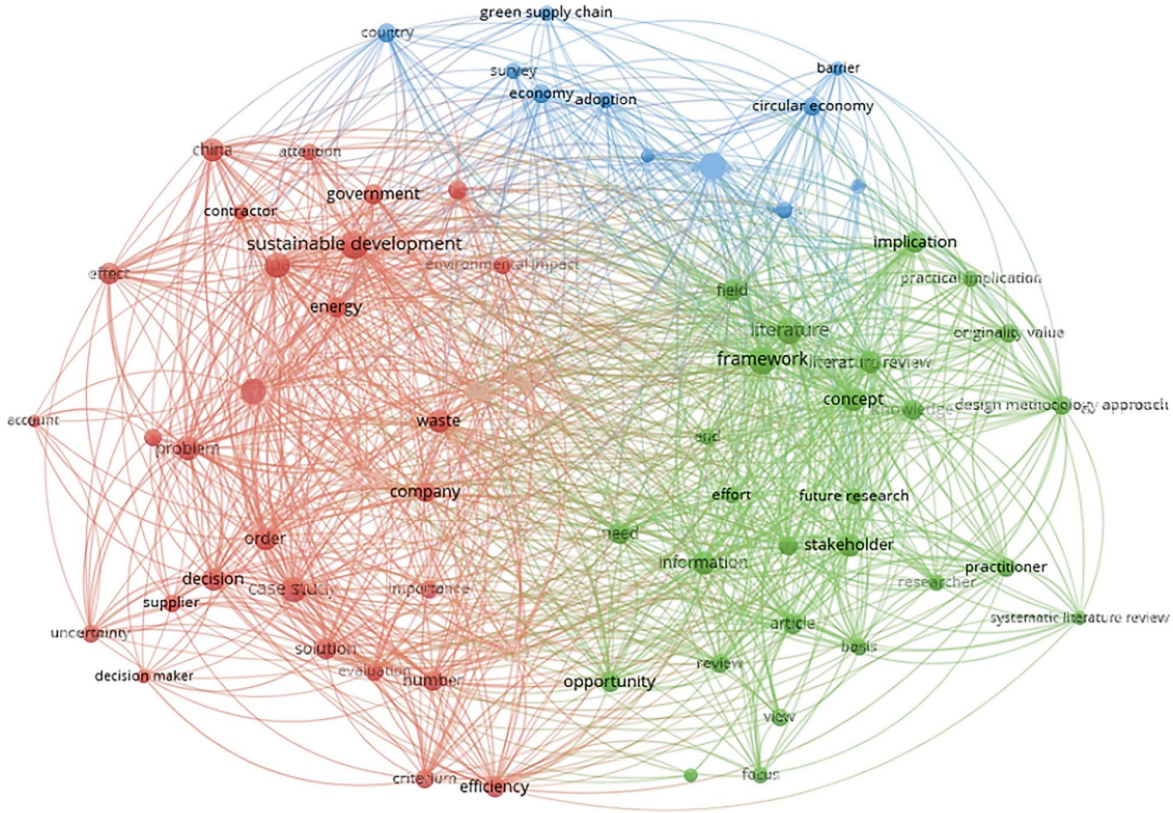

Figure 5. Keywords co-occurrence for sustainable supply chain management in construction

with nodes representing keywords and connections showing keyword co-occurrences found in the research articles. The node's radius corresponds to the recurrence of a keyword or its co-occurrence rate. The keywords that appeared most frequently were "sustainable development", "circular economy", "framework", "stakeholder", "government", "waste", "efficiency", "implication". The primary sustainable supply chain management in the construction study field is visualised in Figure 5, with phrases that commonly appear together being close to each other. These words had the highest frequencies and were the most used keywords. Figure 5 provides the visualisation of regularly used keywords commonly found together or in the same sentence.

Keyword recurrence and linkage may be determined using node sizes, distance between nodes, and keyword connection lines. The size of a node in the network represents its weight, whereas the distance between nodes reflects their connectivity (Lu et al., 2015). Words with similar colours belong to the same cluster, implying that terms in the same cluster are more closely connected. As a consequence, three distinct clusters were formed, as seen in Figure 5. Three distinct clusters were formed, each with its own colour showing how the terms were classified. Words in the red cluster included: "sustainable development", "supplier", "energy", "government", "waste" and "contractor". These themes highlight the development of a subject of study that can profit from sustainability and the future of construction enterprises. The blue cluster includes terms such as "green supply chain", "circular economy", "barrier" and "adoption", and can be related to the significance of research in supply chain management with an emphasis on green logistics, transparency. The green cluster highlights the construction company's leading position, the need of applying new technologies in construction, and the necessity to further investigate sustainable supply chain management in the construction sector. Keywords include "stakeholder", "practitioner", "concept", "framework", "implication" and "future research".

3. Discussion and future research agenda

The current academic literature reveals diverse possibilities and challenges for applying sustainability in construction supply chain management, such as better traceability, general efficiency, logistics management, and authentication and certification systems (Sertyesilisik, 2017).

3.1. Challenges and barriers of SSCM in construction

Several issues of sustainable supply chain management were identified in the construction business while executing the evaluation. Some researchers focused on social challenges such as social pressure from high pollution and high energy consumption (Liu et al., 2018), inefficient storage policies (Nantee & Sureeyatanapas, 2021), complications in applying sustainability approaches due to high skill, data and time requirements (Pande & Adil, 2022), construction companies limiting sustainability merely through public communication (Fracarolli Nunes & Lee Park, 2017) and lack of information (Popović et al., 2017).

The other group of authors stressed the economic aspect of the sustainability problem: inefficiency in the logistics system and lack of cash (Martins et al., 2021). Difficulties in combining the demand for faster economic expansion with sustainability are key issues in emerging countries (Araújo et al., 2020), pushed by increasing stakeholder and social demands, construction firms and supply chains face multidimensional problems that include not only integrating economic goals (Bastas & Liyanage, 2018a), but also a shortage of circular economy enterprises in the construction sector (Hossain et al., 2020).

The third group of researchers focused on the environmental aspects of sustainable supply chain management challenges, such as: increasing carbon footprint (Toufani et al., 2018), environmental problems in demolition processes (Tseng et al., 2021), warehouses as major contributors to greenhouse gas emissions (Bartolini et al., 2019), and steelmaking industries that deplete energy and natural resources (Aghelie, 2020). Table 2 provides the complete SSCM difficulties derived from the reviewed articles.

3.2. Potentials of SSCM in construction

Table 3 show the same three sustainability groups of future potential while analysing the problems discovered in scholarly studies regarding SSCM in the construction sector.

Some examples of social potential include the need to emphasise smart warehouse management and smart production systems (Bag et al., 2018), the inability of new companies to rely solely on their own strengths and the need to communicate with other branches of a supply chain (Jiang & Cao, 2021), the transition of logistics transportation systems from manual to e-supply chains (Ying, 2021), the implementation of Industry 4.0 technology, AI and Blockchain technology (big data analytics powered AI) (Bastas & Liyanage, 2019).

The following are some of the most prevalent ideas when it comes to environmental potentials: to improve pollution emission control capabilities and increase investment in energy conservation and emission reduction technologies to drive sustainable development (Kaufman & Ülkü, 2018; Hsu et al., 2019; Aslam et al., 2020), to use top-ranked sustainability indicators such as natural resource management, energy, greenhouse gas emissions and social investment (Kumar & Ramesh, 2020), to use environmental sustainability enablers for the steel industry (Goyal et al., 2018), strong green supply chain relations are the result of effectively implementing Green Manufacturing rather than a driver of the other enablers (Ghadimi et al., 2021).

Table 2. Future research questions emerge from challenges and barriers of SSCM in construction

Author(s)	Year of publication	Main challenges of SSCM in construction	Research questions for future research
Shahbazi et al.	2017	Improving material efficiency helps to reduce both the volume of industrial construction waste and the amount of resources used. However, there has been little discussion of how to quantify material efficiency in a construction manufacturing firm	RQ1: What are the material efficiency metrics in a construction manufacturing sector? RQ2: How SSCM can contribute to the quantification of material efficiency?
Zhao et al.	2017	Despite the advanced planning and control mechanisms used in the construction sector, data from on-site procedures is often obtained manually. New real-time and location-based data technologies, as well as their applications for less laborious operations, are in high demand	RQ3: How can technology intervention automatically offer real-time datasets to reduce labour operations?
Balasubramanian and Shukla	2017a, 2017b	The construction sector must be greened from the initial design through the end-of-life demolition, despite the fact that efforts to address the negative consequences connected with the building sector have been mostly scattered and disjointed thus far	RQ4: How sustainability-oriented practices can be emerged in construction sector to encourage green protocols?
Fracarolli Nunes and Lee Park	2017	While some businesses do strive to meet stakeholders' expectations for sustainable operations, others appear to limit sustainability to public communication	RQ5: How can policymakers introduce sustainable operations in the construction sector as a general routine?
Popović et al.	2017	Gaps in social sustainability are created by a lack of knowledge, with some of them also being linked to issues in assessing the social sustainability of construction supply chains, which are frequently caused by a lack of adequate quantitative indicators to employ	RQ6: What are the indicators of social sustainability in the construction sector? RQ7: How to prioritise the social sustainability indicators in construction firms?
Acquaye et al.	2017	Despite the convergence of the underlying principles of sustainable SCM in the construction industry, measuring the performance of environmentally friendly supply chains rather than chain comprise has been difficult. The fact that supply networks are fundamentally dynamic and complicated adds to the difficulty	RQ8: What environmental regulations are needed, especially in the construction sector? RQ9: Is there a need to define the environmental sustainability indicators for the construction sector separately?
Liu et al.	2018	The building industry, which uses a lot of energy and emits a lot of pollutants, is under social and environmental pressure as a result of sustainable development	RQ10: How construction industry can contribute to the social and environmental paradigm?
Saavedra et al.	2018	In the renewable energy supply chain, techniques based on modelling and simulation and AI implementation have not been widely used	RQ11: How AI technology can boost the performance of SSCM in the construction sector?
Bastas and Liyanage	2018a	Construction firms and supply chains face the multi-faceted problems of not only integrating economic, environmental, and social agendas into their management systems, but also driving continuous sustainability performance improvement, driven by increasing stakeholder and public pressures	RQ12: What is various stakeholders' role in pushing the construction sector towards TBL sustainability?
Nuñez-Cacho et al.	2018	Due to a lack of psychometrically solid measurements, determining the degree of implementation of sustainability approaches in the building supply chain is difficult	RQ13: How to develop the degree of sustainability implementation measurements in a construction firm?
Aldakhil et al.	2018	Logistics indices are linked to high mass carbon emissions, social variables, and trade openness, all of which necessitate the use of more sustainable, cleaner instruments to achieve broad-based growth in building SC	RQ14: How green logistics can be practically implemented in the construction sector?
Toufani et al.	2018	The building industry's growth will result in a significant carbon footprint, both direct and indirect, as well as globalisation and urbanisation, which may result in the loss of green places	RQ15: How to create awareness of adopting green practices in the building sector to reduce the carbon emissions in their operations?

Continue of Table 2

Author(s)	Year of publication	Main challenges of SSCM in construction	Research questions for future research
Bastas and Liyanage	2018b	Stakeholder focus is at the heart of quality management, and it takes part in a shared end objective to SCM, namely, customer pleasure, but it frequently overlooks the importance of sustainability and conservation	RQ16: How to balance sustainability and customer satisfaction in building firms?
How and Lam	2018	A complicated set of criteria is frequently used to assess the sustainability performance of a construction material supply chain. Because of the redundancy in factors, analysing and diagnosing the results might be difficult	RQ17: What are the selected indicators/factors that define the sustainability performance of construction firms?
Bartolini et al.	2019	The increased desire for mass customisation and the expansion of the e-commerce sector has resulted in an increase in the demand for warehouse space and buildings used for construction material storage. Warehouses play a significant role in increasing greenhouse gas emissions in supply chains	RQ18: How can just-in-time philosophies be used in customisation and e-commerce to reduce the waste generated from excess inventory?
Thies et al.	2019	Products' environmental and social implications are being investigated more every year. This involves the use of systematic assessment methodologies like life cycle analysis. It's not uncommon for implementation in construction industry and the application could be less difficult	RQ19: Which practices can be adopted in the construction sector to offer sustainable products?
Upadhyay and Kumar	2020	Sustainable service and product design remains a difficulty for construction businesses due to the participation of multiple aspects in the architectural design process	RQ20: How can sustainable services and product design be adopted from other industries to construction industries?
Sangwan et al.	2019	Existing frameworks for assessing sustainability in the cement industry lack an integrated assessment that takes into account the product life cycle, resources, crucial elements (product, process, and policy), key performance indicators, and their interrelationships with sustainability aspects	RQ21: What are the possible reasons for trouble integrating the cement industry's existing sustainability framework?
Tetteh et al.	2019	The deficiency is due to insufficient international construction joint ventures (ICJV) performance measures and the omission of corporate sustainability supply chain performance indicators from the ICJVs performance assessment	RQ22: How to promote the IJV performance measures?
Araújo et al.	2020	According to the International Organization for Standardization (ISO), the construction industry is one of the major sectors, and while it generates value and jobs, it also consumes a significant amount of resources, resulting in social and environmental consequences. Conciliating the need for rapid economic expansion with the need for long-term sustainability is a key challenge in development for different countries	RQ23: How economic expansion can lead the construction sector to long term sustainability without challenging the social and environmental pillars?
Aghelie	2020	Because of decreasing energy and natural resources, severe global environmental deterioration, and rising observer comments on personnel health and operational safety, the steelmaking industries are experiencing a great concern about sustainability management	RQ24: What are the possible ways to lead TBL dimensions to complement rather than challenge each other in steel making industries?
Nantee amd Sureeyatanapas	2021	Depending on each company's solutions and objectives, the outcome of several warehouse criteria in the construction industry may be deteriorated (e.g., increasing electricity bills, maintenance costs and job losses)	RQ25: How can generalised solution strategies offer a better outcome for the warehouse of construction firm?
Martins et al.	2021	To compete in the face of globalisation, logistics systems must improve process efficiency. For construction and logistics organisations, competitiveness is not only about economics; the idea of the Triple Bottom Line must also be considered	RQ26: How can TBL's concept of global competitiveness be introduced in the construction sector?
Pande and Adil	2022	Manufacturing in construction: examines the existing sustainability assessment methodologies for manufacturing enterprises, concluding that the majority of sustainability approaches are difficult to implement due to high skill, data, and time requirements	RQ27: What new sustainability methodologies can be introduced/adopted that are easily adaptable and take less time to implement in the construction sector?

End of Table 2

Author(s)	Year of publication	Main challenges of SSCM in construction	Research questions for future research
Tseng et al.	2021	Construction and demolition trash continues to wreak havoc on the environment and society. These tough obstacles result in long-term issues that are becoming increasingly critical around the world. Prior research has failed to connect the triple bottom line to a valid estimation or empirical model for estimating construction waste production performance, and there has been no empirical sensitivity analysis in profit maximisation	RQ28: How sustainability can be seen as an integral part of the construction sector? RQ29: How construction firms can understand financial benefits as a subset of sustainability?
Li et al.	2021	There always exists a various of variability and uncertainty in reality, which may bring risks to companies, resulting in their tendency to risk aversion rather than risk neutrality. Risk aversion plays an important role in decision-making and has been introduced into many studies about supply chain management.	RQ30: When considering the consumer surplus and environmental externality, which model (risk management or green product development) is better off for the society and environment?
Berardi & de Brito	2021	Isolated practices, which are disconnected from the principles of circularity, emphasized actions for reducing the consumption of materials and waste, and thus introduced initiatives that were oriented towards generating a short-term financial return.	RQ31: How does Circular economy literature address the challenges related to collaboration in supply chains in construction?
Kitsis and Chen	2021	Stakeholder pressures significantly impact top management's commitment and their decisions as they engage in green operations. Furthermore, stakeholders' pressures do not automatically lead to green operations without the presence of top management commitment.	RQ32: Do stakeholder pressures influence green supply chain Practices?

Table 3. Future research questions emerge from the potentials of SSCM in construction

Author(s)	Year of publication	Main potentials of SSCM in construction	Research questions for future research
Hanif and Khattak	2017	Main sustainability factors in construction logistics were extracted to determine the elements affecting the construction industry's sustainability and to address the economic concerns of emerging countries like Pakistan	RQ33: Which elements of sustainability affect the sustainability performance of construction logistics?
Arampantzi and Minis	2017	A new multi-objective mixed integer linear programming model, which captures the significant decisions involved in designing or redesigning high-performance sustainable supply chains, including in the construction sector, could be used to investigate the role of sustainability in supply chain network design	RQ34: How decision-making programming tools can be used to analyse the sustainability role in supply chain network design?
Bag et al.	2018	The social dimensions of construction supply chain sustainability have been largely disregarded in prior research projects. Smart manufacturing, smart production systems, smart warehouse management systems, smart logistics, and sustainability must all be prioritised	RQ35: What is smart technologies' role in offering supply chain sustainability in the construction sector?
Kono et al.	2018	Because the regional conditions revealed a correlation between the building's sustainability performance during its operational phase, the conditions may be used as a proxy for information during the product development phase	RQ36: How regional conditions can play a role in building sustainability performance during product development?
Goyal et al.	2018	The findings revealed that over a five-year period, significant improvements in the environmental sustainability performance of steel manufacturing were achieved when environmental sustainability enablers were used more in this sector	RQ37: How do TBL indicators play an essential role in offering the individual TBL sustainability in steel manufacturing?
Balaman	2019	Sustainability principles in the construction industry should constantly be examined and analysed within a well-defined framework to ensure the efficiency of materials, information, and cash flow in biomass-based production networks and manage the competency of fossil source-based systems	RQ38: How much is a continuous assessment of sustainability protocols necessary in the construction industry? RQ39: What are the metrics of assessments of sustainability protocols in the construction industry?

Continue of Table 3

Author(s)	Year of publication	Main potentials of SSCM in construction	Research questions for future research
Bastas and Liyanage	2019	At the manufacturing level, there is the potential to integrate Lean, green, and Six Sigma methodologies for organised, long-term performance improvement in the building industry. The methodology is limited to deployment at focus organisations and does not include SCM, despite the fact that it gives vital practical insights for industry	RQ40: How can green, Lean, and Six Sigma be integrated into supply chain management? RQ41: What tangible benefits can the construction industry obtain by integrating green, lean, and six sigma to SCM?
Henao et al.	2019	Growing sustainability awareness in construction and the Triple Bottom Line approach necessitates an integrated performance based on three key objectives: economic growth, environmental preservation, and social responsibility	RQ42: How can a balanced approach be introduced for TBL sustainability in the construction industry?
Kumar and Ramesh	2020	If the recycling plant is not located in accordance with sustainability standards, the benefits of recycling building and demolition waste will be diluted. Policy and legal requirements such as local government backing and financial support, as well as economic factors such as proximity to the garbage collection location and slope, are critical	RQ43: How essential is it to implement policy regulations theoretically and practically? RQ44: How can the monitoring of policy implementation enhance the sustainability performance in the construction industry?
Kumar et al.	2020a	The management of natural resources, energy, greenhouse gas emissions, and social investment are among the top-ranked sustainability indicators that can aid in the optimisation of the building supply chain	RQ45: What are the most important sustainability indicators of the building supply chain?
Kumar et al.	2020b	Various challenges that are likely to affect sustainability in all activities of the supply chain and the construction organisation as a whole can be addressed at the earliest stage of operation by capturing all sustainability dimensions in the architectural design stage	RQ46: How can addressing the sustainability challenges at the early design stage affect the operations of the construction sector?
Fracarolli Nunes et al.	2020	The results imply that the efficiency of the insurance mechanism is not reliant on alignment across sustainability parameters, which adds to the study of sustainability trade-offs in supply chain contexts (i.e., social responsibility attenuating social irresponsibility). Building supply chain management could be reshaped by digitalisation, such as blockchain technology. The blockchain platform uses distributed ledger technology to create a digital system and database to track transactions throughout the supply chain. The supply chain management is made more transparent, reliable, traceable, and efficient thanks to this decentralised database of transactions	RQ47: What is the role of digital technologies (Such as Blockchain) in the efficiency of the construction sector?
Rostamnezhad et al.	2020	The complex interrelated structure of many influencing factors may be modelled using cause and effect feedback loops for the construction sector, and the qualitative model of social sustainability can be developed using the System dynamic approach	RQ48: How can cause and effect/feedback-based systems develop social sustainability metrics in building firms?
Bag and Pretorius	2020	Adoption of Industry 4.0 technology (big data analytics driven AI) can have a favourable impact on the capabilities of sustainable manufacturing and circular economy in construction industry	RQ49: How Industry 4.0 can impact the sustainable outcomes of the construction sector?
Biuki et al.	2020	To assist in the development of a construction sustainable supply chain, an issue might be phrased as a multi-objective mixed integer programming model after finding more sustainable-oriented providers. A couple of different challenges, such as sustainability, integrated decision-making on location, routing, and inventory control planning, and real-world assumptions, can be handled using the two-phase approach to achieve additional advancements in both research and practice	RQ50: What digital decision-making tools can lead to SSCM in the construction sector?
Jiang and Cao	2021	New initiatives cannot gain a competitive advantage in the market by depending solely on their own strength and resources, and this might even threaten the survival of construction businesses	RQ51: How to strengthen emerging initiatives to offer a competitive advantage?

End of Table 3

Author(s)	Year of publication	Main potentials of SSCM in construction	Research questions for future research
Ying	2021	Companies must evaluate the essential variables of transportation mode selection and utilise model construction to solve the optimisation, in order to combine the low carbon economy with the background of energy savings and emission reduction. The logistics management system would then be built on top of the e-supply chain	RQ52: What are the parameters of selecting transport variables to reduce environmental degradation?
Hu and Chong	2021	Off-site manufacturing (OSM) is a new building process that provides stakeholders with a variety of environmental sustainability benefits. The growing use of OSM in practice has sparked a lot of inquiry into its long-term environmental viability	RQ53: How OSM can lead to a more green ambience in the construction sector?
Ghadimi et al.	2021	Strong green supply chain relationships in the eyes of Irish medium-sized construction firms are the result of effectively implementing Green Manufacturing rather than a driver of the other enablers. Furthermore, GM methods have been observed to result in decreased production costs in medium-sized businesses	RQ54: How GM can affect the supply chain relationship in different country contexts? RQ55: How does adapting GM in different scale enterprises (small and large) differ?
Marzouk and Sabbah	2021	The goal of the study is to develop a computer model of MCDM and offer it to construction companies for use in the supplier prequalification process	RQ56: How MCDM techniques can be used as a prerequisite in the decision making of supplier selection?
Karmaker et al.	2021	To deal with the initial impact on sustainable supply chains caused by COVID-19, financial help from the government as well as supply chain partners in construction sector is required	RQ57: How can stakeholders of a supply chain help deal with the impact of pandemic type situations?
Lima et al.	2021	More research on the operation and maintenance stages is needed, as the papers focus on the planning and execution stages of on-site constructional work	RQ58: How can the role of operation and maintenance practices be explored in the construction sector research?
Schultz et al.	2021	A need for qualitative-empirical analysis of governance mechanisms' directions based on evidence from the European polyurethane industry is growing. Major findings indicate that whereas governance mechanisms for vertical collaboration – mostly discussed in SSCM – are of limited value to facilitate functional CSCM, governance mechanisms for horizontal collaboration can promote the closing of resource loops.	RQ59: How could European polyurethane industry to facilitate functional circular supply chain management?

Several conservative possibilities of SSCM in development: a need for monetary help from the public authority due to the COVID-19 pandemic to facilitate the shock for individuals in the construction production network (Karmaker et al., 2021), to contribute assets to digitalisation, for example, blockchain innovation (Fracarolli Nunes et al., 2020), in the activity and maintenance stages, to invest additional resources in the development of more examinations (Lima et al., 2021), a flow absence of monetary help, and practical perspectives such as proximity to the waste assortment point (Kumar & Ramesh, 2020).

Henao et al. (2019) summarised the potential of sustainable construction supply chain management into one category: increasing awareness of sustainability. The Triple Bottom Line approach requires an integral performance based on three main goals: economic growth, environmental preservation and social responsibility.

3.3. Research agenda

Traditional SSCM in the construction industry faces challenges throughout the supply chain. This includes a stakeholder's unwillingness of the stakeholder to change, excessive waste, theft, late deliveries can cause delays, as well as other unanticipated complications, before construction materials arrive at their destination.

Few studies have investigated the usefulness of sustainability theory in the traceability of construction SCM (Balaman, 2019). Studies that demonstrate how artificial intelligence strengthens the Triple Bottom Line idea (Amarah & Langston, 2017; Henao et al., 2019) in SSCM must propose prototypes and methods to control construction waste management and the use of sustainable resources in supply chains. In addition, it is necessary to investigate how AI-based traceability systems affect inventory, transportation, and distribution decisions in the SSCM at every

stage of the construction process. New tools are required to count the resources required to establish successful sustainable and green construction methods. When talking about efficiency, it is important to mention that there are few studies that emphasize sustainability as a significant enabler for SCM alignment, collaboration, and synchronization. There is a scarcity of research on the viability of green solutions to improve the efficiency of SSCM activities (e.g., logistics, warehousing, distribution, and transportation).

There is a need to introduce AI-based analytical tools (Bag et al., 2018) and methodologies for the detection of frauds and the authentication of sustainable construction materials and procedures in a timely, cost-effective and efficient manner. Some technologies such as IoT, Blockchain, and advanced analytics could be used for research that evaluates user perceptions and intentions to use sustainability in conjunction in construction supply chains using technology adoption theories (for example, technology adoption model, diffusion of innovation). To effectively govern cross-border and globalised SSCM, regulatory support and strategies aimed at increased standardisation are required.

The potentials and challenges brought up some research questions for the future. Some of the main questions that emerged from the challenges were:

- RQ2: How SSCM can contribute to the quantification of material efficiency?
- RQ6: What are the indicators of social sustainability in the construction sector?
- RQ11: How AI technology can boost the performance of SSCM in the construction sector?
- RQ20: How can sustainable services and product design be adopted from other industries to construction industries?
- RQ26: How can TBL's concept of global competitiveness be introduced in the construction sector?

Some of the examples of the research questions that emerged from the potentials found in the articles were:

- RQ40: How can green, Lean and Six Sigma be integrated into supply chain management?
- RQ47: What is the role of digital technologies (such as Blockchain) in the efficiency of the construction sector?
- RQ52: What are the parameters of selecting transport variables to reduce environmental degradation?
- RQ57: How can stakeholders of a supply chain help deal with the impact of pandemic type situations?

Not all of them are the same equal weight, so their importance should be examined in the future researches. These and many more questions found from this research need answers and huge potential for the future can be seen.

Conclusions

The current study examines the function of sustainable supply chain management (SSCM) in the construction industry in depth and includes bibliometric analysis. The SLR is based on 95 articles culled from a variety of web databases. Bibliometric analysis provided a comprehensive picture of prominent nations, continents, trending publishing years and other network indicators. A research outcome framework is also included in Figure 6 to summarise the entire investigation.

Using a systematic literature review (SLR), an examination of the barriers and potentials of SSCM in the construction sector demonstrated that authors from all over the world have addressed various elements of this issue. In the Brundtland Convention, three main components were observed: economic, social, and environmental, often known as a Triple Bottom Line (Henao et al., 2019; Kumar & Ramesh, 2020; Literal & Guhao, 2021). Moreover, some scientists have suggested that a new research agenda for sustainability indicators should be established (Popović et al., 2017; Fetter, 2019; Tetteh et al., 2019; Suhi et al., 2019; Azevedo et al., 2020).

Using VOSviewer three main clusters were found with the common keywords in all of the research papers picked for this article.

A clear and comprehensive understanding of context-specific core concepts and practises underpinning SCM is recognised as critical to supporting SCM integration in the construction sector. On the other hand, studies continue to focus on restricted subject topics and fail to provide a holistic answer. This paper addressed this research gap by doing a thorough literature assessment. A complicated process was applied to obtain 95 relevant publications from several and widely used databases. These publication dates, article study fields, locations, and keyword

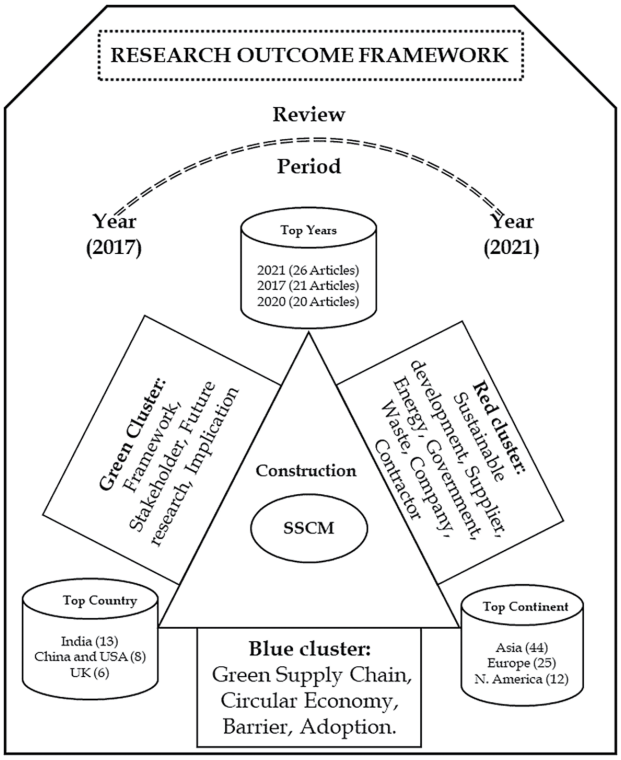

Figure 6. Research outcome framework

co-occurrence were all statistically analysed. The whole spectrum of viewpoints and contributions from different research fields were explored to capture the established essential concepts and practises underlying SCM in the construction industry, going beyond the scope of the study.

There were identified several social challenges of the SSCM in construction, such as social pressure of high pollution and high energy consumption (Leseure & Alexander, 2017; Liu et al., 2018), inefficient strategies of warehousing policies (Nantee & Sureeyatanapas, 2021), complications to apply sustainability approaches for reasons such as high amount of skill, data and time requirements (Pande & Adil, 2022), construction company restraints sustainability merely on their public communication (Fracarolli Nunes & Lee Park, 2017), lack of information and lack of appropriate indicators (Popović et al., 2017).

Another group of authors highlighted the economic component of the sustainability problem: lack of efficiency in logistics systems and insufficient funds (Martins et al., 2021), difficulties in reconciling the need for accelerated economic growth with sustainability are significant dilemmas in developing countries (Araújo et al., 2020), driven by increasing stakeholder and societal pressures, construction companies and construction supply chains face multidimensional challenges (Bastas & Liyanage, 2018a).

Furthermore, the third group of sustainability challenges of SSCM in construction was extracted. The third group of researchers focused on the environmental aspects of sustainable supply chain management challenges, such as: increasing carbon footprint (Toufani et al., 2018), environmental problems in demolition processes (Tseng et al., 2021), warehouses being a main subject of greenhouse gas emission contributors (Bartolini et al., 2019), steelmaking industries depleting energy and natural resources (Koh et al., 2017; Aghelie, 2020).

The results unveiled that sustainable supply chain management offers three groups major potentials for the construction sector anywhere in the world. Some of the social potential examples could be the need to emphasise on smart warehouse management and smart production systems (Bag et al., 2018), new ventures inability to rely only on their own strengths, and a need to communicate with other branches of a supply chain (Jiang & Cao, 2021), move logistics transportation systems from manual work to e-supply chains (Ying, 2021), implement Industry 4.0 technology (big data analytics powered artificial intelligence) adoption (Bag & Pretorius, 2020), a potential integration of Lean, green and Six Sigma approaches (Bastas & Liyanage, 2019) could be included into the social group.

Environmental potentials can be imagined as enhancement of pollution emission control capabilities and increase investment in energy conservation and emission reduction technologies to drive sustainable development (Hashmi & Choudhury, 2020; Aslam et al., 2020), use top-ranked sustainability indicators including the management of natural resources, energy, greenhouse gas emissions and social investment (Kumar & Ramesh, 2020), use environmental sustainability enablers for steel industry (Goyal et al., 2018), strong green supply chain relations are the outcome of successfully implementing green manufacturing and not a driver of the other enablers (Ghadimi et al., 2021).

Examples of some economical potential of SSCM in construction contain a need of financial support from the government because of COVID-19 pandemic to ease the shock for the members of construction supply chain (Karmaker et al., 2021), invest funds to the digitalisation of construction processes, such as blockchain technology (Fracarolli Nunes et al., 2020), invest in the development of more studies on operation and maintenance stages (Lima et al., 2021), a current lack of financial support; economical aspects like proximity to the waste collection point (Kumar & Ramesh, 2020).

The Triple Bottom Line approach requires an integral performance based on three main goals: economic growth, environmental preservation and social responsibility.

The extraction of challenges and potentials in existing scientific literature brought up an idea to find the Research Questions. There were 59 research questions developed as a result of this research and current literature of SSCM in construction sector. Some of the examples of them are: How GM can affect the supply chain relationship in different country contexts, what are the most important sustainability indicators of the building supply chain; which elements of sustainability affect the sustainability performance of construction logistics and etc. These 59 research questions are not equal importance, so future investigation is needed to determine which of these are the most significant. The questionnaire for the experts of the construction sector could be made in order to find the essential questions.

Limitations

According to current academic research, there are several opportunities and challenges for incorporating sustainability into construction supply chain management. Better traceability, general efficiency, logistics management, and authentication and certification systems are among the former. Modern technology can help achieve important supply chain quality criteria like traceability and verification and green consumption and waste reduction in the construction industry. This necessitates regulators having a thorough grasp of the underlying technology and how it impacts and produces current value networks.

The limits of technology, especially consumers' reluctance to adapt, must be better understood. The current legal framework does not fully account for the unique characteristics of AI-based technologies, which is one of the key levers for policymakers to create a regulatory environment that accounts for modern technology's capabilities as well as the expectations of an ever-growing need in the new era of construction and logistics (Banihashemi et al., 2019).

This study aims to add to the academic literature on sustainable supply chain management in the construction industry. It offers a systematic analysis of current ideas about the use of new technologies and efficient logistics in construction and a summary of potential opportunities and significant limitations.

The study's findings can help stakeholders understand the variables that promote and inhibit SSCM adoption in the construction industry and alter their policies and operations as a result. The findings, however, are constrained by the databases used, and hence may not fully cover all published literature on emerging technologies relevant to building research. Additional research could widen the search terms and look at more scientific resources. More empirical studies are needed to fulfil the study agenda provided in this work, which will give sustainable construction researchers, policymakers, and managers with improved insights into the economic and organisational effects of innovative and efficient technologies in this sector.

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