Cleaner Waste Systems 8 (2024) 100141

Contents lists available at ScienceDirect

Cleaner Waste Systems

journal homepage: www.journals.elsevier.com/cleaner-waste-systems

A comprehensive analysis of the barriers to effective construction and demolition waste management: A bibliometric approach

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ARTICLE INFO

Keywords:
Construction and demolition waste
Environmental sustainability
RStudio software
Bibliometric analysis
Literature review

ABSTRACT

The past few decades have witnessed a significant increase in the generation of construction and demolition (C&D) waste, posing a considerable sustainability challenge for the construction industry and environmental sustainability efforts. Due to its detrimental environmental effects, reducing C&D waste has become a crucial priority. However, the construction industry encounters various obstacles to effectively managing C&D waste. This research is centered on a comprehensive examination of these challenges. A systematic literature review was conducted, and the RStudio Bibliometrix package was used to analyze the barriers. This study thoroughly assessed 72 articles concerning C&D waste management (CDWM) from 2003 to 2023, sourced from the Web of Science database. The results revealed five distinct clusters of CDWM barriers, namely "managerial barriers," "culturally ingrained waste behaviors in the construction industry," "financial barriers," "challenges in waste quantification," and "insufficient information modeling." This study makes a significant contribution to the existing literature on C&D waste management by applying quantitative analytical analyses via RStudio software, such as trend topic analysis, *h*-index, cluster analysis, and thematic mapping, which provide a deeper insight into the domain of CDWM barriers. Unlike previous studies, this work offers a holistic exploration of CDWM barriers and the intellectual structure within the field. This study advances the understanding of CDWM barriers by offering innovative quantitative methodologies and comprehensive insights. It is a valuable resource for researchers and practitioners seeking to address CDWM challenges, ultimately promoting sustainable practices in the construction industry.

1. Introduction

The construction industry heavily consumes natural resources and generates significant waste, known as construction and demolition (C&D) waste, which includes excess materials resulting from construction, remodeling, and demolition processes (Shen et al., 2004). Demolition waste results from dismantled structures, while construction waste is produced during construction and refurbishment (Ismaeel and Kassim, 2023). Environmental catastrophes, such as floods, earthquakes, and hurricanes, also contribute to the substantial accumulation of C&D waste (Attia et al., 2021). Typically, C&D waste materials encompass a variety of items such as plasterboard, rocks, asbestos, metals, masonry, sand, asphalt, and cardboard (Fonseca et al., 2021). Globally, C&D waste accounts for over 30% of the total solid waste generated (Ginga et al., 2020). A significant portion of C&D waste materials is recyclable. However, some contain toxic substances with harmful effects on both humans and the environment, emphasizing the need to reduce C&D waste generation and address its sustainable environmental implications (Wu et al., 2019).

Managing waste from building demolition poses a significant obstacle to sustainable urban development because of constraints in landfill capacity, water pollution, elevated energy usage, and release of harmful gases (Ding et al., 2021). It is a global concern affecting both developed and developing nations. Practical construction and demolition waste management (CDWM) is a potential solution, and scholars from developed nations such as the United States, China (Aslam et al., 2020), and the United Kingdom (Ajayi et al., 2015) have made noteworthy strides in advancing CDWM practices. Aslam et al. (2020) compared the CDWM in China and the US and they concluded that the USA possesses a more advanced CDWM, with China exhibiting certain

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https://doi.org/10.1016/j.clwas.2024.100141
Received 2 November 2023; Received in revised form 20 February 2024; Accepted 4 March 2024
Available online 9 March 2024

shortcomings in CDWM practices within the construction industry. Ajayi et al. (2015) explored the barriers to and requirements of CDWM in the UK and they have categorized the barriers to CDWM into five groups called the challenges in waste management, which include externalities, incongruence between waste management and design tools, atomization of waste management strategies, perceived or unforeseen high costs associated with waste management, and a prevailing culture of waste behavior within the industry.

Meanwhile, researchers from developing countries—such as Costa Rica (Abarca-Guerrero et al., 2017), Bangladesh (Hasan et al., 2022), Pakistan (Nawaz et al., 2023a), United Arab Emirates (Al-Hajj and Hamani, 2011), and Egypt (Daoud et al., 2023a), for whom construction is a critical economic activity—have increasingly demonstrated keen interest in promoting CDWM-related research. Abarca-Guerrero et al. (2017) reported the barriers and motivators for CDWM in Costa Rica as a developing country, and they have identified several barriers to and motivators for CDWM under six aspects: financial, institutional, environmental, technical, sociocultural, and policy. Similarly, Hasan et al. (2022) highlighted the barriers to CDWM in Bangladesh, identifying four significant barriers, namely "Negligence and a carefree attitude of workers," "Poor supervision," "Inadequate workers' skills," and "Insufficient space for on-site storage." Nawaz et al. (2023a) discovered that contract management, materials logistics management, materials reuse, waste segregation, and on-site practices exhibit a strong correlation with each other, and serve as contributing factors in the effective minimization of waste on construction sites.

Notably, these endeavors have largely focused on individual countries, However, there is a gap in the literature for a comprehensive and holistic examination of CDWM barriers, which are crucial for efficient implementation. This study aimed to bridge this gap by adopting a novel approach, i.e., conducting an encompassing and interdisciplinary bibliometric analysis.

It is impossible to examine all the academic literature of the scientific disciplines with classical methods. In this context, bibliometric analysis and visualization methods represent an effective approach for quantitatively examining academic literature that could shed light on the disciplines' epistemological and intellectual development (Aydınoğlu et al., 2023). These methods quantify the scientific literature produced in a field, using it as data. They shed light on the longitudinal understanding of the relationships between articles, individuals, organizations, and, more importantly, the transformations within the field. This longitudinal understanding accurately represents the research landscape, aiding scholars in understanding the status and future directions of CDWM barriers. An interdisciplinary bibliometric study, which could enable a more profound comprehension of the topic, is essential to address this research void.

The current research employs innovative bibliometric and scientometric analyses to comprehensively assess barriers in CDWM by utilizing the underexplored RStudio software. This approach helps minimize subjectivity and biases frequently encountered in review-based studies (Song et al., 2016). It also comprehensively analyzes articles from 2003 to 2023 with research objectives, including a thorough review of temporal and geographical distribution, journal landscape, citation patterns, author contributions, keyword prominence, and co-citation relationships in the CDWM research field. The study further explores core research themes and identifies existing research gaps, aiming to establish a framework for guiding future research directions.

2. Existing studies on the barriers to CDWM and the literature gap

The barriers to CDWM have been identified by several researchers around the world endeavoring to enhance its efficiency in the construction industry. Former studies have generally concentrated on the challenges with an overview (e.g., Abarca-Guerrero et al., 2017; Al-Otaibi et al., 2022; Cárcel-Carrasco et al., 2021; Cha et al., 2009; Daoud et al., 2023b; Hao et al., 2011; Hasan et al., 2022; Ibrahim et al., 2022; Keske et al., 2018; Lockrey et al., 2016; Ma et al., 2020; Manowong, 2012; Mohd Nasir et al., 2016; Oyedele et al., 2013; Shooshtarian et al., 2022). Conversely, some researchers have explored the subject by focusing on particular challenges, including material waste (Al-Hajj and Hamani, 2011; Idowu et al., 2021); waste effectiveness (Ajayi et al., 2015); circular economy (Alite et al., 2023; Ghaffar et al., 2020; Hentges et al., 2022; Liu et al., 2021; Low et al., 2020; Oluleye et al., 2022; Purchase et al., 2022); managerial domain (Chen et al., 2018; Nawaz et al., 2023a); environmental impacts (Chen et al., 2021); C&D waste generation and management (Fatta et al., 2003); material flow (Guo and Huang, 2019); strategies and tools (Gupta et al., 2022; Han et al., 2021; Porwal et al., 2023); workers'/designers' behavior toward waste management (Hao et al., 2022; Kulatunga et al., 2006; Li et al., 2015); and waste management policies and laws (Lv et al., 2021; Ma et al., 2023).

Previous research typically focused on quantitative or qualitative examinations using surveys, semi-structured interviews, and system dynamics. Nonetheless, stakeholders in the construction industry need to be aware of all the impediments related to CDWM implementation. Review studies are gaining importance as they comprehensively explore CDWM obstacles. Researchers should explore the topic from multiple angles, leveraging prior research to enrich their knowledge, which is significant for depicting the research landscape accurately, enhancing scholars' understanding of the status and future directions of CDWM challenges, and improving the effectiveness of their investigations. Pickering and Byrne (2014) emphasized the importance of starting new research with a thorough literature search. Similarly, Grant and Booth (2009) highlighted the significance of reviews and scientometric analyses in guiding emerging research. These analyses help reduce information clutter and consolidate relevant studies. In exploring CDWM barriers, previous review studies may be classified into either the quantitative or qualitative category.

A concise summary of the selected review studies on CDWM, as presented in Table 1, illuminates their contributions. While qualitative review studies of CDWM (IDs: 1–6 in Table 1) provide valuable understanding, their examination depends mainly on subjective assessments. This limitation fails to portray the intricate knowledge framework of barriers to CDWM investigations accurately and comprehensively. Significantly, a systematic assessment by Guo and Huang (2019) encompassed an examination of 28 studies focusing on systematically analyzing C&D waste recycling and disposal methods. Abarca-Guerrero et al. (2017) made noteworthy strides in this area by delving into the impediments and driving forces influencing CDWM, and Aslam et al. (2020) conducted a comprehensive review study exploring the landscape of CDWM within China and the United States by meticulously scrutinizing the Web of Science (WoS) database and official online platforms.

On the other hand, the quantitative literature reviews (IDs: 7–17 in Table 1) present diverse viewpoints concerning CDWM through impartial evaluations. Scholars have recently employed quantitative methodologies, including meta-analysis and bibliometric analysis, to build upon preceding qualitative reviews of CDWM studies. For example, Chen et al. (2018) conducted a scientometric review highlighting CDWM research from a managerial framework. Chen et al. (2021) analyzed 112 CDWM-related studies and identified the environmental impacts of C&D waste across three dimensions. Elshaboury et al. (2022) performed a bibliometric and scientometric analysis of 996 CDWM-related studies from 2001 to 2021 using VosViewer, and Li et al. (2022) conducted a scientometric analysis of CDWM studies using CiteSpace. Most of these studies have approached the CDWM issue from a specific perspective and have therefore failed to capture a holistic understanding of the issue.

The afore-mentioned qualitative and quantitative studies have enriched our comprehension of the CDWM research domain. Nonetheless, it is imperative to acknowledge that even with these substantial contributions, several facets within this realm of study necessitate

Table 1
A summary of former CDWM barriers review studies.

ID	Study	Size	Period	Source	Type of Research	Main Method	Main Focus	Software Tool	Type of Literature Review
1	Abarca-Guerrero et al. (2017)	Six articles	2000–2017	Seven journals in C&D waste management	No bibliometric	Literature review	Barriers and motivations for C&D waste practice	-	Qualitative
2	Aslam et al. (2020)	Seven Regulations and Policies	2003–2019	The websites of the Environmental Protection Agency (EPA)	No bibliometric	Literature review	Barriers to C&D waste management	-	Qualitative
3	Daoud et al. (2020)	Undefined	Undefined	Research papers, technical and governmental reports.	No bibliometric	Literature review	Solid waste problem	-	Qualitative
4	Guo and Huang (2019)	27 studies	2000–2018	Web of Science Scopus Engineering Village	No bibliometric	Literature review	Material flow analysis on CDWM	-	Qualitative
5	Hoang et al. (2020)	Undefined	Undefined	Official documents Web of Science Scopus Google Scholar	No bibliometric	Literature review	CDWM in South Asia	-	Qualitative
6	Mesa et al. (2021)	150 studies	2000–2021	Scopus	Bibliometric analysis	PRISMA literature review	Life cycle assessment of CDWM	-	Quantitative
7	Chen et al. (2018)	281 studies	1994–2018	Web of Science	Scientometric bibliometric analysis	Scientific visualization	Managerial areas of CDWM	CiteSpace	Quantitative
8	Chen et al. (2021)	112 studies	2010–2019	Web of Science	Scientometric bibliometric analysis	Scientific visualization	Environmental impacts of C&D waste	VOSViewer	Quantitative
9	Elshaboury et al. (2022)	996 studies	2001–2021	Scopus	Scientometric bibliometric analysis	Scientific visualization[s]	CDWM	VOSViewer	Quantitative
10	Jin et al. (2019)	370 studies	2009–2018	Scopus	Bibliometric analysis	Scientific visualization[s]	CDWM	VOSViewer	Quantitative
11	Kabirifar et al. (2021)	26 studies	2010–2021	Web of Science Scopus	Bibliometric analysis	Scientific visualization	Challenges of CDWM	VOSViewer	Quantitative
12	Li et al. (2022)	494 studies	2007–2020	Web of Science	Bibliometric analysis	Scientific visualization	CDWM	CiteSpace	Quantitative
13	Liu et al. (2017)	857 studies	2000–2016	SCI-Expanded database	Bibliometric analysis	Scientific visualization	Performance of CDWM	CiteSpace	Quantitative
14	Nawaz et al. (2023b)	375 studies	2013–2022	Scopus	Scientometric bibliometric analysis	Scientific visualization	Trends in CDWM research	VOSViewer	Quantitative
15	Oluleye et al. (2022)	116 studies	2014–2021	Scopus	Scientometric bibliometric analysis	Scientific visualization[s]	Circular economy and CDWM	VOSViewer	Mixed (Quantitative + Qualitative)
16	Soyinka et al. (2022)	4374 studies	2000–2021	Web of Science	Scientometric bibliometric analysis	Scientific visualization	CDWM for sustainability	CiteSpace	Quantitative
17	Wu et al. (2019)	511 studies	1994–2017	Web of Science	Bibliometric analysis	Scientific visualization	CDWM	VOSViewer	Quantitative

a: Document co-citation analysis, keywords co-occurrence analysis, cluster analysis, keyword analysis b: Keywords co-occurrence analysis, co-authorship analysis, citation analysis, active country analysis. c: Journal analysis, co-authorship analysis, active country analysis, co-citation analysis, keywords co-occurrence analysis. d: Keywords co-occurrence analysis, content analysis. e: Co-country analysis, co-institution analysis, co-authorship analysis, keyword co-occurrence analysis, co-citation analysis. f: Top cited article analysis, co-citation analysis.

further in-depth investigation.

It is crucial to undertake a comprehensive interdisciplinary bibliometric inquiry to address the existing research gaps, particularly in understanding CDWM barriers. This approach facilitates more extensive data collection, offering a more profound insight into the subject. This effort to expand the bibliometric perspective serves as a valuable addition to previous research. Notably, many previous studies on CDWM have concentrated on individuals or particular countries, limiting their ability to fully comprehend all the barriers to CDWM.

2.1. Contributions

This study embarks on a comprehensive metrological and content-based examination of the CDWM domain within an intellectual structure to address the research gap identified within the existing literature. This study diverges from prior bibliometric inquiries concerning CDWM in three notable ways.

Firstly, this study introduces a fresh bibliometric analysis platform called RStudio Bibliometrix software, which was developed in 2017 to operate within the R programming language. This software encompasses tools for quantitative bibliometric analysis (Aria and Cuccurullo, 2017).

Notably adaptive, this novel tool incorporates various statistical and graphical functionalities. Using the R language for conducting bibliometric analysis represents an innovative approach that facilitates a profound comprehension of the CDWM research landscape.

Secondly, this study distinguishes itself by employing diverse indices and metrological analysis methods, aiming to offer a comprehensive panorama of the CDWM field. While certain types of indices and analyses, such as assessing annual scholarly output, analyzing active countries, and evaluating journal sources, have been utilized in previous bibliometric studies concerning CDWM, this research introduces an innovative set of measures, including the *h*-index, analysis of chronological shifts in keywords, thematic mapping, cluster analysis, thematic evaluation, trend topic analysis, and authors' initial publication years, which are being applied for the first time in the context of bibliometric analyses within the CDWM domain, thereby contributing to an enriched and more comprehensive knowledge of the research landscape.

Lastly, this study delves into the intellectual structure of the CDWM research domain by applying keyword analysis, cluster analysis, thematic evaluation, and trend topic analysis. The term "intellectual structure" pertains to the arrangement and interconnectedness of knowledge within a specific research field or domain. Liu et al.'s (2017) exploration of the intellectual structure offers a comprehensive viewpoint encompassing scientific investigations, research networks, and the evolution of knowledge within the field of study.These insights contribute to a more nuanced understanding of the advancements, collaborations, and dissemination of knowledge. While prior bibliometric investigations of CDWM have frequently employed keyword and citation analyses, as far as our knowledge extends, this study is a pioneering endeavor that undertakes an intellectual structural approach toward CDWM research. To portray the intellectual structure of the CDWM research field from diverse standpoints, a range of scientific maps, including fluctuations in the top 10 keywords by frequency, a conceptual structure map, a keyword co-occurrence network incorporating temporal information, strategic diagrams, Sankey diagrams, and cluster analysis, are executed. Distinguished from prior bibliometric studies on CDWM, these scientific maps offer a global outlook and emphasize noteworthy attributes of the CDWM research landscape. This study both incorporates and extends upon the bibliometric findings of previous analyses of CDWM literature while also providing a fresh reference for future bibliometric investigations in other research domains utilizing the abovementioned methodologies.

3. Materials and methods

This study employs a comprehensive bibliometric approach, combining metrological and content analyses, for investigating CDWM barriers. This approach is widely recognized for its reliability and impartiality compared to other methods, providing systematic and transparent insights into a specific field (Elshaboury et al., 2022; Liu et al., 2017). The methodology employed in this study resembles Anaç et al. (2023) and Shi et al. (2020), who used bibliometric mapping. However, this study goes further by conducting in-depth author analyses with their *h*-index, factorial analyses with clusters, and thematic evaluations particular to CDWM barriers. An inductive approach is adopted, thoroughly examining diverse datasets to yield specific findings and reveal noticeable themes. A visual depiction of the research methodology is presented in Fig. 1.

The initial step in the bibliometric exploration conducted in this study involves carefully selecting a database to acquire high-quality data for subsequent bibliometric analysis. The process of selecting an appropriate search strategy and database(s) is of paramount importance before retrieving articles for review. While numerous databases are available, WoS and Scopus are the most prominent ones. In this study, WoS was chosen over Scopus. This choice was made primarily because the WoS core database encompasses a comprehensive array of the world's most esteemed and influential journals across various academic disciplines, rendering it the most authoritative database for conducting literature reviews in numerous fields, as emphasized by Song et al. (2016). Despite Scopus offering broader coverage compared to WoS, a substantial degree of overlap is noted between the contents of these two

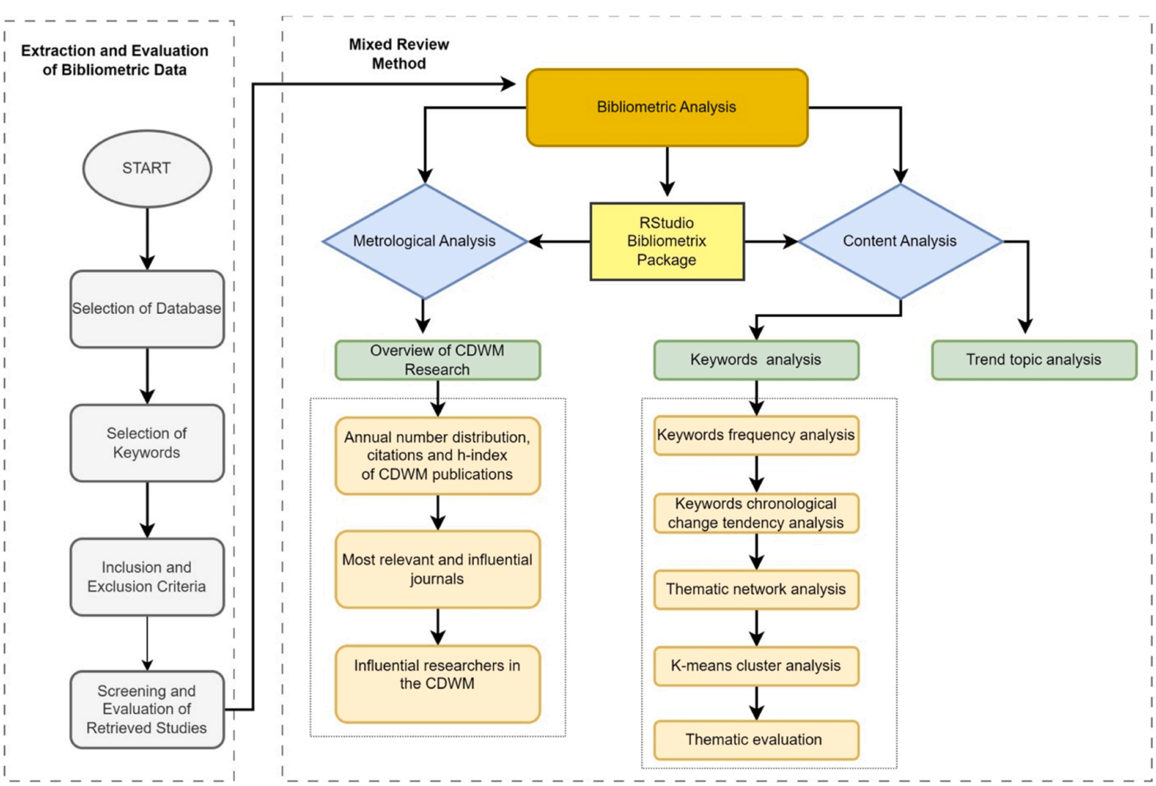

Fig. 1. Methodology framework.

databases. Therefore, the WoS core database, housing the most influential and prestigious publications in the realm of CDWM research, was deemed the ideal data source for this paper, in alignment with the assertion made by Chen et al. (2018).

The second phase involves extracting and refining data from the selected database. Initially, a basic search was performed using pertinent keywords. The scan was executed utilizing the search string ALL FIELDS= "construction waste management" OR "demolition waste management" AND "challenges" OR "barriers" NOT "infrastructure" NOT "biogas." In the last 21 years, there have been rapid technological and methodological advances in scientific research. Former studies may need help in reflecting on the current situation. Therefore, access to up-to-date information and data is often essential.

For this reason, reviewing the last 21 years to capture the changes and developments in the literature has been considered more meaningful, so the publication timeframe was restricted to the previous two decades, encompassing from 2003 to 2023. This search was conducted in July 2023, yielding 1079 articles.

In retrieving these articles, it is imperative to establish explicit inclusion and exclusion criteria to effectively sift through the gathered research publications and retain only the pertinent ones. Consequently, specific inclusion and exclusion criteria have been devised in this study to scrutinize the collected literature. Our inclusion criteria encompass (1) research explicitly addressing obstacles to CDWM within construction projects and (2) studies published in peer-reviewed journals. Embracing a selective approach to academic journals within the research topic is deemed an effective strategy because these publications typically offer higher quality, as Shi et al. (2020) indicated. Conversely, the exclusion criteria are as follows: (1) research published in languages other than English; (2) articles primarily focusing on technical aspects; and (3) studies lacking available full-text resources. Following the application of these inclusion and exclusion criteria, a total of 72 articles were retained. Rogers et al. (2020) suggested a minimum sample size for bibliometric analysis of 200 papers, but they admitted that smaller samples may be acceptable. Within this perspective, Glänzel and Moed (2013) noted that, as a rule of thumb, a value of 50 is suggested as the minimum value for approximate properties. Meanwhile, according to Seglen (1994), between 50 and 100 articles had to be pooled to obtain good correlations. Many studies have successfully performed bibliometric analyses with varying numbers of articles. For example, Ioseliani et al. (2023), Rojas-Rodríguez (2022), and Soares et al. (2023) performed bibliometric analyses of 61, 79, and 48 articles, respectively. Therefore, 72 articles can be considered a sufficient sample size for analysis. A comprehensive depiction of the data collection process is provided in Fig. 2 for detailed reference.

The final phase involves a chart and map of the research domain obtained using bibliometric analysis, serving various purposes, such as revealing connections among information sources, condensing existing knowledge, identifying knowledge gaps, uncovering prevalent themes and trends, and guiding future research inquiries. Several software platforms, such as VOSViewer and CiteSpace, may be used for bibliometric analysis (Cobo et al., 2011). However, many of these applications can be labor-intensive and not so user-friendly (Aria and Cuccurullo, 2017). Therefore, RStudio Bibliometrix, which provides versatility and integrates graphical features different from other scientometric tools, was employed.

As shown in Fig. 1, the bibliometric analysis phase includes metrological and content analyses. Metrological analysis examines fundamental attributes of the literature, including the contributions from actively participating countries and patterns of journal citations, providing an overarching understanding of CDWM barriers. Content analysis centers on aspects such as frequencies of keywords, chronological changes in keywords, thematic explorations, and cluster analysis. These methods unveil the intellectual structure within the domain of CDWM barriers. This comprehensive approach offers an integrated exploration of CDWM barriers, illuminating the field's evolution and trajectory.

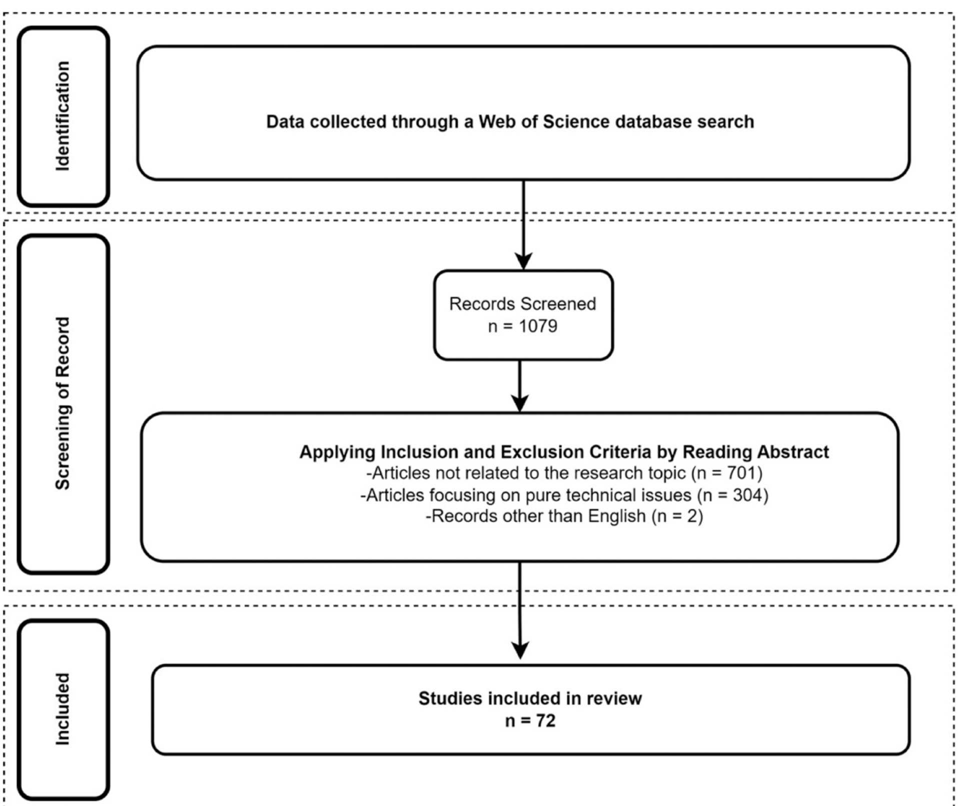

Fig. 2. Data collection process.

4. Results

4.1. General features of literature

This section provides an overview of the fundamental aspects of CDWM barriers. Utilizing Bibliometrix, we derive insights into the annual distribution of document numbers and their corresponding citations. This analysis includes metrics such as mean citations annually, number of publications, and total citations, all depicted in Fig. 3.

Fig. 3 shows a consistent 12.74% annual growth in publications on CDWM barriers from 2003 to 2023, with minor fluctuations and a peak in 2022, which signifies a burgeoning interest in this field. The construction sector's focus on waste management has risen due to environmental concerns, paralleling increased environmental awareness and regulations. The significance of waste management emerged particularly from the latter half of the 20th century, resulting in standards and legal frameworks. Different nations have diverse approaches. Anticipating further growth, data until July 2023 suggests that 2023 publications may surpass 2022. Analysis of cumulative total citations shows steady growth in the popularity of CDWM barriers in research. However, average yearly citations fluctuate, notably declining from 2020 to 2021 due to the construction sector's shift toward CDWM amid the COVID-19 pandemic.

4.2. Active countries analysis

The R program data reveals 27 actively participating countries in CDWM barrier research. Each country's waste management efforts in the construction sector are shaped according to its conditions and needs. Therefore, waste management policies, practices, and work intensity on the subject may vary by country and region. Table 2 presents numerical data from the countries on this issue regarding "Single Country Publications (SCP)" and "Multiple Country Publications (MCP)," which refer to collaborative research efforts involving more than one country.

China leads in CDWM research output due to its significant economy and the challenges posed by rapid construction and urbanization. China generates over 1.5 billion tons of C&D waste annually (Aslam et al., 2020), accounting for 40% of the global annual C&D waste (Jin et al., 2017). Research on sustainable practices for the construction industry is therefore critical (Jin et al., 2019; Yuan and Shen, 2011). However, as summarized in Table 2, China has fewer collaborative efforts despite its high output. India, Iran, New Zealand, and Oman also lack collaboration, while Egypt and the United Kingdom are proportionally more collaborative based on the MCP/SCP ratio.

4.3. The most relevant journal

The 72 articles focused on CDWM barriers, obtained from 2003 to 2023, originate from 41 distinct journals. This quantification aids in identifying key journals. The top journals for CDWM barrier articles are shown in Fig. 4.

Table 2
Total number of articles, SCP, and MCP by the most active ten countries.

Country	Articles	SCP	MCP	MCP/SCP Ratio
China	20	17	3	0.150
Australia	11	5	6	0.545
United Kingdom	7	2	5	0.714
Egypt	4	1	3	0.750
Canada	2	1	1	0.500
Germany	2	1	1	0.500
India	2	2	0	0.000
Iran	2	2	0	0.000
New Zealand	2	2	0	0.000
Oman	2	2	0	0.000

As depicted in Fig. 4, the top five journals are as follows: *Journal of Cleaner Production*, *Resources Conservation and Recycling*, *International Journal of Construction Management*, *Waste Management & Research*, and *Waste Management* (Fig. 4). This situation also shows interest in journals related to the topics of the most cited journals.

4.4. Leading researchers

The top CDWM scholars are identified from author details. Table 3 presents the quantitative indicators of the top 10 authors, recognizing their significant contributions to CDWM literature.

Table 3 highlights Yuan H as the foremost authority in CDWM barriers due to a distinguished *h*-index, TC, and NP. Chen J, Daoud AO, Othman AE, and Tam VWY follow closely in *h*-index prominence. In Fig. 5, the circle size represents the authors' annual output. Notably, in 2018, Wang X had the highest TC/Y ratio (68.00), followed in 2019 by Yuan H with a TC/Y ratio of 33.00 and in 2020 by Tam VWY. This suggests that their research in those years had a more significant impact. There was a noticeable surge in authors' focus on CDWM barriers from 2020 to 2022, indicating that their scholarly output held greater significance.

4.5. Intellectual structure of the barriers to the CDWM field

Bibliometric analysis is invaluable for condensing extensive literature into accessible insights, offering a meaningful understanding of a research domain's "intellectual structure." Various bibliometric methods, such as keyword analysis, cluster analysis, thematic evaluation, and trend topic analysis, reveal the intellectual structure within the broader content analysis.

4.5.1. Keyword analysis

This research utilized 246 keywords from 72 articles in bibliometric analysis. Some keywords have synonymous or similar meanings, which can introduce inaccuracies. Unlike other bibliometric software, the R-

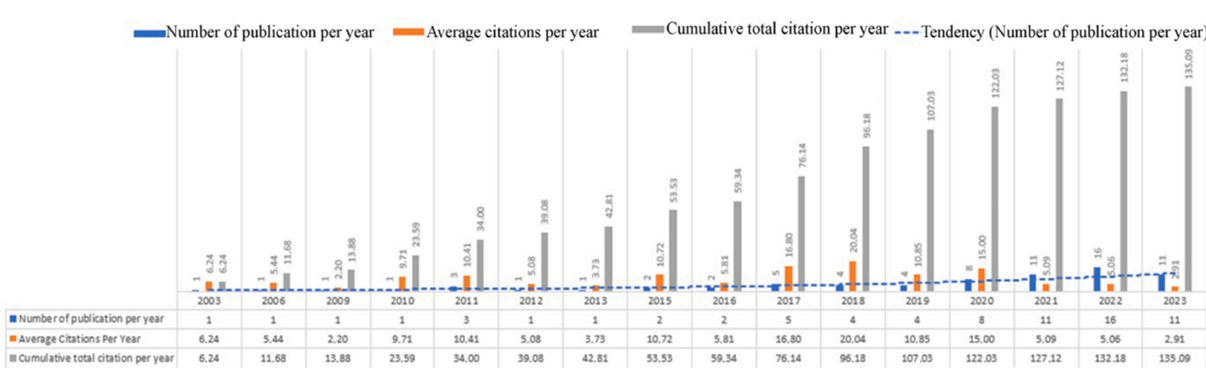

Fig. 3. Distribution of the annual number of citations for CDWM barriers publications.

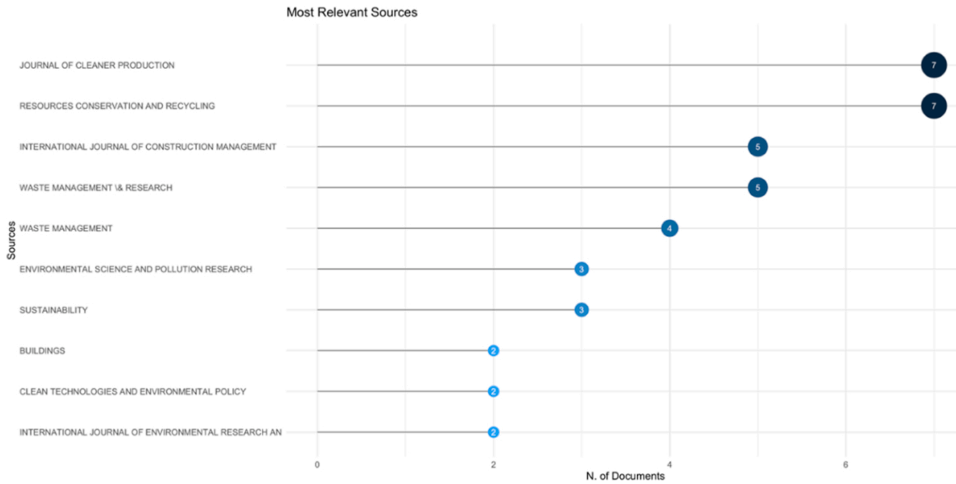

Fig. 4. The top 10 pertinent journals for CDWM barrier research.

Table 3
Top ten foremost researchers in the field of CDWM research.

Author	h-index	Total Citations (TC)	Number of Publications (NP)	Inception year of their initial contributions (PY-Start)
YUAN H	6	787	6	2010
CHEN J	3	109	4	2018
DAOUD AO	3	32	3	2020
OTHMAN AAE	3	31	3	2020
TAM VWY	3	156	5	2011
BAYYATI A	2	28	2	2020
CALDERA S	2	9	2	2022
EBOHON OJ	2	49	2	2013
HAO JL	2	18	2	2011
HUANG B	2	555	2	2018

tool can consolidate these terms, addressing potential challenges by grouping similar words under primary representatives, as summarized in Table 4, to enhance keyword analysis accuracy.

Recognizing that synonyms can introduce shortcomings in bibliometric analysis, we addressed this concern by grouping words with similar meanings under the primary representative words. This approach, as summarized in Table 5, was undertaken to augment the precision of our keyword analysis.

4.5.2. Frequently used keywords

Fig. 6 displays the keywords most employed in CDWM barriers research articles, with "managing construction" as the most prevalent term, followed by "barriers." This aligns with our research focus on examining obstacles to CDWM. Notably, there are fewer keywords for reducing CDWM barriers, which suggests that the issue of different solutions in different countries is open and can be studied. It is noteworthy that keywords for the mitigation of CDWM barriers are less frequent than the word barriers, thus there has been a greater emphasis on identifying barriers than on how to reduce them. The fact that different solutions are proposed in different countries shows that the topic is open and can be studied.

4.5.3. Temporal trends of keywords

Fig. 7 shows the evolving trends in keyword usage from 2003 to 2023. "Generation" emerged in 2011, and "model" gained prominence in 2012. The increasing use of "model" suggests a sequential research process. The rise of "management" in 2015 correlates with the development of certification systems such as LEED and BREEAM. "Management" has remained a significant topic. "Generation" saw a significant increase in interest from 2019 to 2023, possibly due to the impact of the COVID-19 pandemic on emergency hospital and shelter construction. By 2023, "generation" and "management" were the most prominent keywords. The fact that the life cycle assessment parameter shows a moment-accelerated increase in 2021–2022 suggests an orientation toward this field in the literature. For future studies in the CDWM field, the life cycle evaluation will be of more interest.

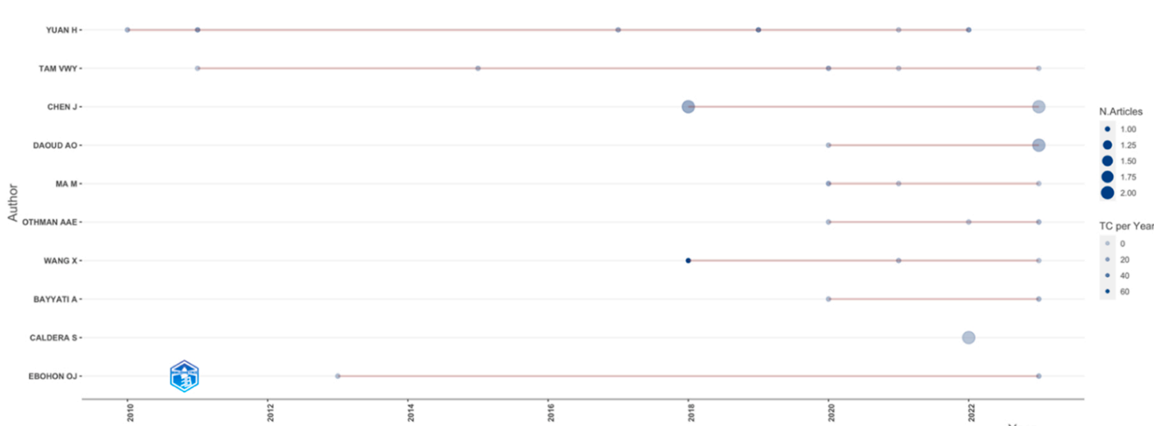

Fig. 5. The productivity of the top 10 scholars in the CDWM research domain over time.

Table 4
The most frequently used 50 keywords in the data set.

Words	Occurrences	Words	Occurrences	Words	Occurrences	Words	Occurrences
Generation	18	Prefabrication	6	Managing construction	4	Mechanical properties	3
Management	18	Reduction	6	Mapping approach	4	Planned behavior	3
Challenges	14	Reuse	6	Quantification	4	Recycled aggregate	3
Life-cycle assessment	14	Industry	5	Sustainability y	4	Reduction management	3
Model	13	Recycled aggregate concrete	5	Bibliometric analysis	3	Science	3
Demolition waste	10	Behavior	4	Buildings	3	Solid-waste	3
Minimization	10	China	4	Carbon	3	Aggregate concrete	2
System	10	Deconstruction	4	Circular economy	3	Assessment score	2
Concrete	9	Design	4	Economic-impact	3	Attitudes	2
Hong-Kong	7	Determinants	4	Emerging trends	3	Building-related construction	2
Performance	7	Economy	4	Energy	3	Charging scheme	2
Barriers	6	Emission	4	Environmental performance	3		
Contractors	6	Implementation	4	Landfill	3		

Table 5
Matched words.

Word	Consignification
Barriers	Challenges
Minimization	Reduction
Circular economy	Economy
Recycled aggregate	Recycled aggregate concrete
Managing construction	Management

4.5.4. Thematic network analysis

Thematic mapping assesses the impact of learned concepts in Fig. 8. Circles represent clusters of related words, sized by the number of associated publications. The vertical axis shows density, indicating interconnections within a cluster. The horizontal axis signifies centrality, showing cluster interaction (Cobo et al., 2011; Karakose et al., 2022). Quadrant I, the “motor” themes, has high centrality and density, indicating pivotal subjects with substantial potential. Quadrant II, “niche” themes, has low centrality but high density, suggesting specialization. Quadrant III represents themes that are either emerging or declining and demonstrate low centrality and density. Quadrant IV represents “basic” themes characterized by high centrality but low density that are pertinent but have received relatively less intensive exploration (Cobo et al., 2011; Karakose et al., 2022).

Examining the motor themes, concepts such as “life-cycle assessment” and “recycled aggregate” hold significant potential for progression. Clusters such as “solid waste,” “energy consumption,” and “impacts” are also pivotal themes with substantial impact on the field.

The cluster comprising “energy,” “management system,” and “trends” demonstrates high density and moderate centrality, signifying well-developed but somewhat isolated themes.

Themes such as “information modeling” and “building information modeling (BIM)” are in Quadrant III, indicating they need further qualitative analysis as emerging or diminishing themes.

The cluster of “managing construction,” “barriers,” and “generation” has the highest centrality and moderate density, indicating their importance in the field even with limited exploration.

4.5.5. Cluster analysis

In this research, k-means clustering analysis is employed to investigate the existence of separate clusters within the dataset. To identify the optimal number of clusters, values of $k = 2, 3, 4, 5$, and 6 are tested, as depicted in Fig. 9. It is apparent that at $k = 6$, there are merely a couple of elements within the cluster, which is not substantial enough to establish a distinct cluster (Raza, 2020). The utilization of the k-means clustering algorithm with $k = 5$ in this study led to the formation of

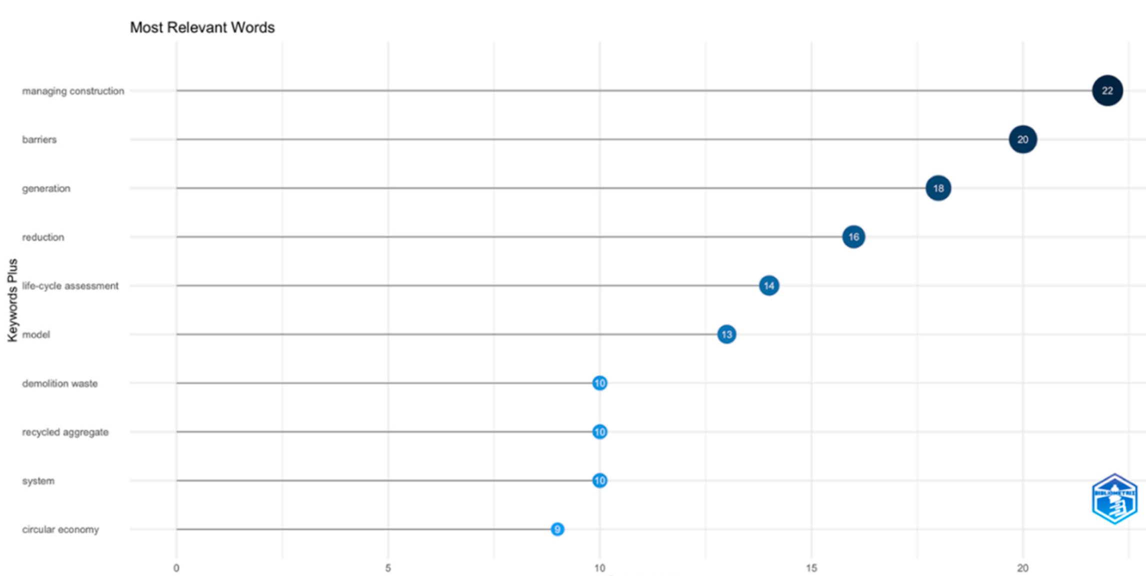

Fig. 6. Top 10 frequently used words in the domain of CDWM barriers.

Fig. 7. Words' frequency over time.

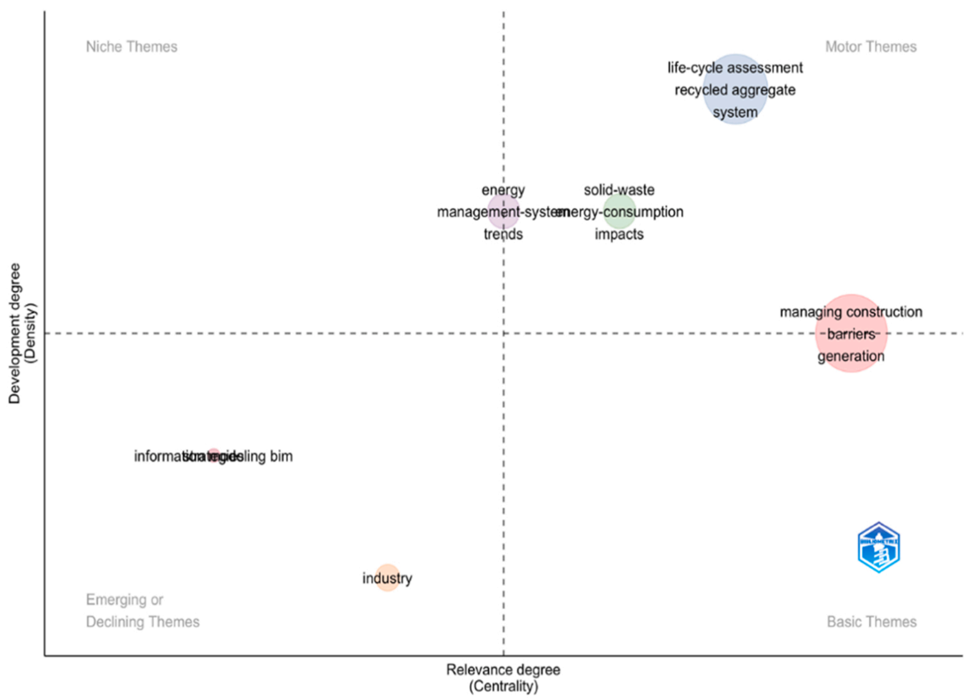

Fig. 8. Thematic mapping.

well-defined and coherent clusters.

Based on the groups formed by k-mean analysis, Cluster 1 in blue color is defined as "Managerial barriers," Cluster 2 in red color is defined as "Culturally ingrained waste behaviors in the construction industry," Cluster 3 in brown color is defined as "Financial barriers," Cluster 4 in pink color is defined as "Challenges in waste quantification," and Cluster 5 in green color is defined as "Insufficient information modeling."

4.5.6. Thematic evaluation

The study's scope involves analyzing articles visually represented using three-fold graphs. The interconnections between these areas are illustrated with a Sankey diagram (Fig. 10), known for tracking thematic progression (Shi et al., 2020). Sankey diagrams help depict flows across networks and processes, illuminating the subject's temporal evolution. Thematic evaluation is integrated to understand how fundamental concepts have changed over time (Riehmann et al., 2005). The year 2016 was a crucial period for waste management in the construction industry. Developed and developing countries established new strategies to reduce construction waste this year. To assess the impact of these strategies on the literature, the Sankey diagram was cut in 2016 and in 2002 to assess the study topics in the last year.

Initially, CDWM focused on modeling and prefabrication, following a typical research progression where studies begin with modeling before expanding to other parameters. Modeling was prominent from 2003 to 2016, evolving into the theme of "managing construction" from 2017 to 2022. In 2023, "managing construction" further evolved into "barriers," "demolition waste," and "managing construction."

Prefabrication, known to reduce construction waste, was one of the early study themes in CDWM (Jaillon et al., 2009). From 2017–2022, "prefabrication" transitioned into the theme of "reduction." In 2023, the theme "reduction" evolved into "demolition waste" and "managing construction." Emerging themes from 2017 to 2022 included "life-cycle assessment" and "industry," with "life-cycle assessment" further evolving into "quantification" and "barriers" in 2023, while "industry" continued to be explored as a theme in 2023.

4.5.7. Analyzing citations

Citation analysis is employed to identify the publications that are referenced most frequently in the field of CDWM barriers. Table 6 presents the top five publications with the highest number of citations, ordered by the number of local citations (LCs) as well as global citations (GCs). LCs reflect how often a document is cited within the dataset of 72

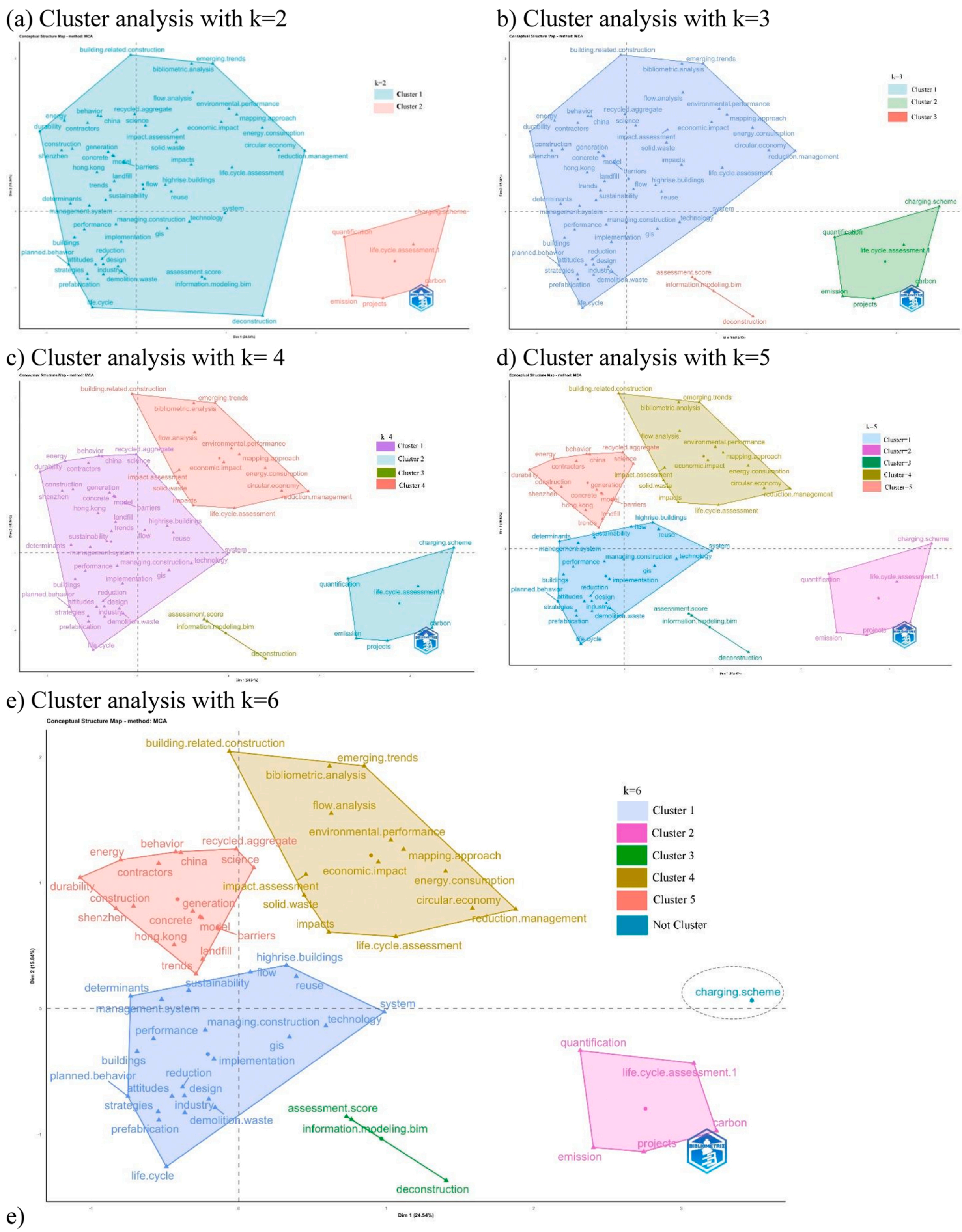

Fig. 9. Cluster detection with factorial analysis.

documents, indicating its impact on CDWM barriers research. GCs are the frequency with which a paper is cited in the WoS, signifying its prominence in the broader academic context.

Lockrey et al. (2016) garnered the most notable LC score of 11, while Ghaffar et al. (2020) received the highest GC score of 167, significantly surpassing the others. To consider the influence of the publication years of these articles, the metric "Total Global Citation per Year" (TGC/Y) is employed to showcase their influence. Aslam et al. (2020), Ghaffar et al. (2020), and Lockrey et al. (2016) are in the top three regarding TGC/Y, indicating that these articles hold considerable importance in the realm of challenges within the CDWM research field.

4.5.8. *Trend topic analysis*

Trend topic analysis highlights the prevalence of critical concepts in

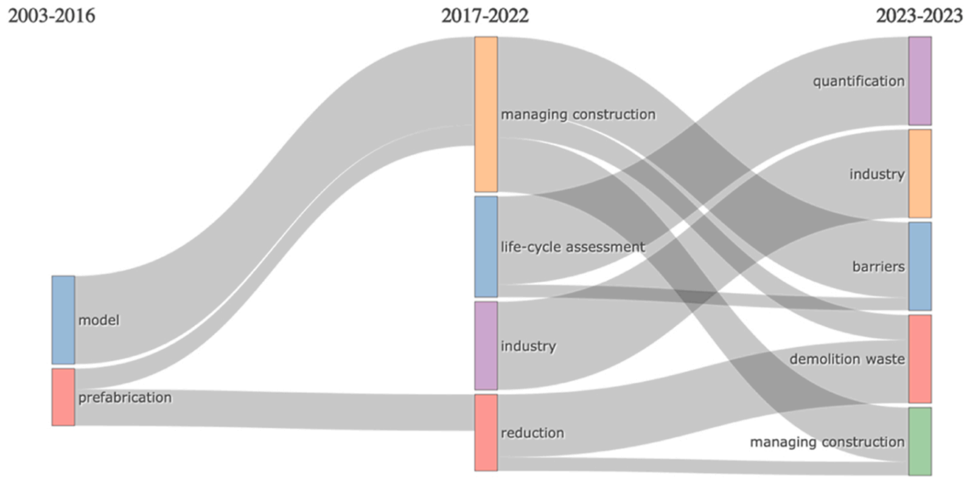

Fig. 10. Thematic evaluation of barriers to CDWM research (2003–2023) with a Sankey diagram.

Table 6
Top 5 cited papers in barriers of CDWM research field.

Document			LC	GC	TGC/Y	Subject
Author	Journal	Publication Year				
LOCKREY S.	Journal of Cleaner Production	2016	11	91	11.38	Opportunities and challenges of construction and demolition waste
GHAFFAR SH	Journal of Cleaner Production	2020	7	167	41.75	Management of construction and demolition waste
ASLAM MS	Journal of Environmental Management	2020	6	147	36.75	Opportunities and challenges of construction and demolition waste
KULATUNGA U	Management of Environmental Quality: An International Journal	2006	4	98	5.44	Perceptions of construction workforce on construction waste
HAO JL	International Journal of Construction Management	2011	4	9	8.00	Construction waste challenges

recent publications. Fig. 11 shows that research on CDWM barriers has been trending with themes such as “sustainability,” “circular economy,” “waste,” “construction and demolition waste,” “waste management,” “managing construction,” “construction waste,” “recycling,” and “reuse.” Notably, “construction and demolition waste” has been a prominent theme since 2015. While “recycling and reuse” were trending from 2016 to 2017, they lost prominence after 2020, giving way to management-related topics, which have been trending since 2019. This suggests a shift in research focus toward management aspects and a reduced emphasis on waste generation in recent years.

5. Discussion

In recent decades, concerns about CDWM have gained global attention. Countries worldwide face the challenge of effectively and systematically reducing C&D waste generation. Extensive research since the 1980 s has aimed to mitigate the detrimental impacts of C&D waste from building structures (Purchase et al., 2022). Despite recent efforts, the construction sector is still in the early stages of addressing CDWM barriers. While substantial research on CDWM barriers exists, a comprehensive bibliometric analysis could be more robust, permitting

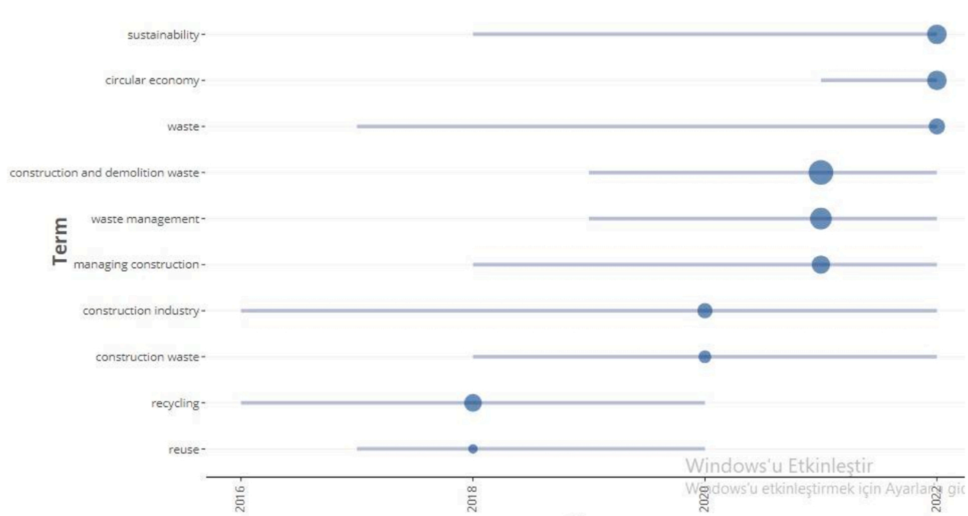

Fig. 11. Trending topics in barriers to CDWM.

access to diverse insights. This research expands the bibliometric inquiry by performing an extensive metrological and content analysis of the CDWM research landscape. It uses the Bibliometrix R-package to overview CDWM barriers and employs content analysis to investigate the intellectual structure within the field. The study addresses the complexity resulting from similar keywords, following the recommendation of Aria and Cuccurullo (2017) to consolidate similar terms during keyword analysis.

This study utilizes a robust dataset of 72 journal articles from 2003 to 2023, sourced from the WoS database, to explore barriers in CDWM. The research covers various dimensions, including the annual distribution of articles, leading countries, influential scholars, and key journals in the CDWM domain.

1. CDWM has seen a notable surge in the exploration of barriers, commencing in 2015 and peaking in 2022. This trend reflects the increasing attention given to CDWM obstacles over the past nine years (Fig. 3).
2. China leads in substantial CDWM research, with mainland China facing landfill capacity challenges due to a large volume of C&D waste, as highlighted by Duan and Li (2016). Additionally, Egypt emerges as a highly collaborative country in this context (Table 2).
3. The study identifies the *Journal of Cleaner Production*, *Resources Conservation and Recycling*, *International Journal of Construction*, and *Waste Management & Research* as pivotal resources for researchers in the CDWM domain (Fig. 4).
4. Yuan H is the foremost researcher in CDWM barriers, followed by Chen J, Daoud AO, Othman AAE, and Tam VWY, as ranked by their *h*-index performance.

This study employs a novel approach to analyze the intellectual structure of the CDWM field. Combining keyword analysis and citation examination uncovers the foundational elements of CDWM knowledge. The study utilizes keyword analysis, changes in the top 10 keywords, conceptual structure mapping, strategic diagrams, and Sankey diagrams to elucidate critical themes and their evolution.

1. This investigation distinguishes itself from previous bibliometric studies by incorporating keyword plus analysis. In addition to researcher-assigned keywords, indexers assign keyword pluses, enhancing readers' understanding of paper themes and content.
2. Analysis of keyword pluses over time highlights "challenges," "production," "life-cycle assessment," "management," and "model" as areas of increasing relevance for future research (Fig. 7).
3. As shown in Fig. 8, thematic mapping and assessment indicate life-cycle assessment and recycled aggregate as emerging research themes. BIM is also explored, reflecting its evolving importance in CDWM research (Ghaffar et al., 2020; Gupta et al., 2022; Purchase et al., 2022).
4. In contrast to relying solely on keyword analysis, this study introduces clustering analysis using the k-means method. It identifies five clusters: managerial barriers, sociocultural behavioral obstacles, financial obstacles, hindrances in life-cycle assessment, and deficiencies in information modeling (Fig. 9), offering a comprehensive view of CDWM challenges and themes.

(i) *Regarding Managerial Barriers*: Top management is crucial in executing innovative organizational strategies (Salem et al., 2005; Small et al., 2017). The practical implementation of an efficient plan and support during transitional phases is vital for organizational progress. Existing literature highlights several managerial challenges in the context of CDWM barriers. These include difficulties in defining project parameters, resource allocation, and timely material distribution, which hinder effective C&D waste management (Olatunji, 2008). Insufficient time for innovation and comprehensive implementation, communication gaps among stakeholders, a lack of management commitment, transparency issues, time constraints, decision-making delays, the absence of established norms, inadequate operational integration, subpar procurement practices, and ineffective materials management collectively present managerial obstacles that must be overcome for successful C&D waste practices (Brady et al., 2011; Camuffo et al., 2017; Enshassi et al., 2021; Hao et al., 2011; Park and Tucker, 2017; Small et al., 2017; Wirahadikusumah and Ario, 2015).

(ii) *Regarding Culturally Ingrained Waste Behaviors in the Construction Industry*: The waste behavior theory suggests the existence of a prevalent waste behavior culture in the construction sector (Teo and Loosemore, 2001). This theory implies that upper-level managers often downplay waste concerns, while frontline workers consistently see waste as a challenge resulting from managerial decisions. Implementing CDWM systems faces sociocultural obstacles, including a reluctance to exchange ideas between clients and contractors. This leads to minimal client interest in environmentally sustainable construction (Daoud et al., 2023b). Ineffective communication between designers and clients results in design errors, modifications, and corrective actions (Laovisutthichai et al., 2022). Sociocultural preferences for on-site construction over prefabrication persist in many countries (Yuan et al., 2011). The absence of gender equality affects the CDWM system, with women being more aware of construction waste pollution and influencing policies and management of such concerns (Teo and Loosemore, 2001). The research also indicates that critical practitioners may only prioritize waste management in projects if actively supported by managers with infrastructure, incentives, and resources.

(iii) *Regarding financial barriers*: Adequate financial resources are crucial for effective waste management (Al-Otaibi et al., 2022). However, minimizing construction waste faces financial obstacles, especially related to recycling (Yuan et al., 2011). Many developing nations grapple with financial constraints due to unfavorable economic policies, widespread poverty, and inadequate infrastructure, hindering the development of CDWM systems (Ametepey et al., 2015; Correia et al., 2021; Luttenberger, 2020; Menegaki and Damigos, 2018; Negash et al., 2021; Ulubeyli et al., 2017). Among these financial barriers, the cost of C&D waste training workshops for project personnel is a significant challenge (Bashir, 2013). Workers often perceive CDWM as needing more cost-effectiveness and efficiency, reducing their motivation for waste reduction. Additionally, volatile market conditions leading to increased waste material prices discourage workers from segregating materials for recycling and reuse (Teo and Loosemore, 2001).

(iv) *Regarding Challenges in Waste Quantification*: Accurate assessment of C&D waste volume is crucial for effective waste management. Project-level quantification assists project managers in organizing storage, scheduling material procurement, and operating cost-effective waste disposal. Regional-level quantification estimates cumulative waste production across projects in a specific area, aiding decision-makers in formulating regulations, resource allocation, and landfill construction strategies (Wu et al., 2014). Two on-site waste volume quantification methodologies exist: soft and hard measurement techniques. Soft methods involve interviews, surveys, and statistical analysis; in contrast, more rigorous methods encompass material flow analysis, waste sorting, and weighing (Hassan et al., 2018). Keywords in this cluster highlight its primary foci: (1) quantifying C&D waste generation, for instance, using GeoSLAM's SLAM-based mobile mapping system in Egypt (Attia et al., 2021). (2) scrutinizing the rates of waste generation, exemplified by Islam et al. (2019) comprehensive research comparing data from various countries; and (3) creating models for C&D waste generation estimation with machine learning techniques (Cha et al., 2021; Lu et al., 2021).

(v) *Insufficient Information Modeling*: This group focuses on underutilized information technology in the CDWM domain and involves keywords such as "construction waste management," "BIM," "information modeling," and "assessment score." Challenges include the absence of historical data, inconsistent data, and the absence of platforms for waste material circularity. Existing CDWM tools must improve data quality, interoperability, and design process integration. Information technology adoption is increasing globally to enhance CDWM efficiency and reduce environmental impacts. Emerging technologies such as BIM and big data are explored to quantify, monitor, control, and manage C&D waste (Akinade et al., 2018; Ratnasabapathy et al., 2019).

5. In the last nine years, there has been a significant increase in attention to CDWM and its associated barriers (Fig. 1). The research themes have evolved, shifting from "prefabrication" and "model" to encompass "managing construction," "life-cycle assessment," "industry," and "reduction" from 2021 to 2022. In 2023, prominent topics included "quantification," "industry," "barriers," "demolition waste," and "managing construction" (Fig. 10). This evolving trajectory presents opportunities for further exploration of the interrelation between life-cycle assessment and CDWM, as well as the study of waste reduction and its associated barriers (Fig. 12).

6. Future research directions

This review of the selected 72 articles indicates five main barriers to CDWM. These CDWM barriers can be sorted based on cluster analysis, and future research directions (FRDs) can be determined. Fig. 12 shows a framework that illustrates the status quo of research and FRDs.

6.1. Managerial barriers

For the topic of "Managerial Barriers," the following three major themes should be further explored:

- Adoption Strategies: Investigate effective strategies for promoting the managerial adoption of sustainable waste management practices within construction firms.
- Organizational Culture: Explore the influence of organizational culture on waste management decisions and identify methods to shift organizational mindsets toward sustainability.
- Leadership and Training: Study the role of leadership in driving change toward sustainable waste management and design tailored training programs to equip managerial staff with the necessary skills.

6.2. Culturally ingrained waste behaviors in the construction industry

For the barrier of "Culturally Ingrained Waste Behaviors in the Construction Industry," the following issues should be addressed in the future:

- Behavioral Studies: Conduct in-depth behavioral studies to understand the cultural and psychological factors influencing waste generation and disposal practices in different construction settings.
- Cultural Interventions: Devise interventions considering cultural nuances to effectively alter waste behaviors, potentially leveraging social norms or community engagement approaches.
- Cross-Cultural Comparative Studies: Compare waste behaviors across different cultures and regions to identify universal and culture-specific factors influencing waste practices in construction.

6.3. Financial barriers

The following three research directions should be noted for the topic

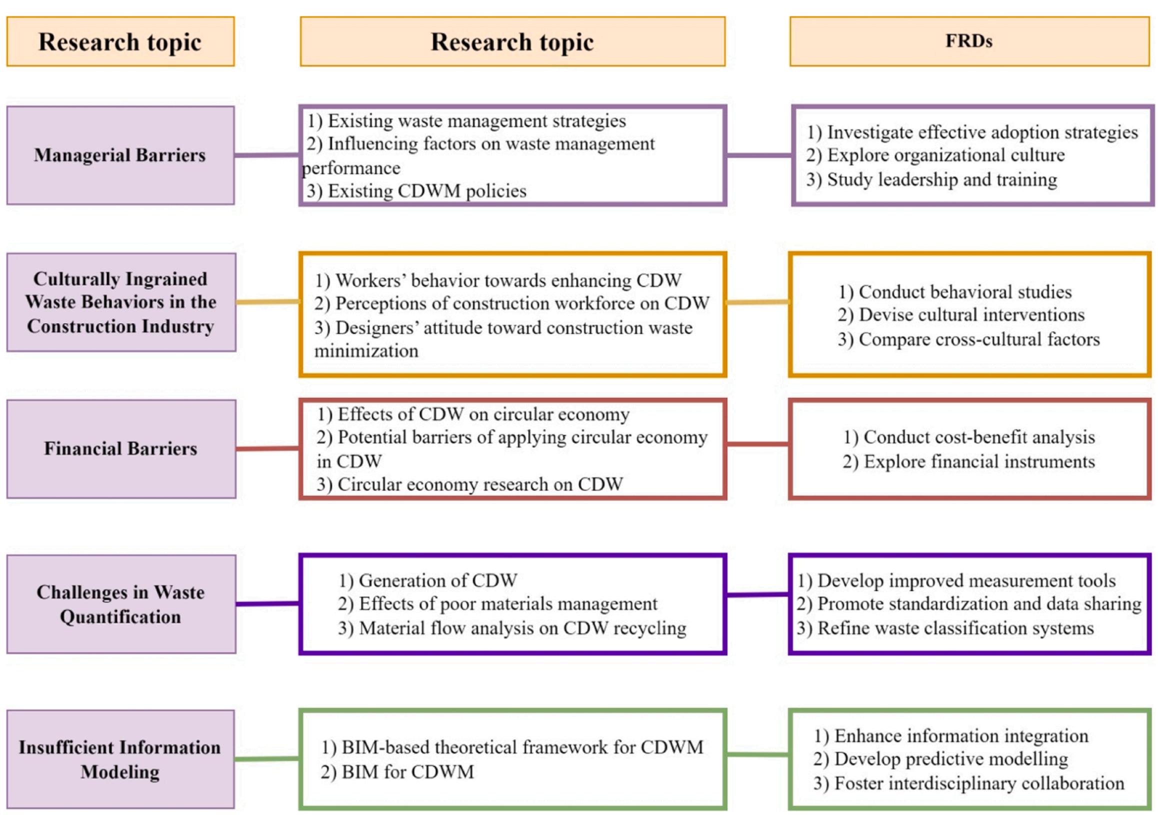

Fig. 12. Framework of the status quo of CDWM barriers and future research directions.

of "Financial Barriers":

- Cost–Benefit Analysis: Conduct comprehensive cost–benefit analyses of sustainable waste management practices to demonstrate long-term financial benefits and incentivize investment in such strategies.
- Financial Instruments: Explore innovative financial mechanisms (e.g., green financing, incentives, subsidies) to alleviate financial barriers and encourage sustainable waste management practices in construction projects.
- Business Models: Develop alternative business models that integrate waste reduction and resource efficiency as core components, aligning financial incentives with sustainable practices.

6.4. Challenges in waste quantification

For the barrier of "Challenges in Waste Quantification," three significant themes should be explored:

- Improved Measurement Tools: Develop and validate improved methodologies and tools for quantifying construction waste more accurately, potentially leveraging advanced technologies such as IoT sensors or machine learning algorithms.
- Standardization and Data Sharing: Advocate for standardized waste quantification methodologies across the industry and mechanisms for transparent data sharing among stakeholders.
- Waste Classification Systems: Refine and develop comprehensive waste classification systems tailored for the construction industry, facilitating better quantification and management practices.

6.5. Insufficient information modeling

The following three FRDs should be noted related to the barrier of "Insufficient Information Modeling":

- Enhanced Information Integration: Investigate ways to integrate waste management information into BIM systems, enabling better decision-making throughout the project life cycle.
- Predictive Modeling: Develop predictive models anticipating potential waste generation scenarios in construction projects, allowing proactive waste reduction strategies.
- Interdisciplinary Collaboration: Collaborate with information modeling experts, waste management specialists, and construction professionals to enhance information modeling frameworks with waste management components.

These future research directions aim to address specific aspects of the identified barriers in CDWM, offering opportunities for innovative approaches, methodologies, and interventions to advance sustainable practices in the construction industry.

7. Conclusion

In this study, a comprehensive bibliometric analysis is performed on 72 articles related to CDWM barriers, obtained from the WoS database from 2003 to 2023 using the RStudio software. This study employs a comprehensive approach in investigating CDWM barriers globally without geographical or specific barrier constraints. The study introduces new indices, such as *h*-index and MCP ratios, to enhance metrological analysis, deepening the scope of CDWM literature investigations. This innovative approach expands upon previous research and is a valuable reference for exploring other research subjects.

As per the outcomes, a noticeable shift has occurred in the evolution and advancement of the CDWM domain. The annual pattern of article publication over the last two decades has been categorized into three distinct publishing periods. The initial phase spans from 2003 to 2014 and includes nine publications. Following this, publications consistently increased between 2015 and 2020, constituting a developmental phase with a cumulative total of 25 articles. Subsequently, the years from 2021 to 2023 denote a phase of acceleration and momentum, featuring 38 publications. It is captivating to note the discernible trend of research studies progressively gravitating toward a more concentrated focus on CDWM. The most substantial contributions to the research community originated from China, Australia, and the United Kingdom, with 20, 11, and 7 research papers, respectively.

Regarding emerging keywords, "managing construction," "barriers," "generation," "reduction," and "life-cycle assessment" ranked as the top five. Concerning leading authors, Yuan H was the foremost author with the highest *h*-index, number of publications, and total citations. Remarkably, concerning the *h*-index, Yuan H's eminence is followed by Chen J, Daoud AO, Othman AE, and Tam VWY, among 235 contributing authors from 2003 to 2023. The most influential journals in the domain of CDWM barriers include the *Journal of Cleaner Production*, *Resources Conservation and Recycling*, *International Journal of Construction Management*, and *Waste Management & Research*.

This study identifies five clusters of barriers in CDWM: "Managerial Barriers," "Waste Behavioral Culture in the AEC Industry," "Financial Barriers," "Waste Quantification," and "Lack of Information Modeling." However, it has limitations, as it relies exclusively on peer-reviewed articles and data from the WoS database. Future research should consider other academic sources and databases, such as Science Direct or Scopus, for a more comprehensive analysis.

The study contributes to both the conceptual and practical aspects of CDWM. Conceptually, it helps academics identify top journals, researchers, and current trends in the field. Practically, it provides insights for practitioners to implement best practices and explore opportunities in CDWM. Additionally, it offers valuable information for governments to create effective regulations promoting waste-free construction and building industries.

Note

During the preparation of this work, the authors used Chat GPT 3.5 to improve language and increase readability. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the publication's content.

CRediT authorship contribution statement

Gulden Gumusburun Ayalp: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Merve Anaç:** Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Investigation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

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