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Research article

Temporal evolution and thematic shifts in sustainable construction and demolition waste management through building information modeling technologies: A text-mining analysis

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ABSTRACT

Construction and demolition activities are significant contributors to waste generation worldwide. As population growth accelerates worldwide, the amount of construction and demolition waste (C&DW) will increase proportionally unless proactive measures are implemented. This study analyzes the evolving research landscape on utilizing Building Information Modeling (BIM) technologies to advance sustainable C&DW management practices. A comprehensive text-mining analysis is conducted on 493 scholarly publications covering evolutions from January 2009 to February 2024 using the PRISMA framework. The research objectives are: (i) to identify key themes in domain of BIM technology in C&DW management using VOSviewer, (ii) to map the temporal evolution of research focus using SciMAT, and (iii) to identify emerging thematic trends.Co-occurrence analysis reveals three major research themes: (i) the use of digital twins and prefabrication for waste reduction, (ii) integrating environmental impact assessments, and (iii) data-driven decision-making. Strategic diagrams produced by SciMAT software uncover shifting priorities over the study period, with "reuse and recycling" emerging as motor themes, and "Prefabrication" (CIT = 481), "Decision Making" (CIT = 66), "Material Passport" (CIT = 92), and "Digital Twin" (CIT = 44) emerging as high-centrality and transversal themes. Temporal evolution mapping unveiled progressive integration of BIM tools such as (i) digital twins (TLS = 34, OCC = 9) and (ii) prefabrication (TLS = 40, OCC = 14), presenting opportunities to optimize waste reduction. This study offers a robust overview of the field, aiming to inform a diverse audience, including researchers from various disciplines, policymakers and industry professionals interested in advancing sustainable practices in C&DW management through innovative digital solutions.

1. Introduction

The rapid increase in global population is driving a notable rise in construction endeavors, thereby intensifying the production of construction and demolition waste (C&DW) (Jahan et al., 2022; Ray et al., 2024). This rapid increase in waste production brings with it a host of sustainability challenges, including land degradation, largely attributed to inadequate C&DW management (Udawatta et al., 2020; Su et al., 2021; Carmo et al., 2022). Recognizing these challenges, the global political agenda now firmly advocates for circular economy principles, emphasizing maximizing reuse and recycling of waste materials to establish closed-loop systems in supply chains (Ghisellini et al., 2018; Akinade and Oyedele, 2019). This transition requires a fundamental shift in how C&DW is perceived C&DW, moving beyond its portrayal as merely an environmental burden and recognizing its potential as a valuable resource for circulating construction materials (Han et al., 2024).

C&DW constitutes a substantial portion of global solid waste, clearance, encompassing waste generated from site leveling, superstructure construction, road construction demolition activities, and building renovation (Quiñones et al., 2021). Notably, China is a significant contributor to global waste generation, producing approximately one-third of the total worldwide. Despite constituting a significant portion of China's waste output, the recycling rate for C&DW remains concerningly low at only 10% (Heigermoser et al., 2019), highlighting a significant gap between waste generation and responsible management practices. In contrast, developed nations such as Germany demonstrate effective and sophisticated C&DW management methods, achieving a

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remarkable 80–90% recycling rate through practices such as selective demolition and green public procurement (Kabirifar et al., 2021). This clear disparity highlights the pressing necessity to implement more sustainable C&DW management strategies worldwide (Sharifi, 2021).

C&DW management is a critical aspect of sustainable practices in the construction industry. Research highlights various approaches to address this issue, such as incorporating circular economy principles by minimizing waste, reducing greenhouse gas emissions, and considering the long-term stockpiling of waste as a significant factor often overlooked in industry practices (Pilipenets et al., 2024). Hazardous substances in demolition waste pose challenges to achieving a circular economy, emphasizing the need for technologies to detect and manage these substances effectively (Ahkola et al., 2024). Additionally, utilizing C&DW and rock processing residues as substrate materials in constructed wetlands shows promising results in treating wastewater, offering environmental benefits, cost savings, and efficient pollutant removal (Kotsia et al., 2024). Furthermore, innovative approaches like using C&DW along with discarded PET plastic bottles in cement mortar formulations demonstrate the potential for creating sustainable building materials for non-structural elements in construction projects (Peisino et al., 2024).

One of the most promising solutions for effective C&DW management is utilizing emerging technologies. Building Information Modeling (BIM) is an innovative technology set to fundamentally transform the landscape of C&DW management. It covers all phases of a building's lifecycle, providing the chance to proactively tackle waste generation and develop sustainable C&DW management strategies (Lu et al., 2017; Soust-Verdaguer et al., 2017). BIM can enhance waste management by integrating with green rating systems like Green Star, enabling better assessment of materials and indoor environmental quality, ultimately reducing construction waste (Doan et al., 2019). BIM enables the quantification of environmental and economic impacts of construction waste through standardized assessment methodologies, such as Life Cycle Assessment (LCA), enhancing the efficiency of waste management schemes (Han et al., 2024). By facilitating the management of material information and tracking C&DW indicators throughout the project duration (Burt and Purver, 2014; Jiang et al., 2018), BIM enables stakeholders to make informed decisions that minimize waste generation and maximize resource reuse (Schamne et al., 2024). Its open data format allows for seamless integration with BIM-based applications, unlocking a range of functionalities vital for sustainable C&DW management (Santos et al., 2019). Given its popularity, bibliometric studies on the use of BIM tools in construction studies are increasingly popular, however the use of BIM on waste minimization is much less researched. Table 1 presents the list of acronyms utilized in this study.

This study's comparative analysis reveals both consistencies and divergences with prior research on BIM-based C&DW management. BIM offers a comprehensive and efficient solution, particularly in the design and procurement phases, outperforming methodologies such as Life Cycle Assessment (LCA), Material Waste Analysis, and Design for Disassembly (Akbarieh et al., 2020; Cheng et al., 2015). BIM provides real-time data analysis and informed decision-making capabilities, though it faces challenges such as the lack of a global framework and the need for improved indicators and interoperability between BIM tools (Akbarieh et al., 2020; Schamne et al., 2022). Despite these limitations, BIM's potential for minimizing C&D waste at the source and design stage remains significant (Gupta et al., 2022).

Table 1
List of acronyms used in the study.

Acronym	Definition
BIM	Building Information Modeling
C&DW	Construction and Demolition Waste
CIT	Citation
LCA	Life Cycle Assessment
OCC	Occurrences
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SDGs	Sustainable Development Goals
TLS	Total Link Strength
WoS	Web of Science

This study offers critical insights for policymakers by emphasizing the crucial role of BIM technologies in reducing C&DW. The findings support the development of policies aimed at integrating digital tools into waste management practices to enhance sustainability and adherence to circular economy principles. The theoretical implications lie in demonstrating the evolving landscape of BIM technologies and their integration into sustainable waste management practices. This study expands the existing theoretical framework by introducing new themes and temporal trends that clarify the relationship between digital innovations and waste reduction strategies. Practitioners in the construction industry can leverage the insights from this study to improve their waste management practices. The identified themes and technological advancements, such as digital twins and prefabrication, offer practical solutions for minimizing waste and enhancing resource efficiency on construction sites.

The primary objectives of this research are to [i] systematically identify knowledge gaps and promising research directions in BIM-based C&DW management strategies from Jan 2009 to Feb 2024 using the PRISMA framework, [ii] delineate the intellectual structure of the BIM-C&DW research domain by employing co-occurrence node analysis using VOSviewer, and [iii] map the temporal evolution of research focus within BIM-C&DW management using SciMat and identify emerging thematic trends and temporal evolution.

Despite the valuable insights provided by previous studies, there is a knowledge gap in comprehensively understanding the thematic development and temporal evolution of research in BIM-based C&DW management (Table 2). This study uses node analysis on the C&DW node to pinpoint research themes in this field. The use of the strategic diagram to visualize theme evolution in BIM technologies for C&DW over time is original. The diagram categorizes themes and specifically spots emerging, declining, and consistent trends in C&DW management. Additionally, the resulting evolution map was used to track the progression of BIM technologies in C&DW management over time, offering a dynamic view of the research landscape, highlighting the temporal shifts in research themes and their connections within C&DW and BIM technologies. This study fills the knowledge gap by providing a detailed analysis of these thematic and temporal shifts, offering new insights into underexplored areas, and guiding future research directions in this rapidly evolving field. This study applied recent guidelines on bibliometric study which contributes to a more comprehensive understanding of the field, providing insights to practitioners, funding agencies, and journal editors.

2. Literature review

The current study aims to provide a critical examination and comprehensive analysis of the existing literature on BIM-based C&DW management strategies. Table 2 summarizes the key text-mining studies related to BIM technologies, providing insights into their methodologies and findings.

One of the major contributions of the present study is systematic identification of knowledge gaps and the proposition of promising research directions in BIM-based C&DW management strategies. While previous studies like Li et al. (2017) have made valuable contributions by mapping the knowledge domains and evolution of BIM research, they primarily focus on static snapshots of knowledge areas and fail to offer a nuanced understanding of the temporal evolution and network dynamics influencing BIM adoption for waste reduction in C&D activities. This study addresses this limitation by employing advanced analytical tools, such as profiling thematic development and assessing temporal evolution, to offer a more dynamic view of the field's progression over time.

Table 2
Knowledge gap in literature on sustainable C&DW management using BIM technology.

Study	Description	C&DW node analysis	Analytical categorization: profiling thematic development	Temporal evolution: tracking field evolution over time
Li et al. (2017)	• Offered insights on the status quo of BIM knowledge. • 60 key research areas identified in BIM knowledge.	NO	NO	NO
Akbarieh et al. (2020)	• The research focused on BIM-based End-of-Life cycle decision-making. • Found disconnection between BIM tools and End-of-Life tools hinders progress.	NO	NO	NO
Aziminezhad and Taherkhani (2023)	• Identified BIM and deconstruction integration trends and challenges. • Co-authorship analysis identified active countries in BIM research.	PARTIALLY	NO	NO
Present Study	• Unveils specific thematic shifts and temporal trends through numerical analysis. • Analyzes progressive integration of emerging BIM tools such as digital twins for waste management.	**YES**, node analysis was conducted using the VOSviewer Tool (Objective 2)	**YES**, thematic development was identified using the SciMat Tool (Objective 3)	**YES**, temporal trends were mapped using the SciMat Tool (Objective 3)

Akbarieh et al. (2020) highlight the importance of BIM in facilitating decision-making at the end of a building's lifecycle and in digital deconstruction processes. However, their study lacks an exploration of analytical tools like profiling thematic development and temporal evolution to quantify the field's evolution. The present study addresses this limitation by integrating techniques such as co-occurrence node analysis using VOSviewer and temporal mapping with SciMat, providing a more nuanced view of the research focus's development over time.

Aziminezhad and Taherkhani (2023) undertook a bibliometric analysis focusing on the applications of BIM in deconstruction, identifying leading countries, authors, and highly cited papers within the domain. However, their analysis often neglects the temporal dimension of technological evolution and the progression of identified themes. This study enhances their findings by explicitly mapping the temporal evolution of research focus and emerging thematic trends within BIM-C&DW management, offering a richer perspective on the field's development.

Recent studies have underscored BIM technologies' potential in reducing C&DW (Doan et al., 2019; Han et al., 2024). However, there is a notable gap in the literature regarding text-mining analyses utilizing BIM technology specifically for managing C&DW (Zhang et al., 2023). While earlier research emphasizes BIM's role in enhancing sustainability practices and waste reduction strategies (Doan et al., 2019; Han et al., 2024), there is an absence of comprehensive studies utilizing text-mining techniques within the BIM framework to analyze and optimize C&DW management processes. This study aims to fill this gap by conducting a thorough bibliometric analysis focused on exploring trends, gaps, and emerging themes in the integration of BIM with CDW management strategies. By leveraging data-driven insights, this research intends to provide valuable contributions to both academia and industry, facilitating informed decision-making and advancing sustainable practices in the construction sector.

Recent decades have seen the growth of software tools for science mapping and text-mining analysis (Cobo et al., 2011b; Richter et al., 2019; Karimi et al., 2023). This study utilizes VOSviewer and SciMat to offer a detailed analysis of the BIM-C&DW research domain, with a particular focus on mapping the temporal evolution of research focus. Previous studies have primarily provided snapshots of research themes at specific points in time. In contrast, this study's temporal analysis aims to offer valuable insights into how the research focus has shifted and evolved, addressing the limitations of previous work.

By adopting a critical approach, identifying knowledge gaps and limitations, delineating the intellectual structure through co-occurrence node analysis, and mapping the temporal evolution of research focus using combined bibliometric tools (Table 2), the present study contributes to a deeper understanding of the BIM-C&DW research domain. This comprehensive analysis addresses the shortcomings of previous studies, offering insights into network dynamics, thematic development, and temporal evolution, ultimately supporting the development of more effective BIM-based C&DW management strategies.

3. Methodology

In this study, the text-mining analysis method was adopted due to its robust capability to handle large volumes of scholarly publications and extract meaningful patterns and trends. Text-mining analysis is increasingly popular in waste studies (Ben Abdallah et al., 2024; Hasan et al., 2024). The theoretical rationale behind using text-mining is grounded in its ability to analyze unstructured data and provide insights that traditional bibliometric methods might overlook. Compared to similar methodologies such as meta-analysis or systematic review, text-mining offers a more dynamic and scalable approach to uncover evolving research themes and intellectual structures. For instance, while meta-analysis consolidates findings from various studies, it often lacks the temporal and thematic resolution provided by text-mining. Systematic reviews, although comprehensive, can be labor-intensive and less effective in visualizing trends over time. Thus, text-mining was selected for its efficiency and effectiveness in capturing the temporal evolution of research in BIM technologies for C&DW management. By employing established tools like VOSviewer and SciMAT, which are widely used in bibliometric studies across various disciplines, this study aligns with best practices and methodological rigor (van Eck and Waltman, 2010; Cobo et al., 2011a).

3.1. Data collection approach

A comprehensive literature search was conducted using the Web of Science (WoS) database to identify relevant scholarly resources on C&DW and BIM published between January 2009 and February 2024. The timeframe was strategically chosen to capture the emergence and evolution of research efforts integrating BIM technologies into C&DW management practices. The year 2009 marks the initial appearance of seminal studies exploring this domain, indicating its inception as a critical research area.

3.2. Search string development

An iterative process was employed to develop a comprehensive search string encompassing relevant terms and their variations. The final

query incorporated three distinct categories of keywords: (1) Terms related to BIM technologies: "Building Information Model*", "BIM"; (2) Terms associated with construction activities: "construction*", "demolition*", "C&D*", "building*", "structure*", "structural*", "deconstruction*", "renovation*"; (3) Terms pertinent to waste management practices: "waste*", "wastes", "recycle*", "recycling*", "reuse*".

The asterisk (*) was used as a wildcard to capture variations of the root terms, ensuring a comprehensive search. The inclusion of synonyms and alternate phrasings aimed to enhance the retrieval of relevant literature while minimizing potential omissions, thereby enhancing the search's comprehensiveness and supporting reproducibility for future studies.

3.3. Utilization of PRISMA framework

Adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, the study upheld rigorous standards of transparency and reproducibility throughout the literature review process.

The article screening process involved a two-step approach. First, the initial search results were filtered to include only English-language publications, reducing the dataset from 715 to 705 articles. Subsequently, abstract screening was conducted to assess the relevance of the remaining articles to the study's focus on C&DW and BIM. The inclusion criteria required explicit mentions of integrating BIM technologies within the context of C&DW management practices in the abstracts. Articles that did not meet this criterion were excluded, resulting in the final corpus of 493 articles deemed relevant for further analysis.

This systematic screening process led to the exclusion of 212 irrelevant papers, leaving a final corpus of 493 articles deemed suitable for further analysis, reflecting a methodical approach to article selection and screening in accordance with PRISMA guidelines. The bibliographic data of the final corpus of 493 articles, including full records and cited references, was exported in two formats: tab-delimited and compatible with the reference software VOSviewer and SciMAT. These tools were chosen for their capabilities in visualizing knowledge networks, identifying thematic trends, and mapping the temporal evolution of research domains.

3.4. Tools and data export

The study utilized VOSviewer and SciMAT to analyze bibliometric data on BIM technologies in C&DW management. VOSviewer excelled in visualizing bibliometric networks and identifying key entities but may overlook subtle thematic shifts. SciMAT, specialized in science mapping, provided insights into thematic evolution and emerging research fronts over time through co-word analysis and strategic diagrams. By integrating these tools, the study gained a comprehensive understanding of how BIM is influencing sustainable C&DW practices, enhancing methodological rigor and validity in exploring this dynamic research field.

This research employs VOSviewer, a bibliometric software that enables the creation and visualization of knowledge networks (van Eck and Waltman, 2010). The study utilizes co-occurrence analysis, a technique that identifies terms that frequently appear together within a corpus. This method is particularly pertinent to the research objective of elucidating key research topics and their interconnections within the context of BIM technologies for C&DW management. A "Thesaurus file" was prepared to enhance the analysis's precision and comprehensiveness to facilitate data cleaning and standardization by amalgamating synonymous terms, variations in author names, and rectifying other potential inconsistencies (Van Eck and Waltman, 2020). For instance, terms such as "LCAs" and "Life Cycle Assessment" were consolidated under the standardized term "LCA" within the thesaurus, thereby ensuring consistency and minimizing noise in the analysis. The resulting network maps comprise nodes and links, with their sizes and thicknesses symbolizing the frequency of the terms and the robustness of the connections between them, respectively (Van Eck and Waltman, 2020). This visual representation aids in the identification of salient research themes and their interrelationships within the field.

In this study's subsequent phase, SciMAT is utilized to discern thematic shifts and temporal evolution. The tool's co-occurrence analysis reveals thematic transitions across four distinct periods delineated in section 4.1. Data integrity is fortified by consolidating synonymous and erroneously spelled terms via SciMAT's "Word Group Manual Set." The analysis's inclusivity surpasses conventional author keyword constraints by integrating both author and indexing database keywords, aligning with recommended practices. The "Equivalence Index" normalizes keyword co-occurrence frequencies, while the "Simple Centers Algorithm" clusters terms effectively within co-occurrence frameworks. SciMAT's analysis generates four key outputs thematic networks, strategic diagrams, overlay graphs, and evolution maps that categorize themes by network "Density" and "Centrality". Density reflects a theme's internal coherence and development potential, while centrality indicates its influence and connectivity to other themes, shaping the field's trajectory (Cobo et al., 2011b). While detailed descriptions of SciMAT's algorithms and functionalities are available (Cobo et al., 2012), the focus is on the specific aspects pertinent to the analysis.

3.5. Thematic analysis approach

The decision to use SciMAT for analyzing thematic shifts and temporal evolution was based on its strong capabilities in managing co-occurrence networks and tracking key themes over time. Themes were categorized using criteria of density (internal coherence and development potential) and centrality (influence and connectivity). This approach aimed to ensure themes are both relevant and influential, helping to identify transversal and emerging themes for a thorough understanding of research in BIM technologies and C&DW management.

3.6. Output interpretation

SciMAT outputs, such as strategic diagrams and thematic networks, were interpreted to derive meaningful conclusions about the thematic structure of BIM technologies and C&D waste reduction research. The SciMAT analysis produces strategic diagrams (Analytical Categorization: Profiling Thematic Development) that categorize major themes within each period into four groups: "motor themes," "basic and transversal themes," "highly developed and isolated themes," and "emerging or declining themes" (Tushar et al., 2023). These diagrams visually represent the thematic landscape using node size to reflect the number of articles published during each period, highlighting the relative prominence of different themes over time.

3.7. Integration of results

The integration of findings from VOSviewer and SciMAT analyses allowed for a comprehensive analysis of the thematic landscape. While VOSviewer provided insights into co-occurrence networks and key research clusters, SciMAT offered a deeper understanding of thematic evolution and shifts. Minor discrepancies between the tools were observed in preliminary trials, including variations in the prominence of certain themes. These discrepancies were reconciled by cross-referencing and validating the results through a qualitative assessment of the literature. For instance, themes that appeared prominently in VOSviewer but not SciMAT in were further investigated to understand their relevance and impact. This integrative approach ensured a robust and credible analysis of the research field (Fig. 1).

4. Results & Discussions

4.1. Temporal analysis in BIM based C&DW management

Preliminary analysis shows a distinct temporal trend. This study encompasses the timeframe from January 2009 to February 2024, delineated into four distinct phases based on quantitative analysis of publication trends and notable advancements within the field (Table 3). The first study was found in 2009, marking the starting point of the analysis. Three turning points were identified in 2014, 2018, and 2022, with each turning point followed by a significant increase in the number of publications (Fig. 2). To investigate the evolution of publication trends and thematic shifts across these periods, the timeframe was divided into four phases: 2009–2014, 2015–2018, 2019–2022, and 2023–2024. This division reflects the observed shifts in publication volume and allows for a detailed exploration of developments in Construction and Demolition Waste management during each phase.

The trend of publications after 2014 and 2015 significantly increased from 3.8 to 17.8 average publications per year, marking a more than 450% rise. One potential reason for this surge is the establishment of the SDGs by the UN in 2015 and the IPCCs 5th Assessment Report (Fifth Assessment Report — IPCC, 2014) in 2014. This finding indicates that researchers have become more interested in sustainable construction following these events. The adoption of SDGs in 2015 has significantly influenced research themes and methodologies in C&DW management, propelling it onto the global sustainability agenda. Specific SDG targets, such as those focusing on sustainable cities (SDG 11) and responsible consumption and production (SDG 12), have driven research towards urban resilience, resource efficiency, and innovative recycling technologies. The integration of SDGs has also promoted interdisciplinary approaches, leveraging advanced digital tools like BIM to optimize construction processes in line with SDG 9. This alignment has been particularly evident during the transformation phase (2018–2021) and was further accelerated by the COVID-19 pandemic, emphasizing the need for resilient and adaptive C&DW management strategies.

Fig. 2 illustrates a discernible upward trajectory in the number of articles related to C&DW published annually with confidence interval. These periods were defined through quantitative analysis of publication trends and the slope of the trend line, as well as by examining the average publication rates within each timeframe, as demonstrated in Table 3. The mean publication count is 30.81, with lower (13.50) and upper (48.12) bounds of the 95% confidence interval. The subsequent transformation phase (2018–2021) witnessed significant advancements in holistic approaches utilizing BIM technologies for C&DW management, with an average publication rate of 54.0 per year. The COVID-19 pandemic significantly increased publication volume after 2020 (Aviv-Reuven and Rosenfeld, 2021). Finally, the current trends period (2022–2024) is characterized by efforts to identify ongoing trends and potential future directions for the field, with an average publication rate of 93.5 per year.

4.2. Identify key themes in C&DW management

The methodology in text-mining analysis enables researchers to move beyond just describing bibliometric results to interpret them actively to provide a deeper insight (Lim and Kumar, 2024). Fig. 3 applies this method to the "C&DW" node, with node size indicating frequency and link thickness representing interconnectedness strength. As depicted in Fig. 3, the node analysis of the co-occurrence network reveals three distinct clusters (blue, red, and green) surrounding the central node "C&DW management," each highlighting key thematic areas within the broader context of BIM integration for C&DW reduction.

The co-occurrence analysis reveals several noteworthy relationships. As expected, a strong link exists between "sustainability" and "C&DW", highlighting the inherent connection between responsible waste management and achieving environmental sustainability in construction. However, a more surprising association emerges between "sustainability" and "BIM". BIM, a software-based process that manages information throughout a construction project's lifecycle, might not initially seem directly linked to sustainability. This unexpected co-occurrence underscores the potential of BIM to influence sustainable construction practices, warranting further investigation into this intriguing relationship. The significant correlation between "sustainability" and "BIM" not only opens new avenues for eco-efficient construction methodologies but also highlights the transformative role that digitalization can play in embedding sustainability into the core of construction project management.

Cluster 1, represented by blue nodes, highlights the role of emerging technologies in enhancing Construction and Demolition Waste (C&DW) management and reducing waste. Central to this cluster is the theme of "Waste Reduction" (TLS = 718, OCC = 63), positioned near the core C&DW node, indicating its recurring importance in publications. Key technologies include prefabrication (TLS = 102, OCC = 28) and off-site construction (TLS = 40, OCC = 14), which minimize on-site material waste and represent a shift from traditional methods. Digital Twin technology (TLS = 34, OCC = 9) improves supply chain coordination with real-time data, while Big Data analytics (TLS = 17, OCC = 7) provides insights into material usage for waste minimization. These advancements collectively contribute to sustainable development by reducing environmental impact and resource consumption in the construction industry.

Cluster 2, depicted by red nodes, centers on "Sustainability" (TLS = 321, OCC = 86) and "LCA" (TLS = 384, OCC = 86). This cluster highlights established methods for minimizing waste through life cycle assessment. Additionally, the theme "Circular Economy" (TLS = 266, OCC = 62), by utilizing BIM technologies, material selection, deconstruction planning, and even future reuse can be optimized within a single platform, promoting a closed-loop system for resources in the built environment. Terms like "Environmental Impact" (TLS = 123, OCC = 24) and "Green Building" (TLS = 58, OCC = 20) exhibit the next highest link strength within the red cluster. This cluster emphasizes the importance of integrating environmental considerations throughout the lifecycle, not solely focusing on waste reduction at the operational level.

Cluster 3, delineated by green nodes, is dedicated to integrating BIM technologies in C&DW management. Illustrated in Fig. 3, the BIM node (TLS = 854, OCC = 344) stands out as the largest and the closest node to the central node, C&DW. Additionally, the theme "System Dynamic" (TLS = 317, OCC = 87) can empower BIM-based C&DW management by simulating complex interactions between design choices, material use, and waste generation. The system dynamic can enable the identification of feedback loops that exacerbate waste and the design of interventions

Table 3
Overview of C&DW research timeline: publication numbers and average studies in a year.

Period	Phase	Time period	Duration (years)	No. of publications	Avg. number of publications per year
1	Initial Adaption	Jan 2009–Dec 2013	5	19	**3.8**
2	Maturing	Jan 2014–Dec 2017	4	71	**17.8**
3	Transformation	Jan 2018–Dec 2021	4	216	**54.0**
4	Current Trends	Jan 2022–Feb 2024	2	187	**93.5**

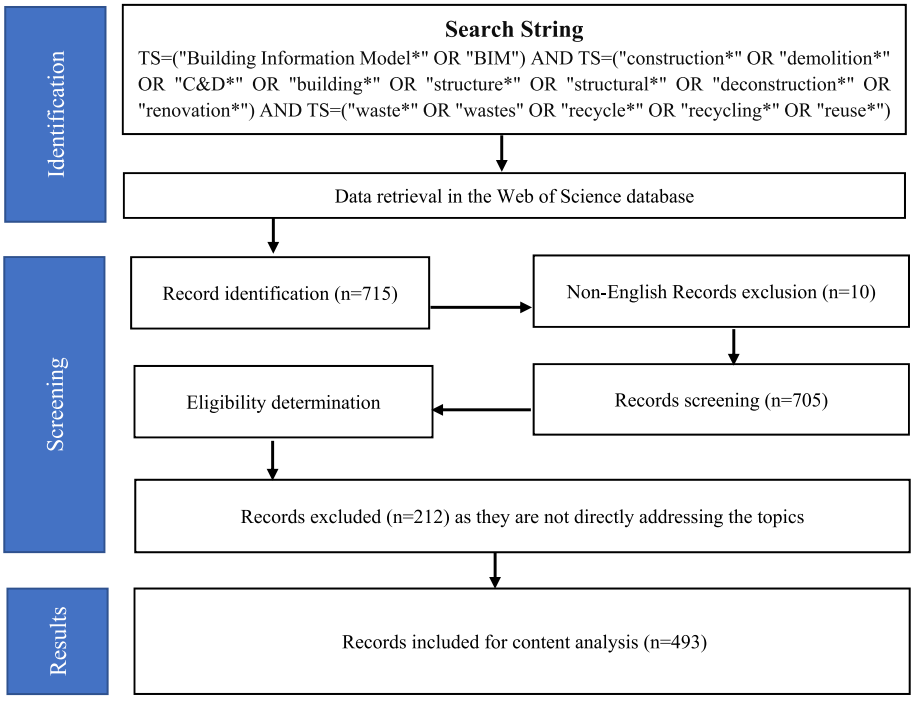

Fig. 1. Temporal Analysis in C&DW management through BIM technologies using PRISMA framework.

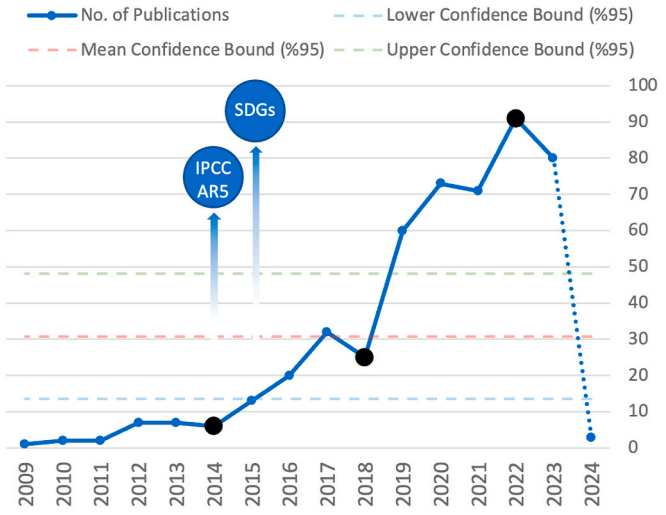

Fig. 2. Annual Publications in BIM and C&DW Studies with confidence interval.

within the BIM platform to optimize material use and minimize waste throughout the building lifecycle. In addition, the theme "concrete" (TLS = 109, OCC28) plays a key role in C&DW management due to its extensive use in building structures. Furthermore, the environmental impact associated with concrete production underscores the importance of sustainable C&D waste management studies. Although terms such as "algorithm" (TLS = 20, OCC = 7) and "decision-making" (TLS = 27, OCC = 5) underscore the necessity for comprehensive assessment tools and data-driven decision-making processes to ensure sustainable C&DW practices, they are situated at the greatest distance from the central node. The significance of this cluster lies in its emphasis on amalgamating technology with decision-making within construction processes.

4.3. Thematic shifts in BIM based C&DW management studies

Fig. 4 presents a strategic diagram analysis, revealing an intriguing shift in the scientific focus on C&DW reduction across two distinct periods: "Jan 2018–Dec 2021" and "Jan 2022–Feb 2024," and the numbers for each theme represent their core citations (CIT). The positioning of themes within a research framework holds significant importance, with each quadrant signifying distinct characteristics. Motor themes, located in the upper-right quadrant, denote themes with high centrality and density within a specific time period, exerting a substantial influence on the development of the field. They are foundational and conceptually broad, forming strong connections within the field. Highly developed and isolated themes in the upper-left quadrant demonstrate internal sophistication but lack external linkages, indicating specialization. Emerging or disappearing themes in the lower-left quadrant represent nascent or declining areas with marginal significance. Basic and transversal themes in the lower-right quadrant encompass fundamental concepts but require further elaboration, highlighting their foundational role. It is noteworthy that periods 1 and 2 are omitted from this analysis as the utilization of the BIM technologies in C&DW reduction was still evolving during these times. As such, these periods were not representative of the fully developed and implemented strategies that are the focus of this study.

In the 3rd period (2018–2021), C&DW Management, Sustainable Construction, and Construction Carbon Emission were in the upper-right quadrant (Fig. 4a) and called motor themes for their centrality and influence on the field. This period also saw the prominence of highly developed, yet isolated themes in the upper-left quadrant (Fig. 4a), like Polymer and Artificial Intelligence, suggesting their specialized applications but limited broader impact. While positions "Optimization" and "Emissions" themes in a quadrant indicating lower centrality and density, potentially suggesting nascent or fading importance, this might be due to a publication lag between 2018 and 2021, with recent research on these rising trends not yet reflected in the data. Alternatively, foundational research in these areas could be emerging, or the chosen database or keyword selection might have limited the capture of relevant studies. Finally, Material Passports and Prefabrication in the lower-right quadrant (Fig. 4a) remained as basic and transversal themes, highlighting

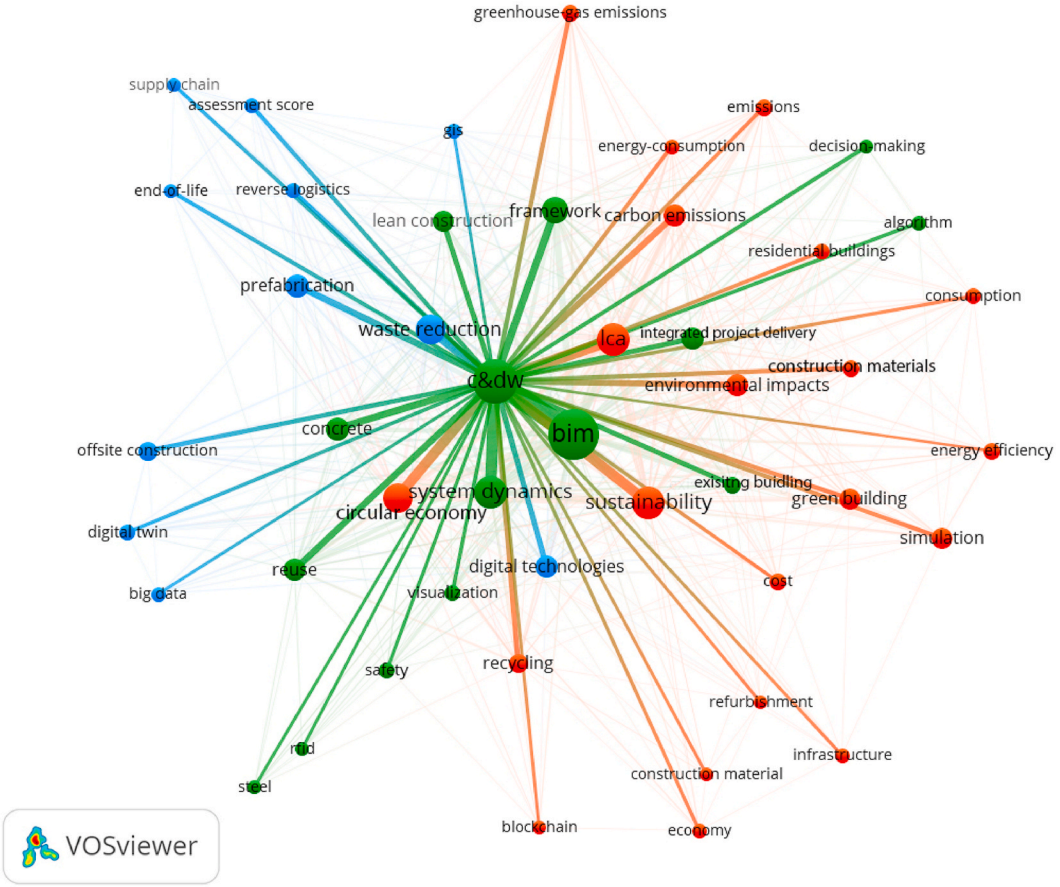

Fig. 3. Charting collaborations: Co-occurrence analysis in the C&DW node.

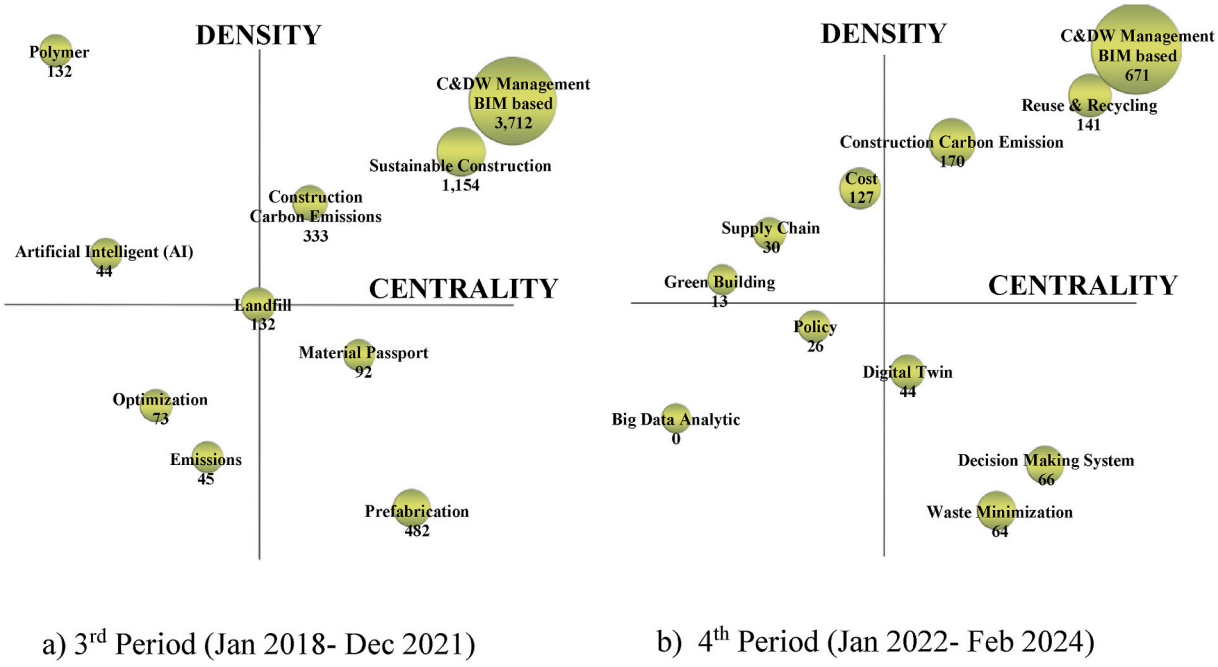

Fig. 4. Strategic Diagram in BIM-C&DW management: Identify the characteristics of prominent themes.

their foundational role but requiring further development.

The latter period (2022–2024) witnessed a significant shift in focus within C&DW Management research. While the "motor theme" remained prominent, the Reuse and Recycling upper-right quadrant (Fig. 4b) emerged as a new co-leader, reflecting the growing emphasis on circularity within the construction industry. This period also found Cost, Supply Chain, and Green Building in the upper-left quadrant (Fig. 4b) became "isolated themes and highly developed," potentially

influenced by the COVID-19 pandemic. The pandemic's disruptions may have prompted researchers to focus more intensely on cost optimization, supply chain resilience, and sustainable green building practices as distinct areas, leading to their isolation as highly developed themes. Notably, Policy and Big Data Analytics in the lower-left quadrant (Fig. 4b) emerged as emerging themes, showcasing their nascent but demonstrably transformative potential to shape future research directions. Interestingly, "Digital Twin", "Waste Minimization", and "Decision-Making System" in the lower-right quadrant (Fig. 4) arose as "basic and transversal themes". This highlights the increasing reliance on technology as a foundation for improved waste management strategies. These themes provide a crucial foundation for integrating technological advancements into future C&DW management practices.

Outliers or declining themes in the lower-left quadrant of Fig. 4 show that the themes of Optimization and Emission in the 3rd period (2018–2021) and Big Data Analytics and Policy in the 4th period (2022–2024) are outliers. This pattern suggests that these themes, while significant, do not align with the prevailing trends within their respective periods. For instance, Optimization and Emission were crucial yet isolated during the 3rd period, likely due to a shift in focus towards more integrated approaches to sustainability and C&DW management. Similarly, Big Data Analytics and Policy emerged as critical yet peripheral themes in the 4th period, reflecting their nascent stage and the evolving interest in data-driven policy frameworks for effective C&DW management. This divergence indicates a dynamic research landscape where certain themes gain prominence while others, though important, remain on the periphery.

This comparative analysis of C&DW management research in the latest period (2022–2024) demonstrates a maturing field that leverages technology for a more sustainable future. While Reuse and Recycling claim a well-deserved spot alongside enduring motor themes, signifying a vital shift towards circularity, the lower-right quadrant (Fig. 4b) exposes a significant trend. Here, "Digital Twin", "Waste Minimization", and "Decision-Making System" emerge as "basic and transversal themes." This positioning underscores the essential acknowledgment of technology's foundational role in future waste management strategies. However, the frequency indicates that despite their centrality, these themes lack comprehensive elaboration. This presents an exciting opportunity for further research to bridge the gap and fully integrate these technological advancements into practice. Ultimately, such efforts can propel C&DW management toward a future characterized by both environmental responsibility and technological sophistication.

4.4. Temporal evolution map in BIM-C&DW studies

Fig. 5 presents an overlay graph that visually represents how keyword usage shifted across the study's designated periods. The graph also emphasizes the count of keywords shared consecutively between these periods. Circled numerals represent the total keyword count for each period, while arrowed numbers illustrate shared keywords between successive periods. Parentheses enclose the computed stability index, which represents the percentage of keywords transferred from one period to the next, calculated as the ratio of shared keywords to the total number of keywords in the earlier period. The directional nature of the arrows further elucidates this dynamic: outgoing arrows depict disappearing keywords, while incoming arrows indicate newly introduced keywords.

Strikingly, the number of keywords significantly increased (Fig. 5) across each period due to the development of BIM technologies and the increase in publications, reflecting the continuous expansion of the field and the inclusion of diverse topics. This aligns with the previously presented findings, demonstrating the field's methodological and thematic growth (Fig. 4). Furthermore, the shared keywords between subsequent periods exhibit a remarkable increase, growing sevenfold from just 6 shared keywords between periods 1 and 2 to 49 shared keywords between periods 3 and 4. This substantial increase quantifies the significant evolution and development of the topic over time, reflecting a stronger integration of related concepts. However, the consistent introduction of new keywords underscores the field's ongoing evolution, unsurprising given the dynamic nature of technological advancements.

In the first period, as depicted in Fig. 6, the initial adaptation phase (2009–2013) focused on using BIM technologies for basic C&DW management tasks. This included tasks such as creating 3D models of buildings to identify potential material conflicts and opportunities for prefabrication.

In the second period, the maturing phase (2014–2017), the focus shifted towards using BIM for more complex decision-making processes and costs, such as selecting materials with lower environmental impact.

In the third period, the transformation phase (2018–2021), saw the emergence of more advanced BIM-based tools, such as Artificial Intelligence. These tools can be used to optimize construction processes and predict waste generation more accurately. Additionally, the concept of material passports began to gain traction during this time. Material passports are digital documents that track the materials used in a building throughout its lifecycle, making it easier to reuse and recycle them at the end of the building's life. Additionally, prefabrication emerged as a prominent strategy, involving the assembly of building components within a controlled factory setting. This method significantly reduces waste generation on construction sites. Similarly, off-site construction gained traction, involving the construction of entire building modules off-site for subsequent transportation and assembly at the construction site.

In the current period, from 2022 to 2024, significant focus is being given to the present and future trajectory of BIM in relation to its role in C&DW management. This focus is specifically directed towards five primary domains: [i] the recent utilization of digital twin technologies, [ii] the optimization of the supply chain, [iii] the development of prefabrication strategies through big data analytics with an emphasis on waste management, [iv] the application of AI in decision-making processes, and [v] the use of material passports for the purpose of reuse and recycling.

4.5. Future outlook on using BIM for managing C&DW

The study identifies "Digital Twin," "Decision Making," and "Waste Minimization" as pivotal themes with broad implications for advancing sustainable practices in C&DW management (Fig. 4b). The temporal

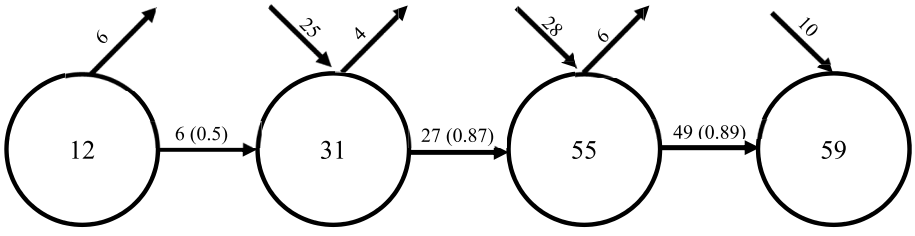

Fig. 5. Overlay graph visualization in BIM-C&DW studies: tracking keyword trends.

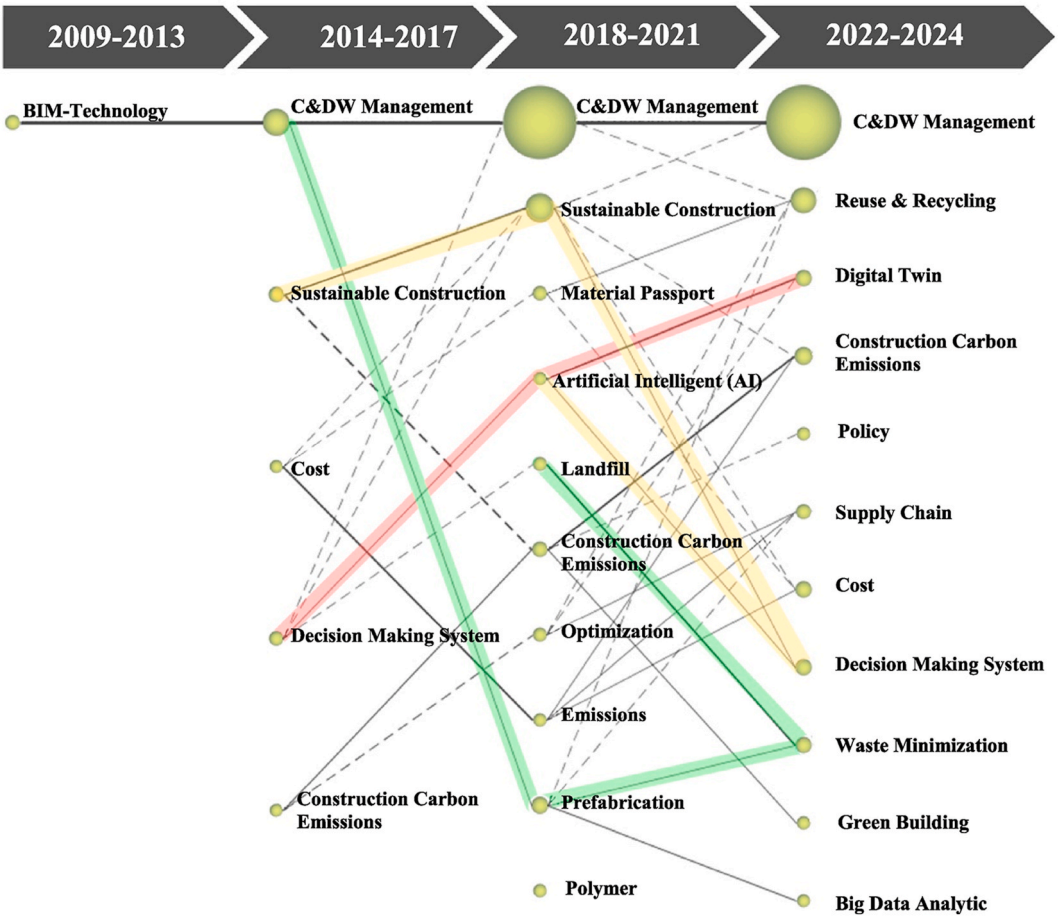

Fig. 6. Periodic evolution map of BIM technologies in C&DW management.

analysis depicted in Fig. 6 underscores these themes' evolving significance. Digital Twin technology, highlighted in red, demonstrates its potential to revolutionize waste reduction through AI and advanced decision-making systems. By harnessing comprehensive construction data within a Digital Twin environment, AI can optimize material reuse, prefabrication strategies, and off-site construction techniques. This integrated approach promises to streamline construction processes and minimize waste across a building's lifecycle, contributing significantly to sustainable outcomes. However, the implementation of Digital Twin technology faces several barriers such as high initial costs, the need for specialized expertise, and data privacy concerns. Additionally, integrating this technology into existing construction workflows may require substantial adjustments and training.

Similarly, the integration of AI with Sustainable Construction principles, depicted in yellow, enhances data-driven decision-making by predicting material needs more accurately and promoting modular construction practices that reduce on-site waste. Yet, practical challenges such as resistance to change within the industry, the need for robust data infrastructure, and the potential for technology interoperability issues must be addressed to fully leverage these benefits.

4.6. Economic implications and relevance to special issue

The results presented in this study have significant economic implications. Integrating BIM technologies into C&DW management can potentially reduce waste management costs, optimize resource use, and enhance overall project efficiency. The thematic shifts identified, such as the move towards digital twins and prefabrication, not only support sustainable practices but also contribute to economic sustainability by reducing material wastage and labor costs. These findings align closely with the theme of the special issue, which focuses on innovative digital solutions for sustainable construction practices. Properly elaborating these economic impacts within the context of the special issue highlights the practical benefits and policy relevance of adopting advanced BIM tools in C&DW management.

Comparative case studies illustrate these economic benefits in practice. For example, Germany's high recycling rates (80–90%) through selective demolition and green public procurement demonstrate substantial cost savings and efficiency gains in C&DW management (Kabirifar et al., 2021). Similarly, the use of BIM for waste reduction in China has shown potential for improving resource allocation and reducing overall project costs, despite the lower recycling rates (Heigermoser et al., 2019). These international examples underscore the economic viability of BIM technologies in optimizing construction practices.

4.7. Policy implications

The findings of this study have significant policy implications. Effective C&DW management through the adoption of BIM technologies can play a crucial role in achieving national and international sustainability targets, such as the United Nations Sustainable Development Goals (SDGs). Policies encouraging the use of digital twins and prefabrication can lead to substantial reductions in waste and resource consumption in the construction sector. Furthermore, integrating environmental impact assessments into BIM processes can support more informed policy-making, driving the construction industry towards greener practices. Governments and regulatory bodies should consider incentivizing the adoption of these technologies through subsidies, tax benefits, or mandating their use in public projects to accelerate the

transition towards sustainable construction practices.

Comparative analyses with international policy frameworks reveal successful adoption scenarios and potential pitfalls. For instance, Australia's approach to integrating BIM in C&DW management involves stringent regulations and incentives, resulting in more efficient waste management and alignment with circular economy principles (Jahan et al., 2022). In contrast, the slower adoption in developing countries highlights the need for supportive policies and financial incentives to overcome initial cost barriers and technological challenges (Carmo et al., 2022).

To accelerate the transition towards sustainable construction practices, governments and regulatory bodies can incentivize the adoption of these technologies through subsidies, tax benefits, or mandates for their use in public projects. Establishing standardized global frameworks for BIM implementation ensures interoperability and consistency across projects, further enhancing the effectiveness of C&DW management strategies.

4.8. Comparative analysis with previous studies

This study's comparative analysis reveals both consistencies and divergences with prior research in BIM-based C&DW management. While Akbarieh et al. (2020) and Cheng et al. (2015) emphasize the advantages of BIM during the design phase, the current study's findings further delineate its superiority in procurement. The lack of a global framework highlighted by Schamne et al. (2022) remains a critical challenge. Unlike previous studies, the current research provides a more granular analysis of BIM's performance across different project phases, offering a nuanced understanding of its application in C&DW management. Additionally, the temporal trend analysis indicates a significant increase in research activity post-2018, corroborating Zhang et al. (2023) and reflecting the transformative impact of sustainability goals on research directions.

Furthermore, this study expands on the comparative analysis by including recent studies, highlighting unique contributions and validating the study's novelty. For instance, Zhang et al. (2023) employed a mixed-method approach combining qualitative and quantitative data, which aligns with our methodology. However, our scope extends beyond the design and construction phases to include procurement, which has not been comprehensively covered in existing literature. By integrating findings from recent studies, this research underscores the evolving nature of BIM applications and reinforces the need for a holistic approach to BIM-based C&DW management.

4.9. Discussions

The findings align with and extend the existing literature on the integration of BIM technologies in C&D waste management. The temporal analysis revealed a marked increase in research activity, particularly post-2018, reflecting a transformative phase in this domain. This surge is consistent with Zhang et al. (2023), who reported a significant rise in academic literature and industrial patents related to C&DW management post-SDG declaration. The thematic evolution underscores a shift towards sustainability and advanced technological integration, with prominent themes such as the circular economy, life cycle assessment, and digital twin technologies becoming central to recent research efforts. These findings echo the sentiments of Han et al. (2024), who highlighted the necessity for centralized data management and coherent DWM planning workflows within the BIM environment to enhance sustainability in construction practices.

Comparative analysis with recent publications indicates that the integration of BIM with sustainable construction practices is gaining substantial traction. Doan et al. (2019) identified key barriers and benefits to the adoption of green building certifications like Green Star in New Zealand, emphasizing the critical role of BIM in facilitating sustainable practices. This study similarly underscores the growing emphasis on themes such as green building, environmental impact, and system dynamics within the BIM framework for C&DW management. Moreover, the emergence of themes like big data analytics and digital twins highlights the increasing reliance on advanced technologies to optimize waste management processes. These advancements suggest a promising trajectory towards achieving greater sustainability and efficiency in construction activities, further reinforcing the strategic importance of integrating BIM technologies with environmental and economic goals.

The results indicate that BIM-based C&DW management provides significant advantages in design and procurement phases compared to LCA, MWA, and DfD (Akbarieh et al., 2020; Cheng et al., 2015). This superiority is attributed to BIM's capability for real-time data analysis and decision-making support. However, challenges such as the lack of a global framework and interoperability issues must be addressed to maximize BIM's potential (Schamne et al., 2022). Furthermore, potential biases in selected studies or methodologies, such as publication bias or sample selection bias, could influence the interpretation of these results. It is crucial to consider these biases when evaluating the findings to ensure a balanced understanding of BIM's efficacy. The implications of these findings suggest that while BIM enhances efficiency and waste minimization, a standardized global approach and improved tool compatibility are crucial for broader adoption and effectiveness.

The current study's findings are consistent with those of Gupta et al. (2022), who also reported BIM's significant role in minimizing C&DW at the source. This study extends the literature by highlighting the specific phases—design and procurement—where BIM's impact is most pronounced. In contrast, other studies such as those by Schamne et al. (2022) have emphasized the need for better indicators and interoperability, which aligns with this study's findings regarding the current limitations of BIM technologies. Addressing potential biases in these studies is vital to accurately assess the limitations and strengths of BIM, guiding future research and implementation strategies.

5. Conclusion

This study employed a comprehensive text-mining approach to investigate the evolving integration of BIM technologies in C&DW management. The research period spanned from January 2009 to February 2024, ensuring a thorough capture of recent trends and developments. Following the PRISMA framework, a robust data collection strategy was implemented to gather relevant academic literature. This meticulous approach yielded a substantial dataset that facilitated the application of advanced text-mining techniques and bibliometric tools such as VOSviewer and SciMat. These tools facilitated the identification of significant themes and their temporal evolution.

A co-occurrence node analysis revealed three distinct clusters converging around the central theme of C&DW management. This analysis underscored the strong correlations between key concepts like "sustainability," "BIM," and "waste reduction." Notably, it highlighted the transformative potential of BIM in fostering sustainable construction practices. The blue cluster particularly emphasized the emergence of technologies like Digital Twin and Big Data analytics, showcasing their significance in optimizing C&DW management and minimizing waste generation.

The strategic diagram and evolution map provided a detailed perspective of the thematic development over distinct periods. During the third period (2018–2021), motor themes such as C&DW Management, Sustainable Construction, and Construction Carbon Emission were prominent, reflecting their foundational influence on the field. In contrast, the latter period (2022–2024) saw a shift with Reuse and Recycling emerging as co-leaders, emphasizing the growing focus on circularity within the construction industry. This period also highlighted the increasing importance of themes like Cost, Supply Chain, and Green Building, particularly in the context of disruptions caused by the COVID-19 pandemic.

The findings of this study underscore the significant impact of BIM technologies on improving sustainability in construction waste management. By identifying and analyzing key themes and trends, this research contributes valuable insights into the current state and future direction of BIM applications in the construction industry.

This study stands out by employing an advanced text-mining approach to analyze a comprehensive dataset over an extended period, providing a nuanced understanding of the evolution of BIM in C&DW management. The use of tools like VOSviewer and SciMat for bibliometric analysis adds a layer of rigor and depth to the findings, which are instrumental in highlighting the transformative potential of BIM technologies.

5.1. Policy recommendations and environmental legislation

The study suggests several policy recommendations to enhance the integration of BIM in C&DW management. Encouraging the establishment of standardized global frameworks for BIM implementation can ensure interoperability and consistency across projects. Policies that support the adoption of advanced technologies such as Digital Twins and Big Data analytics in construction projects are essential to optimize waste management practices. Strengthening regulations and incentives for the adoption of sustainable construction practices, including the use of BIM for efficient waste reduction and management, is also crucial.

5.2. Study limitations

The methodology employed in this study demonstrates a systematic approach to data collection, analysis, and interpretation. By integrating various analytical techniques and tools, the interplay between BIM technologies and C&DW management was explored comprehensively. Potential limitations include the reliance on database-specific keywords and the challenges associated with consolidating synonymous terms. Node analyses were conducted using system generated keywords, which may skew the results. Methodological challenges, such as ensuring data consistency and managing large datasets, were addressed through meticulous data cleaning and validation processes. Acknowledging these limitations provides a balanced portrayal of the study's methodology and reinforces the reliability of the findings.

However, this study acknowledges certain limitations. The analysis was limited by the availability and scope of academic literature within the specified period. The focus on specific BIM technologies may overlook other relevant innovations and practices in the field of C&DW management. The findings may not be universally applicable due to geographical variations in construction practices and regulatory environments.

5.3. Prospects for future research

While this study provides a comprehensive overview of the BIM-C&DW research landscape, future investigations could delve deeper into specific emerging themes, such as the integration of environmental impact assessments and data-driven decision-making processes. Additionally, comparative analyses across different geographical regions or industry sectors could unveil variations in the adoption and implementation of BIM technologies for sustainable C&DW management practices. Future research should explore the potential of integrating advanced BIM tools with sustainable construction methodologies to enhance efficiency and reduce waste. The impact of emerging technologies like AI and machine learning on BIM applications in C&DW management is another promising area of investigation. Conducting longitudinal studies to track the long-term impact of BIM adoption on sustainability metrics within the construction industry will provide deeper insights.

CRediT authorship contribution statement

Farzin Naghibalsadati: Writing – original draft, Software, Methodology, Conceptualization. **Arash Gitifar:** Writing – review & editing, Validation, Formal analysis. **Sagar Ray:** Writing – review & editing, Validation. **Amy Richter:** Writing – review & editing. **Kelvin Tsun Wai Ng:** Writing – review & editing, Supervision, Methodology, Funding acquisition.

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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References

Ahkola, H., Junttila, V., Kauppi, S., 2024. Do hazardous substances in demolition waste hinder circular economy? J. Environ. Manag. 364, 121362 https://doi.org/10.1016/J.JENVMAN.2024.121362.

Akbarieh, A., Jayasinghe, L.B., Waldmann, D., Teferle, F.N., 2020. BIM-based end-of-lifecycle decision making and digital deconstruction: literature review. Sustainability 2020 12. https://doi.org/10.3390/SU12072670, 2670 12, 2670.

Akinade, O.O., Oyedele, L.O., 2019. Integrating construction supply chains within a circular economy: an ANFIS-based waste analytics system (A-WAS). J. Clean. Prod. 229, 863–873. https://doi.org/10.1016/J.JCLEPRO.2019.04.232.

Aviv-Reuven, S., Rosenfeld, A., 2021. Publication patterns' changes due to the COVID-19 pandemic: a longitudinal and short-term scientometric analysis. Scientometrics 126, 6761–6784. https://doi.org/10.1007/s11192-021-04059-x.

Aziminezhad, M., Taherkhani, R., 2023. BIM for deconstruction: a review and bibliometric analysis. J. Build. Eng. 73, 106683 https://doi.org/10.1016/J.JOBE.2023.106683.

Ben Abdallah, A., Ray, S., Mim, S.J., Mahmud, T.S., Richter, A., Ng, K.T.W., 2024. Assessment of demographics and motivations of post-consumer textile waste management using a bibliometric approach. J. Mater. Cycles Waste Manag. https://doi.org/10.1007/s10163-024-01994-8.

Burt, J., Purver, K., 2014. Building information modelling for small-scale residential projects. Proc. Inst. Civ. Eng.: Management, Procurement and Law 167, 134–140. https://doi.org/10.1680/mpal.13.00019.

Carmo, J.L., Rohden, A.B., Garcez, M.R., 2022. Recycling construction and demolition waste as aggregate in porous asphalt pavement for urban stormwater management. J. Mater. Civ. Eng. 34, 04022258 https://doi.org/10.1061/(ASCE)MT.1943-5533.0004420.

Cheng, J.C.P., Won, J., Das, M., 2015. Construction and demolition waste management using BIM technology. https://iglc.net/Papers/Details/1184, 18 Jun 20204.

Cobo, M.J., López-Herrera, A.G., Herrera-Viedma, E., Herrera, F., 2012. SciMAT: a new science mapping analysis software tool. J. Am. Soc. Inf. Sci. Technol. 63, 1609–1630. https://doi.org/10.1002/ASI.22688.

Cobo, M.J., López-Herrera, A.G., Herrera-Viedma, E., Herrera, F., 2011a. Science mapping software tools: review, analysis, and cooperative study among tools. J. Am. Soc. Inf. Sci. Technol. 62, 1382–1402. https://doi.org/10.1002/ASI.21525.

Cobo, M.J., López-Herrera, A.G., Herrera-Viedma, E., Herrera, F., 2011b. An approach for detecting, quantifying, and visualizing the evolution of a research field: a practical application to the Fuzzy Sets Theory field. J Informetr 5, 146–166. https://doi.org/10.1016/J.JOI.2010.10.002.

Doan, D.T., Ghaffarianhoseini, Ali, Naismith, N., Ghaffarianhoseini, Amirhosein, Zhang, T., Tookey, J., 2019. Examining green star certification uptake and its relationship with building information modelling (BIM) adoption in New Zealand. J. Environ. Manag. 250, 109508 https://doi.org/10.1016/J.JENVMAN.2019.109508.

Fifth Assessment Report — IPCC, 2014. Fifth Assessment Report — IPCC. https://www.ipcc.ch/assessment-report/ar5/. (Accessed 5 May 2024).

Ghisellini, P., Ripa, M., Ulgiati, S., 2018. Exploring environmental and economic costs and benefits of a circular economy approach to the construction and demolition

sector. A literature review. J. Clean. Prod. 178, 618–643. https://doi.org/10.1016/J.JCLEPRO.2017.11.207.
Gupta, S., Jha, K.N., Vyas, G., 2022. Proposing building information modeling-based theoretical framework for construction and demolition waste management: strategies and tools. International Journal of Construction Management 22, 2345–2355. https://doi.org/10.1080/15623599.2020.1786908.
Han, D., Kalantari, M., Rajabifard, A., 2024. The development of an integrated BIM-based visual demolition waste management planning system for sustainability-oriented decision-making. J. Environ. Manag. 351, 119856 https://doi.org/10.1016/J.JENVMAN.2023.119856.
Hasan, M.M., Ng, K.T.W., Mahmud, T.S., Xue, J., Ray, S., 2024. The role of collaborative research network on E-waste studies in North American using a bibliometric approach. Ecol. Inf. 82, 102736 https://doi.org/10.1016/j.ecoinf.2024.102736.
Heigermoser, D., García de Soto, B., Abbott, E.L.S., Chua, D.K.H., 2019. BIM-based Last Planner System tool for improving construction project management. Autom Constr 104, 246–254. https://doi.org/10.1016/J.AUTCON.2019.03.019.
Jahan, I., Zhang, G., Bhuiyan, M., Navaratnam, S., Shi, L., 2022. Experts' perceptions of the management and minimisation of waste in the Australian construction industry. Sustainability 2022 14. https://doi.org/10.3390/SU141811319, 11319 14, 11319.
Jiang, S., Wang, N., Wu, J., 2018. Combining BIM and ontology to facilitate intelligent green building evaluation. J. Comput. Civ. Eng. 32, 04018039 https://doi.org/10.1061/(ASCE)CP.1943-5487.0000786.
Kabirifar, K., Mojtahedi, M., Wang, C.C., 2021. A systematic review of construction and demolition waste management in Australia: current practices and challenges. Recycling 2021 6, 34. https://doi.org/10.3390/RECYCLING6020034, 34 6.
Karimi, N., Ng, K.T.W., Mahmud, T.S., Adusei, K.K., Kerr, S., 2023. A systematic review of the latest research trends on the use of satellite imagery in solid waste disposal applications from 2012 to 2021. Environments 2023 10. https://doi.org/10.3390/ENVIRONMENTS10070128, 128 10, 128.
Kotsia, D., Sympikou, T., Topi, E., Pappa, F., Matsoukas, C., Fountoulakis, M.S., 2024. Use of recycled construction and demolition waste as substrate in constructed wetlands for the wastewater treatment of cheese production. J. Environ. Manag. 362, 121324 https://doi.org/10.1016/J.JENVMAN.2024.121324.
Li, X., Wu, P., Shen, G.Q., Wang, X., Teng, Y., 2017. Mapping the knowledge domains of Building Information Modeling (BIM): a bibliometric approach. Autom Constr 84, 195–206. https://doi.org/10.1016/J.AUTCON.2017.09.011.
Lim, W.M., Kumar, S., 2024. Guidelines for interpreting the results of bibliometric analysis: a sensemaking approach. Global Business and Organizational Excellence 43, 17–26. https://doi.org/10.1002/joe.22229.
Lu, W., Webster, C., Chen, K., Zhang, X., Chen, X., 2017. Computational Building Information Modelling for construction waste management: moving from rhetoric to reality. Renew. Sustain. Energy Rev. 68, 587–595. https://doi.org/10.1016/J.RSER.2016.10.029.
Peisino, L.E., Barbero-Barrera, M. del M., García-Castro, C.B., Kreiker, J., Gaggino, R., 2024. Assessment of the mechanical and physical characteristics of PET bricks with different aggregates. J. Environ. Manag. 357, 120720 https://doi.org/10.1016/J.JENVMAN.2024.120720.
Pilipenets, O., Kin Peng Hui, F., Gunawardena, T., Mendis, P., Aye, L., 2024. New circularity indicator for decision making in the stockpile management of construction and demolition waste: perspectives of Australian practitioners. J. Environ. Manag. 363, 121345 https://doi.org/10.1016/J.JENVMAN.2024.121345.
Quiñones, R., Llatas, C., Montes, M.V., Cortés, I., 2021. A multiplatform BIM-integrated construction waste quantification model during design phase. The case of the structural system in a Spanish building. Recycling 2021 6. https://doi.org/10.3390/RECYCLING6030062, 62 6, 62.
Ray, S., Ng, K.T.W., Mahmud, T.S., Richter, A., Karimi, N., 2024. Temporal analysis of settlement areas and city footprints on construction and demolition waste quantification using Landsat satellite imagery. Sustainable Cities and Society 105, 105351. https://doi.org/10.1016/j.scs.2024.105351.
Richter, A., Ng, K.T.W., Fallah, B., 2019. Bibliometric and text mining approaches to evaluate landfill design standards. Scientometrics 118, 1027–1049. https://doi.org/10.1007/S11192-019-03011-4/TABLES/4.
Santos, R., Costa, A.A., Silvestre, J.D., Pyl, L., 2019. Integration of LCA and LCC analysis within a BIM-based environment. Autom Constr 103, 127–149. https://doi.org/10.1016/J.AUTCON.2019.02.011.
Schamne, A.N., Nagalli, A., Soeiro, A.A.V., 2022. The use of BIM to automated construction and demolition waste management: a literature review from 2009 to 2020. Revista Brasileira de Gestão Ambiental e Sustentabilidade 9, 377–394. https://doi.org/10.21438/RBGAS(2022)092124.
Schamne, A.N., Nagalli, A., Soeiro, A.A.V., Poças Martins, J.P. da S., 2024. BIM in construction waste management: a conceptual model based on the industry foundation classes standard. Autom Constr 159, 105283. https://doi.org/10.1016/J.AUTCON.2024.105283.
Sharifi, A., 2021. Urban sustainability assessment: an overview and bibliometric analysis. Ecol Indic 121, 107102. https://doi.org/10.1016/J.ECOLIND.2020.107102.
Soust-Verdaguer, B., Llatas, C., García-Martínez, A., 2017. Critical review of bim-based LCA method to buildings. Energy Build. 136, 110–120. https://doi.org/10.1016/J.ENBUILD.2016.12.009.
Su, S., Li, S., Ju, J., Wang, Q., Xu, Z., 2021. A building information modeling-based tool for estimating building demolition waste and evaluating its environmental impacts. Waste Manag. 134, 159–169. https://doi.org/10.1016/J.WASMAN.2021.07.025.
Tushar, Q., Sun, W., Zhang, G., Navaratnam, S., Hou, L., Giustozzi, F., 2023. Evolution in impacts assessment for managing and recycling of waste: a scientometric analysis. J. Clean. Prod. 430, 139685 https://doi.org/10.1016/J.JCLEPRO.2023.139685.
Udawatta, N., Zuo, J., Chiveralls, K., Zillante, G., 2020. From green buildings to living buildings? Rating schemes and waste management practices in Australian educational buildings. Eng. Construct. Architect. Manag. 28, 1278–1294. https://doi.org/10.1108/ECAM-03-2019-0177.
Van Eck, N.J., Waltman, L., 2020. VOSviewer Manual: Manual for VOSviewer Version 1.6. 15. Centre for Science and Technology Studies (CWTS) of Leiden University, Leiden.
van Eck, N.J., Waltman, L., 2010. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics 84, 523–538. https://doi.org/10.1007/s11192-009-0146-3.
Zhang, K., Qing, Y., Umer, Q., Asmi, F., 2023. How construction and demolition waste management has addressed sustainable development goals: exploring academic and industrial trends. J. Environ. Manag. 345, 118823 https://doi.org/10.1016/J.JENVMAN.2023.118823.