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Review

A Scientometric Review and Analysis of Studies on the Barriers and Challenges of Sustainable Construction

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Abstract: Despite numerous concerns about climate change and the deterioration of nature, the construction industry is still one of the largest consumers of minerals and natural resources. In recent decades, sustainable construction using renewable and recyclable materials, reducing energy, and the adoption of more green technologies with the aim of reducing harmful impacts on the environment have received profound worldwide attention. The more key stakeholders involved strive to achieve sustainability, the more barriers they may face, which requires investigating them to have an effective plan to recognize, prevent, and control them. This paper reviews, classifies, and analyzes the major barriers of sustainable construction between January 2000 and April 2023. In this scientometric study, 153 articles were selected from the Web of Science database. Then, bibliometrics, the creation of maps from network data, as well as the illustration and exploration of those maps were conducted with the HistCite 12.03.1 and VOSviewer 1.6.20 software programs. The analytical results showed that the most profound barriers of sustainable construction are classified into 12 groups: price, economic parameters, awareness, technical, policy and regulations, design, management and government, environmental, social, materials, planning, and market.

Keywords: sustainable construction; green building; Scientometric review; VOSviewer; HistCite

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1. Introduction

The construction industry goes back 10,000 years and has had a lot of ups and downs. Since humanity felt the need for a permanent residency, it has given all its efforts to achieve its objectives [1]. Despite numerous barriers and difficulties, it has tried to reach its objectives, i.e., to see the construction of traditional buildings, modern towers, industrial, shopping centers, etc., in its portfolio [2]. In recent years, construction activists have been thinking about the fear of limited resources and damage to nature [3]. These threats have resulted in the concept of sustainability. Sustainability is generally defined as various approaches to social, environmental, and economic issues [4]. In the 1987 Brundtland Commission Report, sustainable development was introduced as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”, which has been cited the most so far [5]. Some have defined sustainable development as a subject that can be sustained and have pointed out the three key areas of sustainability: environmental responsibility, social consciousness, and economic return [6].

In sustainable construction, the goal is a process that gets off to a good start in the early planning and design stages and continues well after the construction team leaves the site [7]. Buildings interconnected with their surrounding built environments throughout their lifecycle, from planning to design, construction, operation, maintenance, renovation, and destruction, have the most significant effect on the energy balance of cities [8]. Therefore, this industry is responsible for various negative impacts on other areas, such as the environment [9]. In 1994, Kibret was one of the first authors to conceptualize sustainability in construction. He believed that the construction industry should look for "sustainable methods" that protect infrequent resources and promote a healthy environment [10]. The advancement of the sustainable development concept has become a basis for advancing the understanding of sustainable construction. Sustainable building principles were developed on four bases, namely social, economic, biophysical, and technical, with a set of general rules to orientate the process [7].

Undoubtedly, there are barriers in implementing any plan. Sustainable construction is not excluded from this group either. The most effective barriers to mainstreaming sustainability into construction projects are a lack of understanding of the potential benefits; insufficient cooperation among practitioners, research institutions, and environmental organizations; a lack of a systematic approach to achieving sustainability objectives; the availability of various sustainable materials with distinctive features; affordability; building regulations; a lack of client awareness; a lack of understanding of the business aspects; a lack of client demand; a lack of proven alternative technologies; a lack of labelling and measurement standards; and scheduling policy. These barriers necessitate substantial resource allocations [6,11–13].

In view of the wide range of materials utilized and studies carried out, it has been possible to summarize and evaluate the results presented in the abovementioned papers in a review paper [14]. Such studies include an assessment of the potential value of analyzing data from bibliometric and scientometric sources [15]. The purpose of scientific mapping is to construct bibliometric maps that describe how specific disciplines or scientific or research areas are conceptually, intellectually, and socially structured [16]. This study presents a scientometric review of research conducted on the barriers of sustainable construction, including the challenges, limitations, issues, risks, disputes, and obstacles observed during the period of January 2000 to April 2023.

The 'barriers' and 'challenges' represent distinct concepts, although they are interrelated. Barriers refer to specific obstacles that hinder effective implementation or impede progress or movement in projects, which can include technical, organizational, behavioral, and financial factors. On the other hand, challenges encompass broader issues that firms or organizations face in projects, for example, engaging with innovation or adopting new practices, market competition, demand uncertainty, and the sustainability of practices. While barriers are often more concrete and specific, challenges can be seen as the overarching difficulties that arise from these barriers and other external factors. Thus, while both terms are related to the difficulties encountered in practice, 'barriers' are specific obstacles, whereas 'challenges' refer to the broader context of difficulties faced in overcoming those obstacles. Therefore, as it is more precise to use 'barriers' when discussing specific impediments to implementation, this term was considered to cover both 'barriers' and 'challenges' in this study. This paper provides a thorough analysis of the barriers to sustainable construction, outlining the existing knowledge base and proposing future actions. The primary research questions formulated for this study are as follows. (1) What have been the attitudes towards barriers and challenges in sustainable construction over the past few years? (2) What barriers to sustainable construction does the research literature present, and what techniques are recommended to address these challenges?

2. Research Methodology

2.1. Data Sources

The attractiveness, significance, and variety in the field of sustainability in today's global construction industry were the main incentives for this research. In scientific study, one of the most important ways to achieve defined goals is to examine existing barriers. After looking at all aspects, barriers in sustainable construction are discussed in this study. To reach the goal of the study, a scientometric analysis technique was implemented. In today's scientific world, there are numerous scientific resources that scientists can use for their research purposes [17]. "Scientometrics" is used in the study of all aspects of the scientific and technological literature. The term acquired broad recognition through the foundation of the journal "Scientometrics" by Tibor Braun in Hungary in 1978 [18]. Bibliometric methods are used in many fields for various purposes, including the assessment of research [19]. This approach was developed through computer science, which became possible after the introduction of computer technology [15]. Scientometrics and bibliometrics go back to the first quantitative studies in the early twentieth century, with the foundation of the international society for scientometrics and informetrics (ISSI) in 1993 [17]. Thomson Reuters' Web of Science and Elsevier's Scopus are both primary and common bibliometric data sources [19]. In fact, they are two concurrent reference databases [20].

As shown in recent years, sustainable construction can be regarded as progress toward sustainable development and a balance between health, economy, and social issues [21]. This conviction has inspired many researchers to conduct research in this field. The initial title of this study was "Study of Barriers and Issues in Sustainable Construction from January 2000 to April 2023". Through searches of Google Scholar sources, relevant papers were reviewed. Next, in the WoS, a document search (i.e., searches the title (TS)) was carried out using the following keywords: "sustainable construction" AND TS = "Barriers" OR TS = sustainable construction AND TS = "obstacles" or "green construction" AND TS = "challenges" OR TS = "green construction" AND TS = "drivers". In this study, the keywords "sustainable construction", "sustainable buildings", and "green buildings" were searched simultaneously with other keywords such as "barriers", "dispute", "challenges", "obstacle", "conflict", "issues", and "drivers" with the conjunctions AND and OR.

At this stage, 186 papers were identified. The next stage involved validating the papers. Search terms were considered either direct or indirect. Direct terms, i.e., "barriers" or "challenges" or "problems", were those explicitly mentioned in the title of the papers. Indirect status was applied to papers that embraced the concept more generally. For instance, a paper entitled "Success in Sustainable Building" indicates that the topic is covered positively; however, it was assumed that the barriers were first discussed and then solutions were provided. Therefore, this group of papers was also used for our research. Ultimately, 153 papers were selected, and the analysis phase began.

2.2. Research Methods

In 1981, Pritchard and Wittig defined bibliometrics as a method used in different ways over the last century or more [18]. In 1992, Sengupta claimed that in 1896, Campbell produced the first bibliometric study using statistical methods to study the dispersion of subjects in publications [18]. In addition, some believe that scientific or bibliometric mapping is a spatial representation of how disciplines, fields, specialties, and individual documents or authors are interrelated [16]. Scientometric analysis is an intellectual structure that generates an exploitable analysis of publications on a particular topic. The results of this method are the visualization of important research patterns and trends in a large body of literature and an illustration of a map of scientific knowledge and the identification of major research topics [22,23]. Available software tools such as Bibexcel, CiteSpace, and VOSviewer allow researchers to generate various kinds of bibliometric networks [16]. WoS is used as a database together with other search providers, such as Google Scholar and Scopus, to classify journals according to their productivity and the number of citations they receive in order to indicate the impact, prestige, or influence of journals [24]. The search engine chosen for this search was WoS. Initially, after selecting papers from WoS, the data analysis was carried out using HistCite. This program is another used to carry out this research and is a software system that generates chronological maps of bibliographic collections. These collections are grouped together by topic, author, institution, or source journals or vocabulary from WoS export files [17,25]. The third part of this search was performed by VOSviewer. VOSviewer is an open-source software developed to build and visualize bibliometric maps. Showing a map in different ways and focusing on a different aspect of the map are a few capabilities of this [26].

3. Literature Review Findings

3.1. Top 15 Most Frequently Cited Papers

Due to complete systems thinking, i.e., the basic cooperation between the stakeholders and the need for the main principles, sustainable construction is fundamentally different from traditional construction [27]. Generally, with the development and growth of construction projects as well as the growing need to resolve barriers and legal conflicts and for better integration in this industry, the number of scientific papers has also increased [28]. As previously mentioned, 153 papers published in 80 journals by 419 authors between January 2000 and April 2023 were collected as part of this study. The 15 most frequently cited WOS papers and the analysis carried out by HistCite 12.03.1 are presented in Table 1.

As it possesses various functions for analyzing and drawing bibliographic information, HistCite was used in this research to provide a list of authors of selected papers; institutions and countries that have published papers; lists of journals that have published papers; key terms, along with all sources and citations; and the number of local and global citations of papers; we also carried out data analysis according to the year of publication [28–31]. These papers were ranked according to the number of citations as a critical indicator, demonstrating the quality of the search. While the search period started in 2000, the first papers in this section were published in 2011. That year, two highly cited publications were published. Hakkinen and Belloni emphasized that sustainable construction is not impeded by the lack of technology and assessment methods; on the contrary, it is faced with organizational and procedural difficulties related to the adoption of new methods [32].

In another 2011 paper, Robichaud and Anantatmula provided specific modifications to conventional construction practices to maximize the delivery of sustainable and cost-effective construction services, such as green construction projects [33]. These two papers are among the first papers in Table 1, which are the most cited, and it seems that this year can be considered a turning point of attention to this field. As shown in Table 1, there have been numerous papers focusing on the topic of sustainable construction and the approach of identifying barriers affecting optimal implementation, acceptance barriers, and drivers [34–39]. Undoubtedly, the occurrence of barriers in the implementation of any project causes time delays, financial losses, and environmental damage [5,8,40,41]. The focus of researchers on these areas of research shows that stakeholders are interested in optimum implementation and proper functioning throughout the long life of the project [12].

3.2. Keyword Co-Occurrence Analysis

Since the introduction of computer technology, computerized data processing has become common among researchers, which has prompted the development of bibliometric software [15]. One of these softwares is VOSviewer. The VOSviewer 1.6.20 software was used for the scientometric analysis in this research. It is capable of drawing co-occurrence maps of authors, institutions, and keywords. The following analyses were conducted to identify research patterns: keyword co-occurrence analysis and author co-citation analysis. These two analyses provide a general description of the research area before clustering analysis [15,26].

Table 1. The 15 most frequently cited papers from WOS and HistCite.

Rank	Paper Title	Journal	Reference Count	Citation Count	Year	Ref.
1	Barriers and drivers for sustainable building	*Building Research and Information*	78	319	2011	[33]
2	Greening Project Management Practices for Sustainable Construction	*Journal of Management in Engineering*	22	313	2011	[34]
3	Green building project management: barriers and solutions for sustainable development	*Sustainable Development*	23	237	2012	[42]
4	Project management knowledge and skills for green construction: Overcoming challenges	*International Journal of Project Management*	44	233	2013	[43]
5	Investigating the awareness and application of sustainable construction concept by Malaysian developers	*Habitat International*	31	213	2010	[44]
6	What is stopping sustainable building in England? Barriers experienced by stakeholders in delivering sustainable developments	*Sustainable Development*	27	192	2007	[45]
7	Identifying the critical factors for green construction—An empirical study in China	*Habitat International*	59	177	2013	[46]
8	Critical analysis of green building research trend in construction journals	*Habitat International*	87	176	2016	[47]
9	Critical success factors of sustainable project management in construction: A fuzzy DEMATEL-ANP approach	*Journal of Cleaner Production*	93	149	2018	[48]
10	Factors affecting the implementation of green specifications in construction	*Journal of Environmental Management*	46	126	2010	[49]
11	Review of Barriers to Green Building Adoption	*Sustainable Development*	74	120	2017	[50]
12	Sustainable construction and drivers of change in Greece: A Delphi study	*Construction Management and Economics*	21	111	2006	[51]
13	Circular economy and the construction industry: Existing trends, challenges, and prospective framework for sustainable construction	*Renewable & Sustainable Energy Review*	101	103	2020	[52]
14	Strategies for Promoting Green Building Technologies Adoption in the Construction Industry-An International Study	*Sustainability*	79	97	2017	[53]
15	Awareness, Actions, Drivers, and Barriers of sustainable construction in Chile	*Technological and Economic Development of Economy*	28	89	2013	[40]

The co-occurrence network of keywords of sustainable construction barriers in the 2000–2023 period. Figure 1 shows that the keywords with the highest frequencies include "barriers" (49 times), "sustainable construction" (45 times), "sustainability" (35 times), "management" (29 times), and "drivers" (25 times). Other high-frequency keywords included "construction industry", "industry", "design", "framework", "sustainable development", "awareness", "performance", "energy", "challenges", "implementation", "critical success factors", "green building", and "risk". The regions involved mainly included China, Singapore, and Nigeria. Keywords were identified in 53 cases, and more than 83% of the literature had keywords with more than five occurrences. This indicates that keywords in the sustainability literature have acceptable centrality.

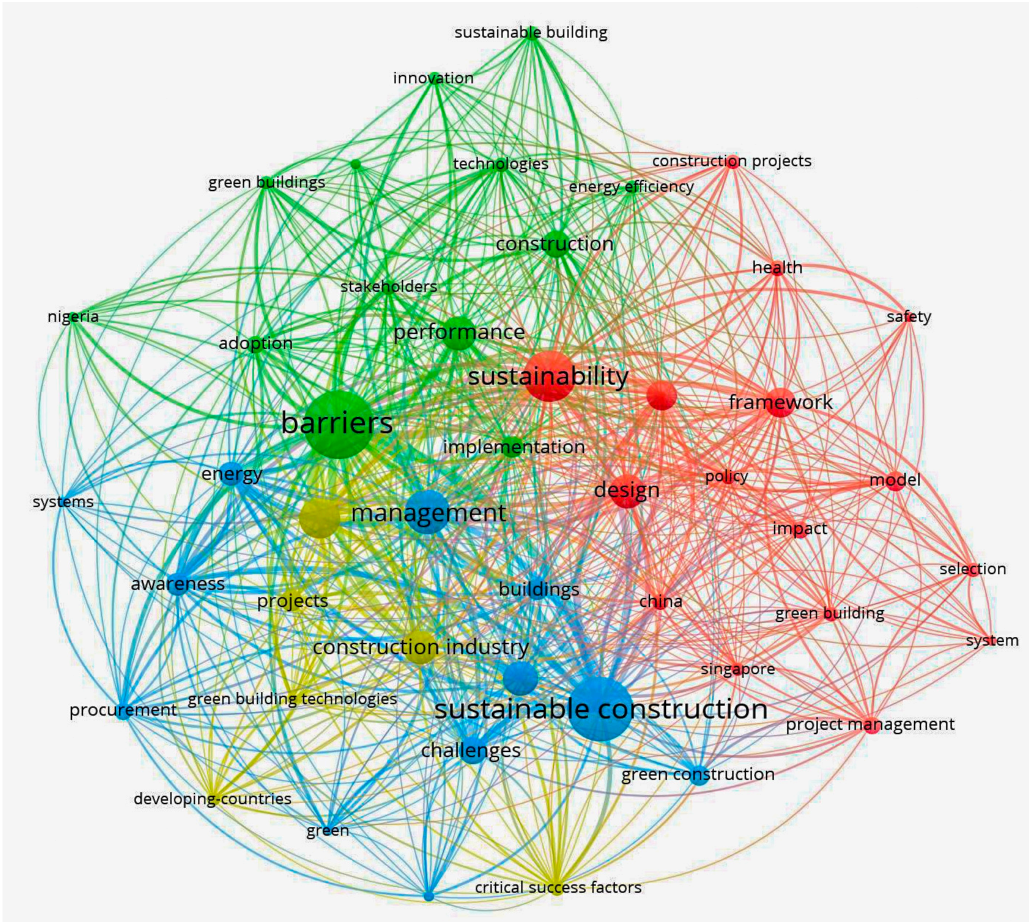

Figure 1. Keyword co-occurrence analysis.

3.3. Top 15 Institutions for Producing Papers

An initial WOS search obtained 153 documents including 113 (73.86%) papers, 13 (8.5%) proceeding papers, 10 (6.54%) reviews, and 9 (5.88%) book chapters. The first 15 institutions producing the most papers and receiving the most citations (including the University of Johannesburg (UJ), the National University of Singapore (NUS), the Hong Kong Polytechnic University (PolyU), RMIT University (RMIT), the Federal University of Technology Akure (FUTA), Islamic Azad University (IAU), Universiti Sains Malaysia (USM), the American University of Sharjah (AUS), the Ara Institute of Canterbury (AIC), Birmingham City University (BCU), Northumbria University (UN), Southeast University (SU), the University of Minho (UM), the University of Tehran (UT), and the Canadian International College (CIC)) are reviewed and presented in Figure 2.

The survey shows that the University of Johannesburg is in first place, producing 15.1% of papers, but the citation rate of these publications is 6.5%. The Natl University of Singapore was second with a 13.7% share in paper publication. However, the proportion of citations was much higher, at 31.4%. In third place was the Hong Kong Polytechnic University, with an 11% share in paper publications, and their 26% citation rate deserves attention. A total of 87% of all papers were published by universities, indicating that this topic is a topic of interest for university researchers.

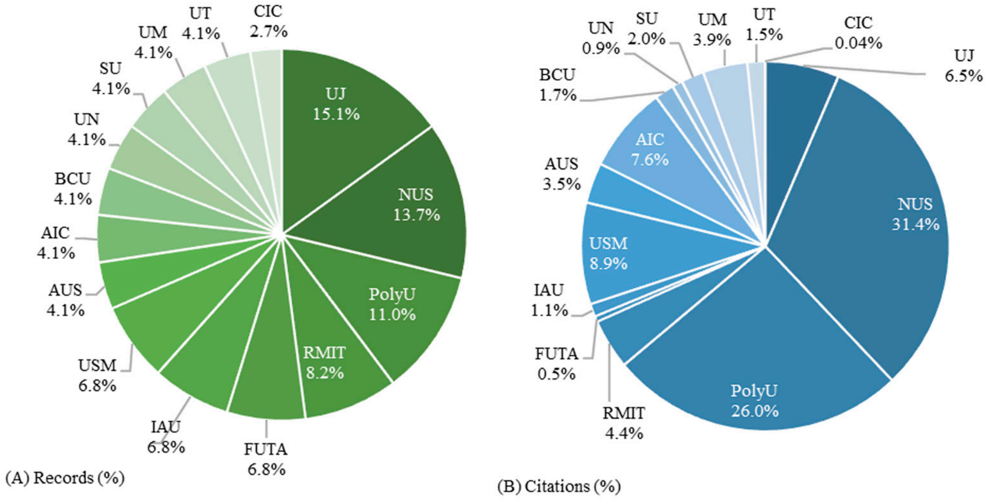

Figure 2. Top 15 institutions in publishing papers and citations (subfigures (**A**,**B**) illustrate the publications' records and citations according to the universities, respectively).

3.4. Top 15 Journals

The influence of a research publication in a particular field can be reflected in several deserved citations whose highly cited papers are recognized as important milestones [14]. Also, the volume of research publications in a particular research area may be proportionate to the scope of industry policies and practices in the specific research area [41].

The following table presents the top 15 journals publishing research in this area. Table 2 indicates the number of papers published, the citation rate, the impact factor, the H-index, the impact score, and the quartile of each journal. As can be seen, the *Journal of Sustainability*, while ranked Q2 in terms of quartile, is a leader in this area as it has publishing 18 papers. In addition, the *Journal of Cleaner Production* ranks second, having published 10 papers. Although quartiles rank the journals from highest to lowest based on their impact factor or impact index, this research shows that Q2 journals like *Sustainability* received high numbers of citations as well as accepting and publishing more papers. The WOS and Scopus databases use an impact factor to classify journals. In addition, the H-index is calculated by counting the number of publications for which an author has been cited by other authors on at least the same number of occasions [24].

3.5. Author Co-Citation Analysis

The number of citations received by a researcher is used to determine their impact on a subject matter [14]. To illustrate the bibliometric network, the term "Co-Authorship" was used for the type of analysis, "Author" for the unit of analysis, and "Full counting" for the counting method; this is shown in Figure 3.

Hwang is the most prolific author in this field with 10 papers, 710 citations, and a total link strength of 10. From 2012 to 2020, this author conducted extensive research in the areas of sustainable development and sustainable construction. In the first year, he published a paper on the recognition of barriers and providing practical solutions for sustainable development [42]. Darko is in second position with 4 papers and 477 citations. He published "Review of Barriers to Green Building Adoption" in 2017 [43]. Some of the most influential researchers in this field include Chan, Shi, Zou, and Abidin. These four investigators have 296, 223, 211, and 211 citations, respectively, with two papers each.

Table 2. Top 15 journals in the WOS database.

Rank	Journal	Documents	Citation	Impact Factor	h-Index	Impact Score	Quartile	Publisher
1	*Sustainability*	18	397	3.889	109	4.17	Q2	MDPI
2	*Journal of Cleaner Production*	10	432	11.072	232	10.96	Q1	Elsevier
3	*International Journal of Construction Management*	5	84	3.097	31	3.83	Q2	Taylor and Francis
4	*Smart and Sustainable Built Environment*	5	52	2.054	20	3.47	Q3	Emerald
5	*Sustainable Cities and Society*	5	224	10.696	82	11.03	Q1	Elsevier
6	*Environmental Science and Pollution Research*	4	55	5.19	132	5.03	Q1	Springer
7	*Journal of Engineering Design and Technology*	4	51	1.47	26	2.48	Q2	Emerald
8	*Journal of Green Building*	4	20	0.906	24	1.31	Q2	College Publishing
9	*Sustainable Development*	4	548	8.562	70	7.88	Q1	John Wiley and Sons
10	*Building Research and Information*	3	411	4.967	92	4.97	Q1	Taylor and Francis
11	*Engineering, Construction and Architectural Management*	3	37	3.85	63	4.08	Q1	Emerald
12	*Environment, Development and Sustainability*	3	54	4.08	62	4.35	Q1	Springer
13	*Habitat International*	3	564	5.205	89	5.35	Q1	Elsevier
14	*Architectural Engineering and Design Management*	2	7	2.567	32	2.57	Q1	Taylor and Francis
15	*Construction Management and Economics*	2	118	3.796	99	4.05	Q1	Taylor and Francis

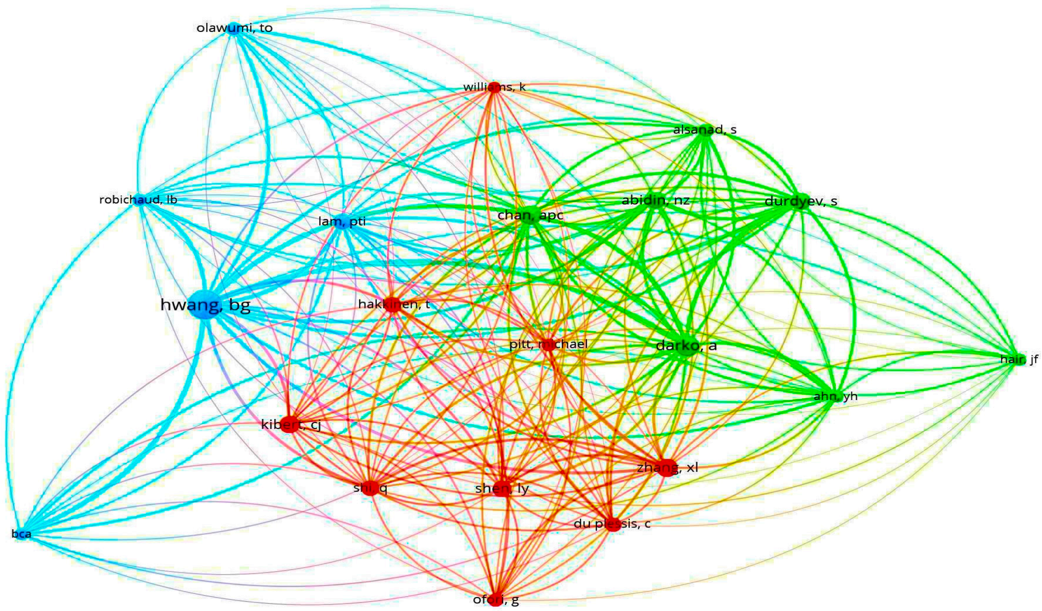

Figure 3. Author co-citation.

3.6. Countries' Contributions to Papers on Sustainable Construction Barriers

This scientific field has seen greater contributions from some countries than others over time. VOSviewer 1.6.20 was used to create a network diagram of the top 15 countries that produced papers. The visualization network was created to enable readers to view countries dedicated to solving sustainable construction barriers. "Citations" were selected as the "type of analysis" and "countries" as the "unit of analysis". The minimum number of research papers produced for each country was set at 3.

The 15 top countries in terms of publications and citations in the current study area are listed in Figure 4. Of the total 53 countries that have published research papers on sustainable construction barriers, almost 14 countries have contributed more than four research papers on sustainable construction barriers. The four top contributors, with 28, 20, 19, and 17 research papers each, were China, Australia, the USA, South Africa, and the UK. In addition, China leads the list of countries with the most citations, at 1087, while the United States and the United Kingdom rank third and fifth with 645 and 577 citations. Although second place is taken by Singapore with 757 citations, as it has produced only 10 publications, this is a surprise. Iran and Nigeria are in the middle of the list, with seven and nine papers and 52 and 57 citations, respectively, and at the bottom of the list, Saudi Arabia, Turkey, and the UAE are ranked 13th to 15th.

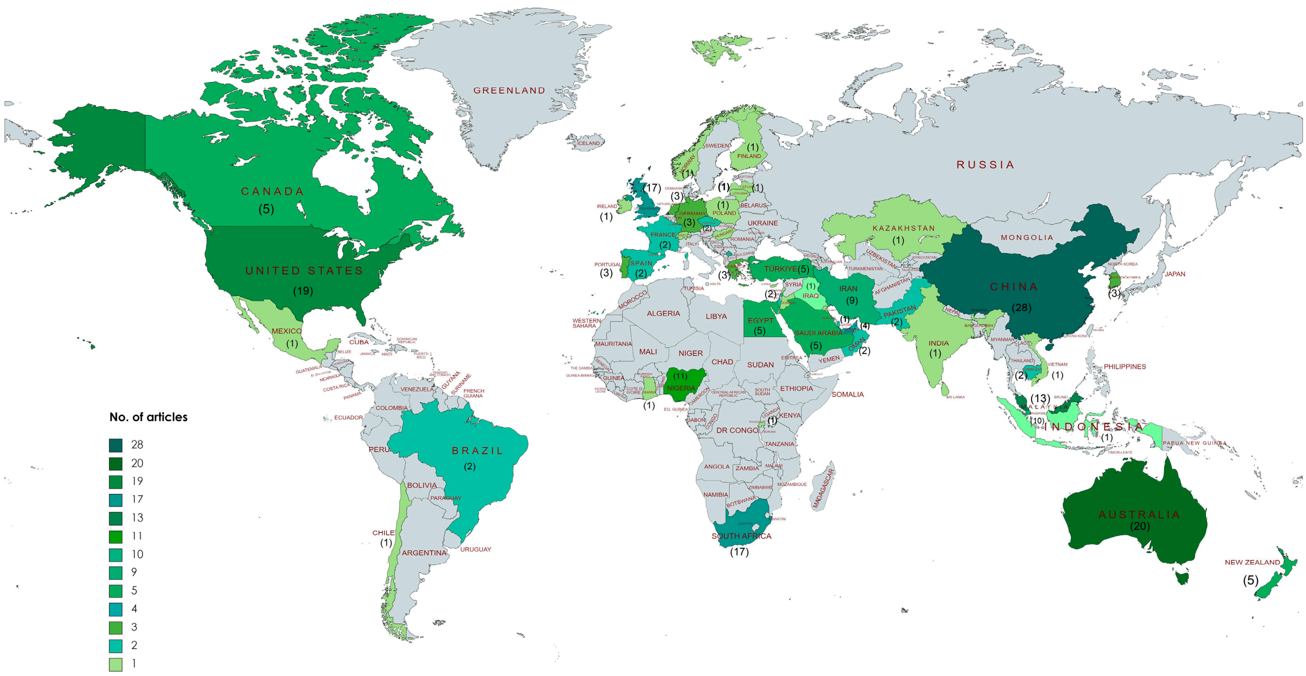

Figure 4. Country contributions.

3.7. Annual Publication and Citation Trends in the Field of Sustainable Construction Barriers

This research examines the trend of annual publications and citations in the field of investigating the barriers to sustainable construction in the period from January 2000 to April 2023. As shown in Figure 5, the first research in this field was started in 2000 by Bon and Hutchinson. They investigated the economic barriers to building sustainability [44]. Vanegas and Pearce presented a paper on the drivers of change in structural stability at the 6th Building Congress [45]. In 2002, Van Bueren and Priemus published a paper titled "Institutional barriers to sustainable construction" [46]. In the first decade of research, in the years 2001, 2003, and 2008 no studies in this area were undertaken and no papers were published; however, in the years 2005, 2006, 2007, 2009, and 2010, 13 studies were carried out. In these years, research on issues such as environmental barriers and design in sustainable structures [47,48]; planning for the implementation of sustainable construction [49]; examining drivers for change [50]; barriers experienced by stakeholders [51]; barriers such as financial risk; and strategies and influencing factors in the implementation of sustainable structures [52,53] was carried out. It is worth noting that in the research conducted in 2009, the examination of the barriers in the field of building sustainability was highly regarded. This research was conducted in various countries throughout Asia and Europe such as India, England, the Czech Republic, France, and the Netherlands [54–57]. "Barriers and drivers for sustainable building", written by Hakkinen and Belloni in 2011, is considered one of the most popular papers in this field [32]. It seems that with this paper, the field of building sustainability was welcomed again. This paper is most cited, next to "Greening Project Management Practices for Sustainable Construction", which was published by Robichaud and Anantatmula in 2011 [33]. Since 2012, research and the publication of papers has continued. The main topics in recent years have been barriers and limitations, issues and barriers, safety risks, preventing claims caused by barriers, awareness and action in overcoming barriers, and investigation opportunities. The content of papers has moved away from introducing and identifying the field of research, as was common in the early years, to providing solutions, which became popular during the middle period of research, with constructive suggestions for a more secure future being focused on in recent papers. The years 2020 and 2021, with 45 publications, can be considered the most productive years in this 23-year period, demonstrating the importance of investigating and recognizing barriers and providing solutions for correction and suggestions for prevention in the future. In summing up this section, it should be mentioned that from 2000 to 2023, 153 papers were published in this field in total, which were cited 5017 times. The average citation number per item is 32.79, and the average H-Index is 35.

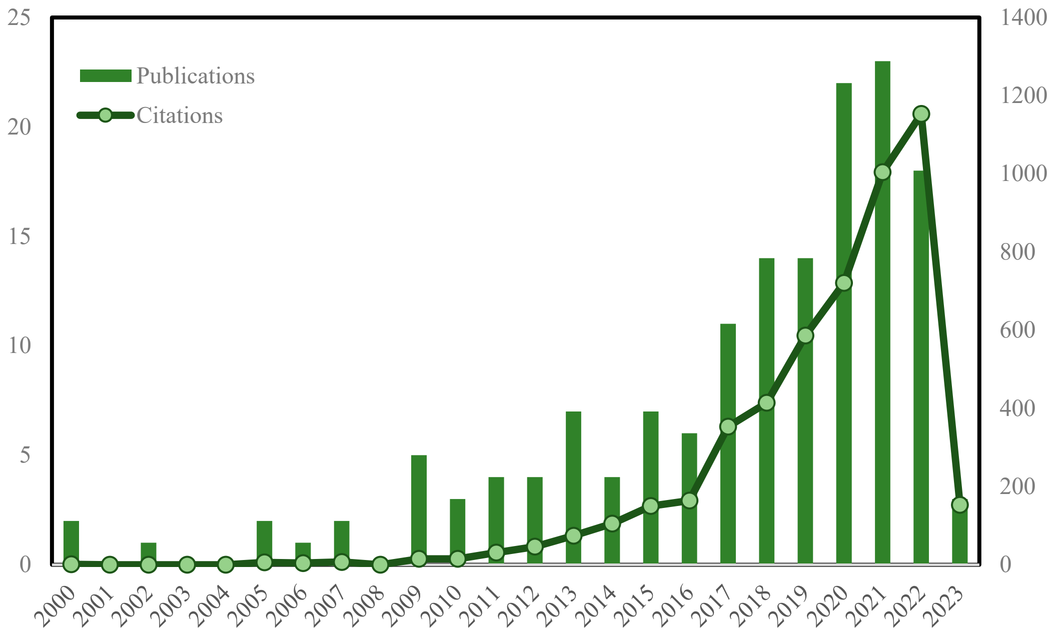

Figure 5. Annual publication and citation trends of published papers.

4. Discussion of Literature Review and Analysis Findings

Sustainable development and, by extension, sustainable construction are evolutionary concepts whose implementation is based on developing regional and local approaches and solutions [49]. Sustainable construction projects are at greater risk than standard projects [58,59]. The emergence of risks is a barrier to the proper implementation of sustainability objectives in construction. As a result, it is important to identify and assess risks and to have appropriate planning and control measures in place for facing barriers [58,60]. These barriers have typically been grouped into several areas like management; technical regulations; environmental barriers; sustainable teams; contractual factors; rules and economic concerns; institutional levels; a lack of client funding; inadequate or erroneous information on sustainable design; design changes; unreasonably tight timelines for sustainable construction; complex procedures for obtaining approvals; inflation; the durability of green materials; overlooked high initial cost and overall project costs; damage caused by human error; the accessing of sustainable materials and equipment; and the misinterpretation of the scope sustainable construction [6,11,27,57,60–62].

The goal of sustainable construction practices is highly correlated with a cost-effective and competitive construction industry, improved customer satisfaction, and efficient use of resources [63]. However, there is insufficient focus on sustainable construction practices around the world. Sustainable construction has provoked various reactions in different countries. The idea of sustainability was likely intuitively understood by early human civilizations, such as the South African Bushmen [7]. However, the acceptance of this significant change in the construction industry has not been the same everywhere. Reviewing feedback on the implementation of sustainable building in different countries can clarify the discussion. Due to political volatility in Yemen, although the construction sector is moving forward to address the country's housing needs, traditional construction methods are commonplace and it is not yet possible to construct buildings in a sustainable, economically feasible, socially responsible, and ecologically beneficial manner [64]. In Kosovo, surveys have noted that not only is the concept of sustainability not present or incorporated into urban planning legislation but regulations also do not cover the ecological labeling of building materials [65]. In more developed countries like Hong Kong and Nigeria, in spite of many barriers in implementing sustainable construction, stakeholders have found that deploying digital systems has helped improve building construction processes [66]. A study from England demonstrates that there has been both downward and upward pressure to deliver a sustainable built environment [51]. A study carried out in India revealed that there is an awareness of green building practices. Although these are driven by governmental and international regulations, they have faced many barriers [57]. Environmental performance and benefits for both end-users and investors are necessary for sustainable buildings to become mainstream [53]. In Oman, a country with a fast-growing construction industry, the introduction of sustainable construction is a major challenge. The lack of demand for green construction and the lack of governmental pressure have been major barriers in this area [67]. One of the areas of the world that requires more sustainable building is the Middle East and North Africa (MENA) region. Although the MENA region is one of the fastest developing areas in the world, it has been the slowest to implement sustainable construction practices [27]. In Nigeria's construction industry, to enhance the sustainability of construction projects, the implementation of strict government policies on sustainable construction and leaving the traditional method of building in favor of innovative methods aimed at sustainable development became necessary [63,68].

The implementation of sustainable construction in developing countries requires special economic and social attention and the globally efficient practices of the construction industry to be achieved [39,55]. In developing countries such as Iran (which has few resources), the existence of various sustainable materials with particular characteristics makes decisions more difficult for project teams. Although the expansion of sustainable buildings is regarded both as an effective method for energy consumption and as an important strategy in the construction industry, due to a lack of knowledge and awareness, as well as project context, investment levels, uncertainty, and permission barriers, these technologies have not been successful in attracting the attention of developers and buyers [11,69–72]. In the process of implementing sustainable buildings, it has been demonstrated that despite their relative acceptance in the construction industry in different parts of the world, there are several concerns about how to implement them as well as any feedback on them. Many of these concerns relate to the barriers in this area. Many stakeholders are still unaware of these barriers, so the best thing to do is identify these barriers and plan to address them. Research into identifying these risks can be a great help in finding and managing them correctly. Table 3 presents a summary of the barriers to sustainable building in twelve classifications. These groups include price, economic parameters, awareness, technical, policy and regulations, design, management and government, environmental, social, material, planning, and market.

Table 3. Overview of the barriers to sustainable construction.

Category	Barriers
Cost	High cost premium [73], lack of funding [74,75], fear of the increased cost of investment [76], high initial cost for materials and overall project costs [27,77], long payback period [78], fear of the cost of adopting sustainable construction [1], maintenance cost [79], estimating the operational and functional costs [80], extra costs [81], real and perceived costs [51], other financial restrictions [82], inadequate cost data [76], lack of financial incentives [39]
Economic Parameters	Economically feasible [64], inflation [36,83,84], currency and interest rate volatility [83], budget limitations [85], poor economic conditions [82]
Awareness	Lack of awareness [1,27,36,38,39,63,74,86–89], lack of understanding and information for all stakeholders [75], lack of information and professional knowledge about new techniques [75], damage caused by human error [83]
Technical	Lack of experience [60,90], skills, and technical know-how [63,66]; lack of training and education [36,90]; contractual barriers [91]; lack of professionals to handle a task [63]; technology standards barriers [92]; workforce expertise [66]; hesitancy to change working practices [66]; more complex and unfamiliar construction techniques and procedures [86]; complexity of using new technology such as AI and big data [73]
Regulations and Policies	Insufficient/inconsistent/complex policies and regulations [44,74], lack of urban and construction policy [63], legislations or legal requirements [88,92,93], complex procedures to obtain approvals [62]
Design	Design changes [2,58,59], adequate design flexibility [94], designers' and contractors' inexperience [27], lack of professional capabilities/designers [34,95], insufficient or incorrect sustainable design operation [58,59], resistance to change [74,76,88,96], level of experience of consultants [97], poor communication among designers [96], lack of sufficient sustainability modules in the education of interior architects/designers [90]
Managerial and Governmental	Lack of comprehensive governmental standards and procedures [94], failure to support institutions to create an effective application of sustainability guidelines [92], shortage of incentives and commitment by leadership [74], conflicts in institutions influencing the decision-making in the building sector [32,75,98,99], lack of pressure by government [67], client preferences [76], communication/coordination between key parties [97], lack of government incentives [73,81,100], lack of government enforcement [95], managerial constraints [101], incompetence of project managers [100], lack of a systematic approach to pursuing sustainability goals [11]
Environmental	Insufficient cooperation among practitioners [11], research institutions and environmental organizations [11,89,92], energy conservation measures, resource conservation strategies and waste reduction [50], lack of environmental concern [102]
Social	Speed of decision-making by client and all project teams [97], communication/coordination between key parties [97], unclear requirements by owners [62], employment constraints [62], lack of interest and demand [43,75], environmental and social responsiveness dimensions [103], social influences [35], conflicts of interest among stakeholders [81], scientific infrastructure [85], cultural and geographical aspects [85], corruption [36], unequal distribution of benefits [42], steering mechanisms [32]
Materials	Complex supply chain management and procurement [104], lack of availability of green materials and equipment [62], durability of green materials [58,83], shortage of green materials [58,83], alternative materials in a variety of contexts [13], material selection [87,105], poor quality [83], limited sustainable materials [100], lack of sustainable waste management [106], unavailability of sustainable materials and equipment [77,107]
Planning	Inadequate proactive plans [102], planning and sequencing of work [2], project delays [2,102]
Market	Absence of historical data and exemplary projects [63], lack of demand for green construction [67,75], lack of professional liability [108], project delays [2,97], tendency to maintain current practices [109], integration of urban metabolism [105], lack of demonstration projects [34], lack of a systematic approach to pursuing sustainability goals [11,71]

4.1. How Barriers Impact Sustainable Construction

Sustainable construction is a critical component in reducing environmental impacts and promoting energy efficiency. However, the adoption of sustainable practices in construction faces significant barriers. These barriers are multifaceted, involving various aspects that hinder the widespread implementation of sustainable construction techniques. Understanding how these barriers affect the environmental sustainability of construction projects helps facilitate the engagement of policymakers and project managers in effectively addressing them. Therefore, this section explores the impact of barriers to sustainable construction based on each group.

Cost barriers: One of the most cited barriers is the perceived higher initial costs associated with sustainable construction, known as the 'green cost premium'. This includes the costs of sustainable materials and technologies, which are often higher than traditional options [82–84]. Furthermore, in developing countries, there is a notable lack of financing schemes to support the implementation of energy management technologies, which is a significant barrier to adopting sustainable practices [110]. Besides this, in the commercial real estate market, issues such as the split incentive, where the benefits of energy savings do not directly pass to the investors, and leverage barriers make sustainable investments financially irrational for building owners [89–91]. Moreover, the selection of sustainable materials often results in higher initial costs and construction delays, posing a challenge in justifying these decisions to stakeholders [111].

Economic parameters: This group involves institutional, financial, and market-related factors that hinder the widespread implementation of sustainable methods. Despite the technological potential for sustainable construction, these economic barriers often prevent its full realization. In countries like France, the UK, and the Netherlands, institutional barriers such as traditional contracting methods and professional identities impede sustainable construction. These barriers are deeply rooted in the decision-making processes and organizational structures of the construction industry [62]. In developing regions like North Cyprus, the absence of government policies on sustainability leads to reliance on traditional construction methods. This lack of policy support is a significant barrier to adopting sustainable practices [112]. In Yemen, macroeconomic problems such as unemployment, inflation, and an inequitable balance of payments exacerbate the economic barriers faced by the construction industry, making it difficult to prioritize sustainable practices [71,74]. The construction industry struggles to communicate the benefits of clean technologies to potential buyers, which affects market demand. This is a significant challenge in promoting energy-efficient technologies in residential buildings [91,92].

Awareness barriers: These barriers hinder the environmental sustainability of construction projects by limiting stakeholders' understanding of sustainable practices and their benefits. In Nigeria, for instance, low awareness level among building professionals directly impacts the implementation of environmentally sustainable practices, leading to detrimental effects on construction projects' sustainability [113]. Conversely, Malaysia exhibits a moderate awareness level, which still poses barriers for the effective adoption of sustainable construction methods (ibid). Moreover, contractors' awareness of environmental management systems, such as ISO14001:2004, is crucial for promoting sustainable practices; a lack of awareness can prevent effective implementation [114,115]. Additionally, stakeholders often struggle with understanding the implications of environmental regulations, which further complicates their ability to integrate sustainability into capital projects [84]. This lack of awareness extends to the potential benefits that sustainable approaches can offer, resulting in missed opportunities for enhancing project outcomes and commitment to environmental sustainability (ibid). Therefore, addressing these awareness barriers is essential for fostering a more sustainable construction industry [1,27,36,38,39,63,74,86–89].

Technical barriers: These barriers in construction impact the environmental sustainability of projects by complicating compliance with increasingly stringent environmental regulations and standards. These barriers include design complexities, material limitations, and the need for regulatory compliance, all of which can hinder the effective execution of sustainable practices [68]. As the construction industry faces stricter environmental conservation and protection laws, it must adapt its processes to meet these requirements, which often necessitates changes in project design and execution [116]. This adaptation can lead to increased costs and project delays, ultimately affecting the sustainability goals of capital projects. However, adopting a sustainable approach can mitigate these technical barriers by integrating environmental considerations throughout the project life cycle, from planning to decommissioning. By systematically incorporating sustainability into decision-making, the construction industry can better navigate the complexities imposed by regulatory compliance and leverage opportunities for more efficient resource use [68].

Thus, while technical barriers pose significant hurdles, they also present an opportunity for the industry to innovate and enhance its commitment to environmental sustainability.

Regulations and policy barriers: This group of barriers to the sustainability of construction projects are created through complex compliance requirements that can hinder the effective implementation of sustainable practices. The construction industry, as a major consumer of natural resources, faces increasingly stringent environmental regulations and standards aimed at mitigating its impact on the environment [117]. These regulations often require adherence to specific environmental conservation and protection laws, which can complicate project planning and execution [78,79]. Moreover, the integration of sustainability objectives at both national and sector levels influences how these regulations are applied to individual projects, necessitating a tailored approach that considers unique project requirements [96,98,99]. As a result, construction companies must navigate a landscape of rapidly changing laws and standards, which can create barriers to innovation and the adoption of sustainable technologies [72]. Ultimately, while these regulations aim to promote environmental sustainability, their complexity and the associated compliance costs can pose significant barriers for the construction industry, potentially stalling progress towards more sustainable practices [55,83].

Design barriers: Architects often face barriers that hinder the incorporation of sustainable practices, which can lead to long-term negative environmental consequences [73]. The failure to transform sustainability concepts into actionable design strategies exacerbates this issue, as it prevents the effective implementation of sustainable building practices. Moreover, the sustainability evaluation procedure plays a crucial role in identifying and addressing these design barriers. A systematic assessment of sustainability, which includes both objective and subjective criteria, is essential for evaluating the performance of construction designs [95,100–102]. The choice and application of appropriate indicators are vital, as they link measurable parameters to the overall sustainability of the built environment. Ultimately, the decisions made during the design phase, influenced by these barriers and evaluation methods, have profound implications for the environmental outcomes of construction projects. Educating architects about these issues is critical to fostering a more sustainable approach in the building sector [66,67].

Managerial and governmental barriers: Managers face various barriers that hinder effective decision-making and resource allocation, which are crucial for implementing sustainable practices [118]. These barriers are compounded by governmental regulations that can either promote or restrict sustainable construction practices, creating a complex landscape for compliance and innovation [102–107]. Moreover, government legislation acts as a catalyst for the sustainable movement in construction, pushing companies to align their processes with sustainability goals [83,84]. However, barriers from clients, such as unrealistic demands and expectations, can further complicate the adoption of sustainable practices, representing a significant challenge for both managers and policymakers [73]. To navigate these barriers, top management involvement is essential. Leadership commitment is crucial for promoting environmental management systems, which can help overcome managerial hurdles and enhance sustainability efforts within the industry [105,118].

Environmental barriers: Construction activities are major contributors to air, water, and noise pollution, which collectively degrade environmental quality and public health. Air pollution arises from emissions generated during construction, adversely affecting air quality and contributing to health issues in surrounding communities [119]. Similarly, water pollution occurs when improper discharge from construction sites contaminates local water bodies, threatening ecosystems, and human health (ibid). Noise pollution, another critical concern, disrupts the surrounding environment, leading to disturbances that can affect both wildlife and human populations [94]. Moreover, the identification and prioritization of environmental risk issues are essential for mitigating these impacts. By recognizing the specific activities that pose the greatest environmental threats, construction projects can implement strategies to minimize their ecological footprint [98,108]. The construction industry, while vital for infrastructure development, must adopt sustainable practices to address these environmental barriers effectively, thereby improving overall environmental performance and aligning with sustainable development goals [94,98,119].

Social barriers: Issues such as poverty, a lack of education, and insufficient community engagement can hinder progress in these projects, leading to suboptimal environmental outcomes [120]. Moreover, stakeholder satisfaction plays a crucial role in achieving social sustainability, which is intrinsically linked to environmental sustainability. When the needs of diverse stakeholders are met, a collaborative environment that supports sustainable practices is fostered [102]. Effective community engagement is essential for this collaboration, as it ensures that local stakeholders are involved and are supportive of the project, further enhancing its sustainability outcomes [109,121].

Materials barriers: These barriers significantly impact environmental sustainability through various dimensions, primarily in material selection and sourcing. The choice of materials directly influences the embodied impact, which encompasses the total environmental effects associated with their production and supply [111]. Life cycle assessment (LCA) serves as a critical methodology to evaluate these impacts, helping stakeholders understand how material choices affect sustainability throughout the construction process [122–124]. However, selecting environmentally sound materials poses barriers, as conventional materials often rely on energy-intensive and non-renewable resources, complicating efforts to adopt sustainable practices [123]. Additionally, justifying the use of locally sourced materials can lead to higher costs and potential construction delays, further complicating the decision-making process [72]. Responsible sourcing is essential in this context, as it involves obtaining materials while considering their environmental and social impacts, thereby enhancing overall sustainability [111].

Planning barriers: These barriers significantly impact the environmental sustainability of construction projects by complicating the integration of sustainability goals within urban development. These barriers can delay project timelines and increase costs, ultimately hindering the adoption of sustainable practices [125,126]. A sustainable approach to capital projects necessitates a comprehensive strategy that considers minimal resource use and environmental impact throughout all stages of construction, from planning to decommissioning [2]. Infrastructure providers often face internal dissonance, as they must balance the push for sustainability with existing institutional behaviors that resist change [108]. This resistance can manifest in conflicts over material selection, where the justification for using locally sourced materials—often more expensive and time-consuming—becomes a significant hurdle [108,125]. The challenge lies not only in the financial implications but also in fostering cohesive decision-making that aligns sustainability goals with practical implementation strategies. Addressing planning barriers enables stakeholders to navigate the complexities of modern construction demands while promoting innovative and sustainable solutions [126].

Market barriers: The absence of historical data and exemple projects creates a knowledge gap, making it difficult for companies to adopt effective sustainable practices [127]. Additionally, the lack of demand for green construction further hinders the industry's transition towards sustainability, as market incentives are crucial for driving change [111,128]. Professional liability concerns also play a critical role, as the fear of legal repercussions can deter construction professionals from implementing innovative sustainable solutions [11]. Moreover, project delays disrupt the timely integration of sustainability measures, leading to increased resource consumption and inefficiencies [4]. The tendency to maintain current practices reflects a broader resistance to change within the industry, which can impede progress towards sustainability goals [73,77,129]. This reluctance is compounded by a lack of demonstration projects and a systematic approach to pursuing sustainability, which are essential for showcasing the benefits and feasibility of sustainable construction methods [127,130–133]. Collectively, these barriers underscore the need for a comprehensive framework to facilitate the integration of sustainability into the construction market.

Thus, it can be seen that the pursuit of sustainable construction has many barriers that stakeholders must confront. Together, these constraints create a complicated environment that must be discussed to better the sustainability of building projects, underlining the need for improved awareness, data, and coordination among stakeholders.

4.2. Strategies for Overcoming the Barriers to Sustainable Construction

To fulfil essential objectives, each profession must develop strategies to overcome the barriers and challenges [122]. Overcoming these barriers requires a multifaceted approach that integrates various strategies. Numerous scholars have proposed diverse strategies to overcome obstacles to sustainable construction. Overall, strategies for overcoming sustainable construction barriers can be categorized into four primary factors: financial [133], technical [63], legal [44], and managerial [100] barriers. These strategies significantly enhance the widespread adoption of sustainable construction methods.

Strategies for overcoming financial barriers. One effective method is the development and utilization of a 'funding toolkit', which assists local authorities in managing and overcoming funding challenges. This toolkit is designed to address the barriers related to the funding process and the availability of both revenue and capital funding, which often hinder the effective implementation of sustainable projects [133]. In addition, leveraging 'government incentives' and 'subsidies' can significantly alleviate financial burdens. These incentives encourage investment in sustainable construction by making projects more financially attractive to stakeholders [73]. Furthermore, engaging in 'public–private partnerships' can provide additional funding and resources, enhancing the financial viability of these projects. Such collaborations can allow the pooling of resources and the sharing of risks, making it easier to tackle the upfront costs associated with sustainable construction [41]. Exploring 'innovative financing models', such as green bonds or crowdfunding, also represents alternative funding sources that can support sustainable initiatives. These models can attract a diverse range of investors who are interested in supporting environmentally friendly projects [133]. Additionally, providing a 'guidance note for funders' can help stakeholders understand the specific barriers faced by local authorities and offer recommendations for alleviating these challenges. This targeted strategy can streamline funding processes and improve access to necessary financial resources [92]. A 'sustainability-oriented approach' is crucial for integrating sustainability principles into business practices, which can transform environmental and social liabilities into financial opportunities. By adopting this approach, organizations can enhance their economic prospects while ensuring environmental protection [6]. Moreover, focusing on 'resource productivity'—the efficient use of materials and a reduction in waste—can lead to lower production costs, directly addressing financial barriers in sustainable construction [13]. Implementing 'energy-efficient designs' further reduces operational costs, making projects more attractive to investors by demonstrating long-term savings potential [91]. Lastly, conducting a 'circular economy strategy' helps justify initial investments by showcasing the long-term financial benefits of sustainable construction [134].

Strategies for overcoming technical barriers. One of the most effective strategies is the adoption of industrialized construction methods, which 'utilize standardized technologies' to improve efficiency and reduce waste. This approach not only minimizes labor and material resources but also addresses sustainability challenges in construction practices, as evidenced by studies carried out in the Netherlands and Chile [92]. Innovation plays a critical role in this context, as 'developing new technologies' and methods can effectively tackle the technical challenges associated with sustainable construction [76]. For instance, the 'implementation of building information modeling (BIM)' can significantly enhance information management and support lifecycle thinking, which is essential for sustainable building delivery [135]. BIM facilitates better the planning and execution of construction projects, thereby reducing errors and improving overall sustainability outcomes. Another key strategy is the use of 'prefabrication techniques', which can substantially decrease construction time and costs while maintaining quality and sustainability standards [136]. By employing prefabricated components, construction projects can achieve greater efficiency and resource productivity, ultimately leading to lower production costs and reduced waste. This aligns with the broader goal of increasing resource productivity through the efficient use of materials, which is vital for overcoming technical barriers in sustainable construction [6]. Moreover, addressing low levels of technical skill within the workforce is crucial. Enhancing technical skills through targeted 'training programs' can equip practitioners with the necessary expertise to implement sustainable construction techniques effectively. This is particularly important in regions where the adoption of sustainable practices is hindered by insufficient education and awareness [36]. Providing comprehensive training and education for construction professionals can significantly improve their knowledge and implementation capabilities, thereby fostering a more sustainable construction environment [90].

Strategies for overcoming legal barriers. 'Regulatory frameworks' play a crucial role in shaping the adoption of sustainable construction practices by establishing legal and policy guidelines that govern the industry. These frameworks, such as the Leadership in Energy and Environmental Design (LEED) rating system and the International Green Construction Code, provide structured approaches for evaluating and certifying sustainability in building projects [74]. 'Building codes' also significantly influence sustainable construction by setting minimum standards that often include sustainability criteria. These codes can increase the energy performance of buildings and help achieve regional sustainability goals, particularly when local governments revise municipal building regulations to align with sustainable practices [63]. Furthermore, 'energy efficiency regulations' mandate the use of energy-saving technologies, which directly promote sustainable building designs [92]. Climate change policies further drive the construction industry towards sustainability by imposing 'regulations aimed at reducing carbon footprints'. These policies create a framework within which construction practices must evolve to meet environmental standards, thereby influencing the adoption of eco-friendly methods [93]. Additionally, 'building performance standards' set specific requirements for energy use and emissions, reinforcing the need for sustainable construction practices [88]. Sustainability standards, such as BREEAM and NABERS, provide benchmarks that encourage the adoption of sustainable practices through certification and recognition. These standards not only guide construction practices but also enhance market demand for sustainable buildings, creating a competitive advantage for compliant projects [44]. 'Green building certifications', like LEED, further influence industry practices by establishing a framework for assessing sustainability, which can lead to increased recognition and marketability of certified buildings [42]. Lastly, 'Environmental Management Systems (EMS)', such as ISO 14001, help organizations systematically manage their environmental responsibilities, promoting sustainable construction practices. The adoption of EMS can lead to improved environmental performance and the greater awareness of sustainability issues among contractors [87].

Strategies for overcoming managerial barriers. One of the most effective strategies is to 'promote the cost and value benefits' associated with sustainable construction. By emphasizing lower life-cycle costs and increased building value, stakeholders who may not prioritize environmental considerations can be engaged [73]. This financial perspective can help mitigate concerns regarding the higher initial investments often associated with sustainable practices, thereby encouraging broader adoption. Additionally, the implementation of 'supportive government policies and regulations' is crucial. These incentives can create a conducive environment for stakeholders to embrace sustainable construction practices, facilitating a necessary paradigm shift in the industry [67]. Without such a framework, the transition to innovative solutions may be stymied, as stakeholders often require external motivation to change entrenched practices. 'Leadership commitment' plays a pivotal role in driving this change. Effective leadership is essential for guiding organizations through the transition to sustainable practices, addressing skepticism, and fostering a culture that embraces sustainability [105]. Leaders must not only advocate for sustainability but also ensure that commitment is reflected at all organizational levels, which is vital for the successful implementation of sustainability initiatives [118]. Moreover, addressing the lack of incentives is critical. Many organizations face barriers such as insufficient education, low technical skills, and a lack of customer demand for sustainable practices. By providing targeted 'incentives and educational resources', organizations can better equip stakeholders to adopt sustainable techniques and materials, thus overcoming resistance to change [11].

As shown in Figure 6, by implementing these strategies, the construction industry can move towards more sustainable practices, ultimately contributing to environmental conservation and resource efficiency.

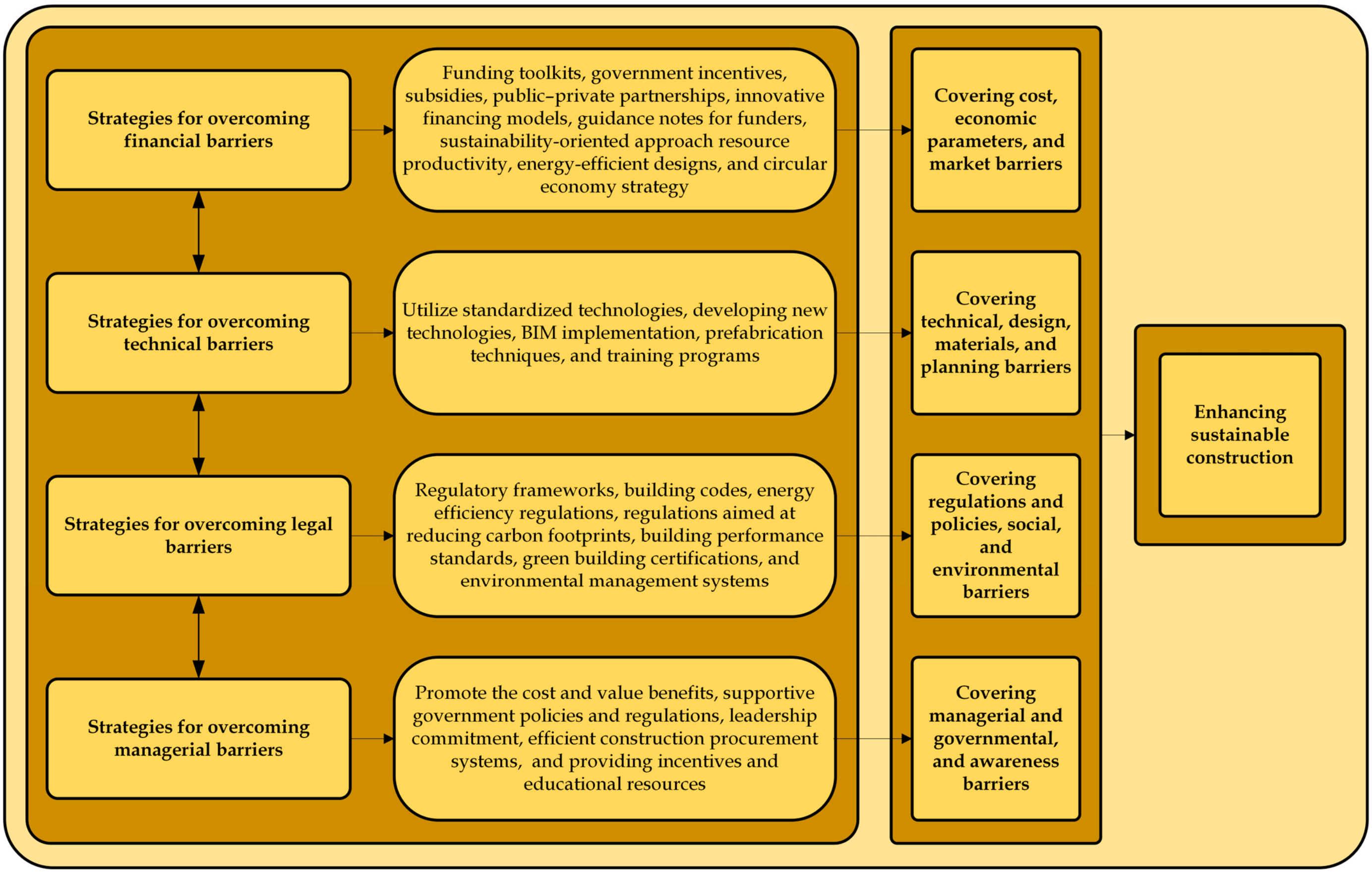

Figure 6. Strategies for overcoming the barriers to sustainable construction.

5. Conclusions

While the question of sustainability has been used in various industries for several decades and sustainable construction generates added value, it is still relatively new. There is a substantial difference between definitions, approaches, and priorities for sustainability in developed and developing countries. This technology is supported as long as energy costs are on the rise. The implementation of any technology faces many barriers and issues, and sustainable building is no exception. Many stakeholders have many concerns about the impact of implementing this issue because they are unfamiliar with the barriers of advancing it. Consequently, in-depth investigations into barriers, problems, and barriers in different phases of design, implementation, and operation, as well as clarifying the way forward for recipients, provide for the possibility of establishing an international program to recognize this category. This study shows the scope and how to deal with the topic of research in different areas. Furthermore, HistCite and VosViewer software programs are widely used in the review paper in the conduct of bibliometric studies and network drawing. Countries and institutes participating in the production of papers, top papers and authors, journals, and their characteristics are the result of the use of the software mentioned in the production steps of this paper. By analyzing the recognized barriers and assessing the literature trends on sustainable construction, future research can be delineated. Future research should prioritize the improvement of scientific assessment and the forecasting of sustainable functions within the industry. Moreover, the principal procedures and research techniques are essential for proposing solutions. Despite the nascent phase of sustainable construction, the suggested solutions advocate for the construction industry to supplant sustainable building practices with traditional construction methods in the future. Renewable energy sources, essential for future infrastructures, must be integrated into structural design, harmonize with their environment, and emphasize the health, well-being, and quality of life of forthcoming generations. To attain sustainable development, it is essential to foster the advancement of the four pillars: economic, environmental, social, and cultural, while mitigating any hurdles or obstacles that may emerge throughout this process. Moreover, artificial intelligence (AI) will imminently impact the sustainability of construction. AI will not only influence design and manufacturing processes but will also transform resource management and deliver precise forecasts of issues and obstacles within this sector. Researchers now have a significant opportunity to leverage this technology, which will facilitate expedited and more rational decision-making by minimizing human error and repetitive chores. The outcomes demonstrate that education is essential to expedite advancement for forthcoming undertakings. Furthermore, it is imperative to consider legal and contractual issues in future inquiries on obstacles and hurdles in sustainable construction. This paper can be of assistance to executives, researchers, and other stakeholders in the construction industry.

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