Transformational Metrics of BIM-based Construction in the Artificial Intelligence Era _ BIM 11D

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Abstract

The construction industry is experiencing a major digital shift through the integration of Building Information Modeling (BIM) and Artificial Intelligence (AI), a convergence recently conceptualized as the 11th dimension of BIM (BIM 11D). This paper presents a scientometric review of 82 peer-reviewed papers. It tempted to quantitatively analyze the evolution, thematic trends, geographical distribution, and research hotspots in BIM-AI integration. The study showed that BIM-AI nexus adoption in construction remains emergent, with an uptrend attention and noticeable pick in 2024. Among 39 contributing countries; China, the UK, Italy then Australia hosted most studies, highlighting regional imbalances and the need for wider global engagement. Keyword and terms clustering revealed six major thematic categories—Technologies, Applications, Benefits, Applied Outputs, Implementation Axes, and Research Methods—indicating the field's diversity and potential. Despite the discerned promising development of original research, the nexus implementation remains fragmented, with few integrated frameworks and only individual efforts in addressed axes. This review offers evidence-based insights into current research dynamics and highlights critical gaps such as limited interdisciplinary integration, geographic disparities and lack of empirical validation of claimed benefits, offering a wide range for future research perspectives. This remains a strong contribution to the body of knowledge as provides researchers, practitioners, and policymakers with a strategic guide and measurable metrics of BIM-AI integration into the construction industry practices toward enhanced sustainability and efficiency. However, the restricted covered dataset by the scientometric analysis could be considered as a limitation of this study.

Keywords

AI; BID 11D; Building Information Modeling; Data; Machine Learning; Information Management; Automation; Design Thinking.

1. Introduction

The construction industry is undergoing a profound digital transformation, driven by the integration of advanced technologies such as Building Information Modeling (BIM) and Artificial Intelligence (AI). These technologies are reshaping traditional construction practices, enabling more efficient project planning, design, execution, and facility management (Bassir et al., 2023). BIM offers a digital representation of physical and functional characteristics of built assets, supporting visual displaying, information sharing among stakeholders and applications, and collaborative workflows across the entire lifecycle of a project (Bassir et al., 2023). AI, on the other hand, brings intelligent decision-making capabilities through data-driven analytics, machine learning, and pattern recognition (Li, Liu, et al., 2024). Combining BIM and AI, lately addressed as the 11th dimension of BIM technology (Bouhmoud & Alzarrad, 2025), would present unprecedented opportunities for addressing some of the industry's most persistent challenges – such as cost overruns, time delays, safety risks, and waste generation.

Research has increasingly focused on automating construction processes, optimizing resource allocation, enhancing safety and risk management, and supporting predictive maintenance through digital technologies. Despite the independent maturity of BIM and AI, their combined application within the construction domain remains relatively nascent. Yet, the increasing volume of academic and industrial research in this domain (Pan & Zhang, 2023) reflects a growing interest in harnessing these technologies for holistic and scalable solutions.

Several attempts have been made to review the nexus between BIM and AI but focused on environmental aspects (Li, Liu, et al., 2024; Li, Shirowzhan, et al., 2024; Omotayo et al., 2025), specific regional contexts (Omotayo et al., 2025; Porubcinova et al., 2025), or qualitative analysis(Bassir et al., 2023; Pan & Zhang, 2023). However, given the interdisciplinary nature of BIM and AI, research outputs are highly diverse in scope, methodology, and application areas, making it difficult for scholars and practitioners to obtain a measureable indication of the field's evolution, current trends, and future directions.

In light of this, a "scientometric literature review" becomes essential. Scientometrics, a subfield of bibliometrics, involves the quantitative analysis of academic literature using statistical and visual methods to evaluate publication patterns, research trends, collaboration networks, and thematic structures. By employing scientometric tools, researchers can objectively map the intellectual structure of a field, identify influential authors, sources, and countries, and reveal the dynamic development of key topics and emerging research fronts. Unlike traditional narrative reviews, which are often subjective and limited in scope, scientometric reviews provide an evidence-based, replicable, and logical approach to literature synthesis. This methodology is particularly suited for multidisciplinary and rapidly evolving fields like BIM and AI in construction, where large volumes of data need to be organized and interpreted.

This paper, therefore, aims to fill this gap and provides thorough, measurable insights of the BIM 11D field's development through a comprehensive analysis research metrics, keyword co-occurrences, and thematic clusters. Notably, the paper will answer 5 main questions: How has the thematic focus evolved over time? Which countries are leading research in BIM 11D? What are the most influential parties? What are the emerging research hotspots? And are there underexplored areas requiring further inquiry? By answering these questions, this scientometric review can serve as a strategic roadmap for academics, practitioners, and policymakers aiming to understand, contribute to, and capitalize on this technological convergence.

2. Materials and Methods:

This scientometric study adopts a methodical and data-driven approach to map and analyze the academic landscape at the intersection of BIM and AI within the construction industry. A four-stage methodological framework was adopted, comprising data extraction, filtering, data analysis and results display and discussion (Fig. 1).

To ensure broad and credible coverage of relevant literature, data were extracted from three prominent academic databases: Web of Science (WoS), Scopus, and Google Scholar. These sources were chosen due to their comprehensive indexing of peer-reviewed and high-impact scholarly publications across multiple disciplines. The search strategy consisted of extracting papers based on their titles employing Boolean operators and 2 keywords sets: S1= {Building Information Modeling; BIM; Building Information Model; Building Information Modelling} and S2= {Artificial Intelligence; AI}. Consequently, 394 papers were identified.

The search was intentionally broad to capture a wide range of relevant papers, which were subsequently refined through a multi-step screening process. First, duplicate entries across the databases were identified and removed. Second, non-peer-reviewed documents, such as editorials, short communications, white papers, and non-English publications, were excluded. Third, each remaining paper was manually reviewed by title, abstract, and keywords to ensure that it explicitly addressed both BIM and AI within a construction-related context. Papers discussing BIM and AI independently or superficially, without a clear integrative focus, were excluded. As a result, 82 papers were considered as relevant.

Fig. 1. Materials and Methodological flowchart.

The curated dataset was investigated to extract the relevant metrics. Meanwhile, it was imported into VOSviewer, a specialized scientometric analysis tool, to conduct a visual and statistical exploration of the literature. VOSviewer was used to generate bibliometric networks, namely keyword co-occurrence maps, author collaboration networks, and co-occurrence maps of terms from titles and abstracts. The software's clustering algorithms enabled the identification of key thematic areas and relationships within the dataset.

In addition to network visualizations, a cross-analysis of the quantitative findings was performed to extract and categorize the diverse aspects discussed in the literature regarding BIM 11D. This included identifying prevalent

applications, technologies, methods, and integration approaches related to BIM and AI, providing a structured understanding of the field's intellectual and practical development.

3. Results

3.1 Evolution and Types of Published Scientific Work

The integration of BIM with AI was first proposed by Singer et al. in (2016) as an integrated solution to capture and re-use product and process knowledge for bridges. After an absence in 2017, the scholars started timidly be interested in BIM 11D with a steady growth pace of 2 to 3 extra papers year to year between 2018 and 2023 (Fig. 2a). In 2024, the publications' number doubled compared to 2023, which could be explained by the worldwide AI booming. The given statistics till 2024 (Fig. 2b) indicates a continuous rise of the research activity in this context following equation (1) with a coefficient of determination (R-squared) of 0.9595, validating an excellent fit of the model to the data. Till May 2025, 12 papers were published, i.e., 10% more than 2024 at the same period, confirming the expected rise trend.

$$y = 0.54x^2 - 2178.9x + 2E06\ [R^2 = 0.9595] \qquad (1)$$

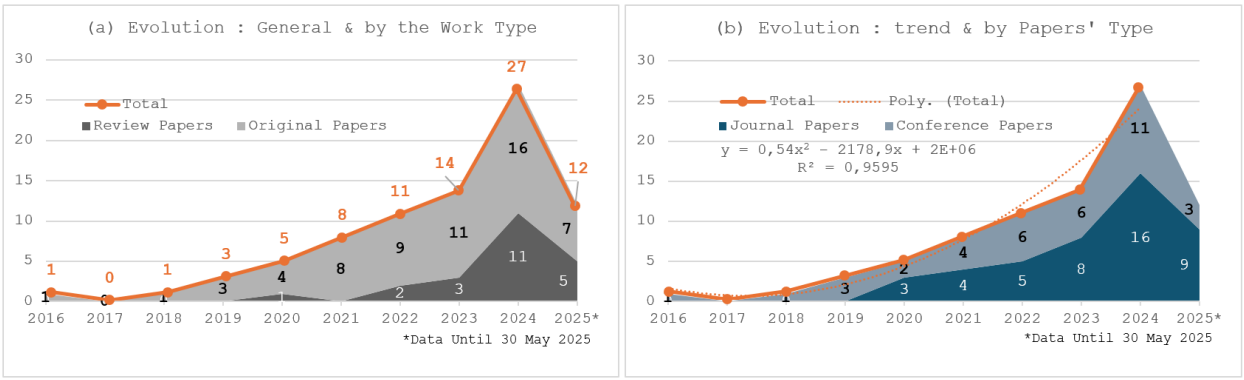

Fig. 2. Publication Evolution over time by type: (a) General Publication Evolution over the Time and distribution by the published work type – Original or Review | (b) Trend of the Publication Evolution and distribution by the peer-reviewed papers' type – Journal or Conference papers.

The majority of published work regarding BIM 11D fall under original research, reflecting active experimentation and applied studies. Notably, original papers spike in 2024 (16 papers) and remain significant in 2025 (5 papers so far) (Fig. 2a). While less frequent, review papers show a consistent rise, peaking in 2024 with 11 publications. Their increasing presence suggests maturing interest and consolidation in the research field (Fig. 2a).

Journal Papers represent the majority share of published work, especially from 2021 onward, indicating a preference for archival, peer-reviewed dissemination. The number peaks in 2024 with 16 papers and continues with 9 in early 2025 (Fig. 2b). Conference outputs also increase gradually, peaking at 11 papers in 2024 before declining to 3 in 2025 (Fig. 2b). This suggests strong recent engagement in conference discourse, reflecting the possible fast-paced developments in BIM-AI integration.

3.2 Regional Contribution to BIM-11D Research

Fig.3 illustrates the repartition of the BIM-AI scientific work by region and reveals a high disparity between continents contribution and more explicitly between countries. Indeed, Asia and Europe are the most active continents in the field, where 17 Asian countries contributed 41 papers and 14 European countries contributed 42 papers. China leads globally with 18 contributions to BIM-AI research.

Within Asia, China's output alone exceeds the combined contributions of 16 other countries, including Taiwan (4) and India, Turkey, and South Korea (3 each) (Fig. 3). This highlights China's central role in shaping the regional research landscape. In Europe, the UK and Italy dominate with 11 and 10 papers respectively, far surpassing other European countries like Germany and Spain (4 each) or France (3) (Fig. 3).

On the other hand, Americas, Africa and Oceania contributed 6, 7 and 2 publications, respectively (Fig. 3). Yet, Australia, although a single country in the Oceania region, surprisingly contributes 7 papers (Fig. 3), a figure higher than the combined total of all American and African countries. This underscores the country's significant research capacity despite its regional isolation.

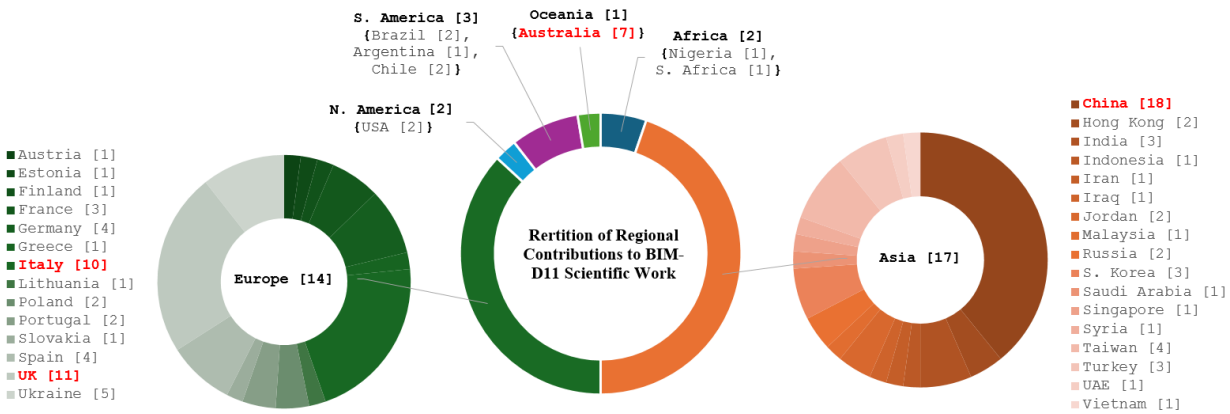

Fig. 3. Regional distribution of the contribution to the BIM 11D research by continent with the indication of leading countries in this regard.

3.3 Most Contributing Sources and Authors

The most contributing sources are journals rather than specific conferences, which confirm scholars' penchant for more elaborated dissemination. As showed in Table 1, Buildings is the leading outlet for BIM-AI-related research with 7 papers. This journal's open-access model and broad scope likely make it attractive for authors aiming to reach interdisciplinary audiences. Automation in Construction follows closely with 5 articles, consistent with its reputation as a high-impact (IF=11.5 | CiteScore=20.7), specialized journal in automation technologies and digital construction.

Lecture Notes on Data Engineering and Communications Technologies, Sustainability, and Journal of Building Engineering contributed equally 2 publications each. These journals indicate a cross-disciplinary reach, covering topics from engineering applications to sustainable design. All other sources contributed 1 paper.

Table 1. Contribution Share of Involved Sources and Authors in the BIM 11D research with the highlight of the most impacting ones

Sources	Contribution
Buildings	7
Automation in Construction	5
Lecture Notes on Data Engineering and Communications Technologies Sustainability Journal of Building Engineering	2
Remaining Sources	1

Authors	Contribution
Honcharenko, T. | Dolhopolov, S.	4
Croce, V. | Caroti, G.	3
Savenko, V. | Bevilacqua, M.G. Sepasgozar, S.M.E. Borrmann, A. | Piemonte, A. Chernyshev, V.	2
Remaining Authors	1

267 authors participated in the dissemination in BIM 11D research but only four published more than twice. The most prolific authors are Honcharenko T. and Dolhopolov, S. with 4 common papers and Croce, V. and Caroti, G. with other 3 common papers (Table 1). Six other authors authored or co-authored 2 papers (Table 1) but collaborated with the previous four. Among those authors Dolhopolov S., Chernyshev, V., and Croce, V. were first authors on 2 papers each, yet Dolhopolov S. contributed Chernyshev's papers as second author.

3.4 Terms Co-Occurrence Analysis:

In the visual presentation of the terms co-occurrence mapping, each node represents a term (from keywords, abstracts or titles), and the size of the node reflects its frequency in the corpus, while the links' thickness indicates the strength of co-occurrence with other terms.

3.4.1 Keywords Co-Occurrence Analysis:

For the keywords Co-Occurrence analysis, an adjustment of ambiguous keywords was necessary. Consequently, a total of 678 keywords were identified, 22 of them occurred at least 5 times (Fig. 4). Other than search keywords whose occurrence frequency are obviously high, the nodes' sizes (Fig. 4) demonstrated that "Architectural design" and "Information Management" had the highest frequency with 39 and 12 times respectively. The mapped network (Fig. 4) of these 22 displayed 4 clusters with a total link strength of 535 and total links of 162.

The analysis of links' strengths of the nodes clustering (Fig. 4a) showed that the red, green and yellow clusters highlight the strong benefit of the interoperability between "Building Information Modeling"/"BIM" and "Artificial

Intelligence (AI)" for the "construction industry"; notably "Architectural design", "Structural design", "decision making", "project management", "Object Recognition", "Information Management"/ "Information Theory", "Construction sites", and "Life cycle". Alternatively, the bleu cluster focuses on AI techniques, containing terms like "machine learning" and "deep learning".

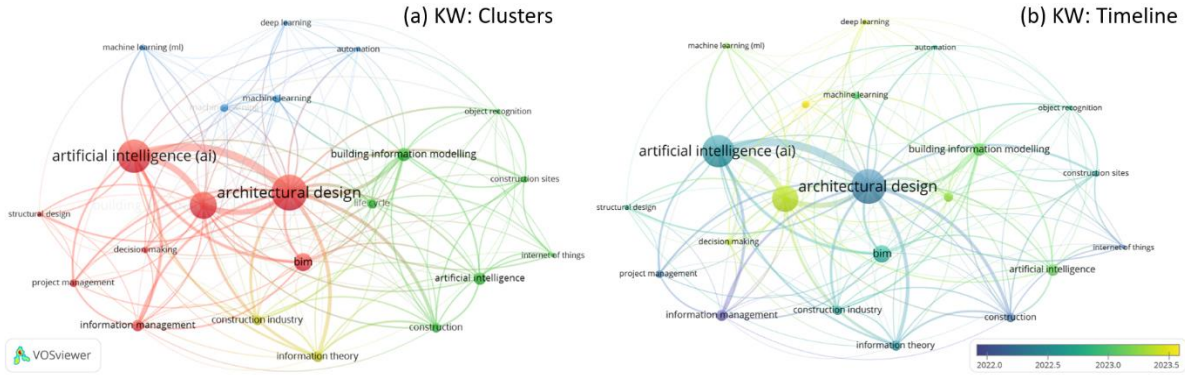

Fig. 4. Keyword co-occurrence network (minimum occurrence = 5 times), (a) Color Coding by Clusters and (b) Color Coding by Timeline

Fig. 4b reveals that discussed topics regarding BIM 11D progress rapidly over the time. Indeed, they extended from only "information management" and "architectural design" in 2022 to cover further aspects in 2023 such as "structural design" and "decision making" among others. This is more likely due to the high introduction of AI techniques in the same period (Fig. 4b).

3.4.2 Titles' and Abstracts' Terms Co-Occurrence Analysis:

Using the binary counting approach, 2430 terms were shortlisted by VOSviewer algorithm as relevant for terms Co-Occurrence analysis. 35 of those terms were cited at least 10 times with on the top "BIM" and "artificial intelligence" are the most prominent and connected terms (Fig. 5), which is reasonable since they are part of the search keywords for data collection of this study. The resulting mapped network (Fig. 5a) exhibited 3 clusters with a total link strength of 4934 and total links of 558.

The red cluster centers on technical terms such as "model", "data", "process", "system", "study", "Effectiveness" and "accuracy." This suggests a strong focus on methodological development and computational modeling, particularly in how AI supports BIM-based processes (Fig. 5a). Likewise, the green cluster includes terms like "construction," "application", "engineering", "Challenge" and "development" pointing toward the practical implementation of BIM-AI tools within real-world construction stages. The blue cluster features terms like "Construction Industry", "building", "Research", and "bim technology," indicating a foundational dimension of papers development (Fig. 5a).

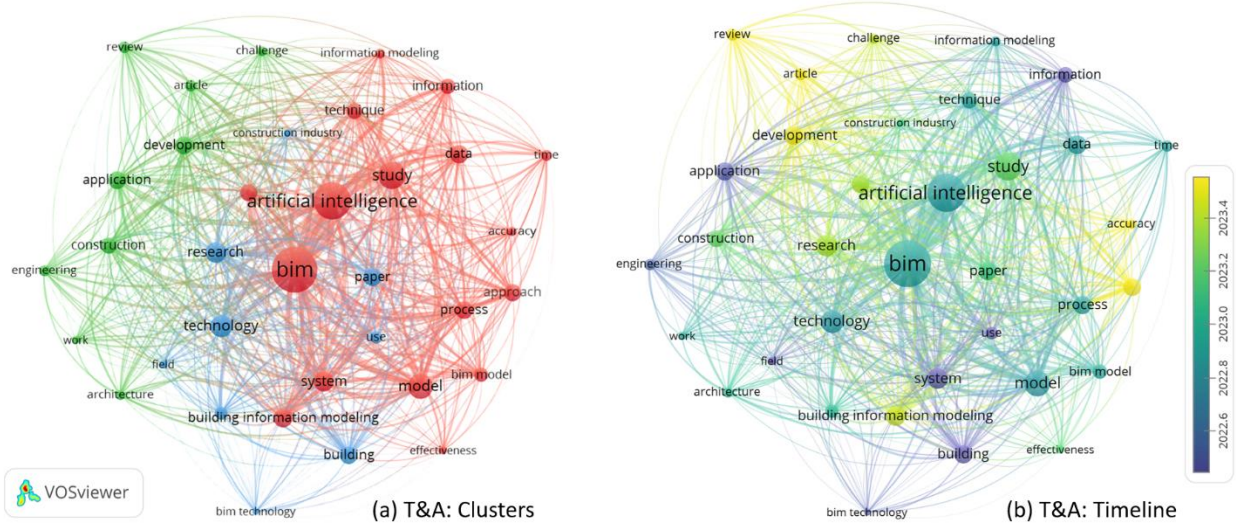

Fig. 5. Co-occurrence network of Terms from Abstracts and Titles (minimum occurrence = 10 times), (a) Color Coding by Clusters and (b) Color Coding by Timeline.

Fig. 5b overlays the same co-occurrence network with a temporal color gradient representing the average year of appearance of each term, from dark blue (older, ≈2016) to yellow (recent, ≈2024). The color coding analysis showed the early stage terms include "engineering", "application", "field" and "system"; demonstrating that BIM and AI were associated to develop applied research solutions since early publications. The research likely progressed toward addressing "accuracy" and the nexus "challenges". Later terms show the appearance of more "reviews" and "approaches" (Fig. 5b).

4. Discussion

The study revealed noticeable upward in BIM-AI scientific work, which aligns with global efforts toward digital transformation in the construction industry (Meisels et al., 2024). The dominance of original research papers over reviews and the growing preference for journal articles over conference proceedings indicate a penchant maturing research field with more in-depth contributions in applied research. Alternatively, the analysis of authors' implication shows that a few individuals are emerging as nexus leaders. However, the long tail of authors with single contributions suggests that the field remains relatively fragmented and decentralized at the individual level.

The regional distribution of scientific output highlights the dominance of China (18), UK (11), Italy (10) and Australia (7) in the field where their outputs, though being undersized, exceeds the combined contributions of all other regions in their own continents. This confirms a fragmented research landscape regarding AI-BIM nexus with limited high-output contributors. Likewise, it reveals a clear imbalance: while BIM-AI research is expanding globally, it remains heavily concentrated in a few countries, underlining the need for broader international collaboration.

The considerable contribution of China, UK, Italy and Australia in BIM-AI nexus reflects their advanced digitalization strategies, infrastructure development, and academic investment in construction innovation. This suggests these regions are more proactive in integrating cutting-edge technologies like AI into BIM processes toward enhanced sustainable development (Edirisinghe & London, 2015; Meisels et al., 2024). Contrariwise, the low contributions from Africa and South America point to a digital research divide. This could stem from systemic issues such as limited access to funding, technological infrastructure, and policy incentives for construction digitization (Khan et al., 2024).

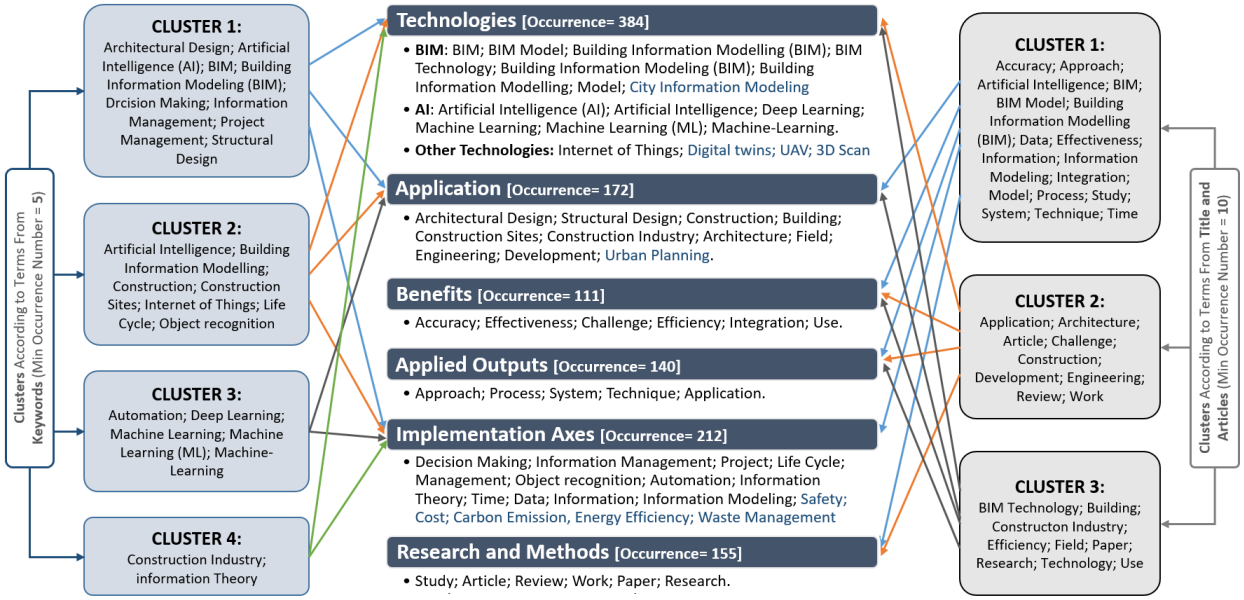

Fig. 6. Segregation of BIM-AI research aspects into subject-oriented clusters using cross analysis of terms and keywords clusters

Although clusters based on keywords (Fig. 4) lean toward more technical specificity, while title/abstract clusters (Fig. 5) trend toward broader conceptual themes; their cross analysis reveals the semantic and functional alignment across the field. Fig. 6 presents a structured cross-analysis of conceptual clusters derived from the keywords and titles/abstracts of scientific work related to BIM 11D in construction. It maps six clusters against major thematic dimensions: Technologies, Application, Benefits, Applied Outputs, Implementation Axes, and Research and Methods.

The study discloses that BIM-AI studies involve different techniques of AI ("machine learning" and its subset "deep learning") and specific modeling types ("City Information Modeling"), and call for other data-driven technologies

(i.e., “internet of thing”, “digital twin” as well as GIS subsets – “UAV” and “3D scanning”), increasing the nexus efficiency (Fig. 6). The nexus application covers different stages of a construction project lifespan including “design”, “engineering”, and “field” implementation, reflecting the wide operational reach of BIM-AI impacts (Fig. 6). Out of this application, scholars are mostly intending to achieve high “accuracy”, “effectiveness”, “efficiency”, and “integration”, implying that scholars tend to focus on performance improvements (Fig. 6). The presence of “challenge” suggests awareness of existing limitations.

As inferred by the previous analyses, the proposed BIM-AI research provides more applied outputs, notably “approaches”, “processes”, “systems”, and “techniques”. Those outputs fall under fragmented and numerous implementation axes from diverse categories. Indeed, implementation axes span from managerial topics – “decision-making”, “project” “management”, “information management”– to technical concerns – “data”, “information theory”, “object recognition”, “automation” – and even sustainability-related aspects – “carbon emission”, “energy efficiency”, “waste management” (Fig. 6). This diversity is promising, reflecting BIM-AI’s capacity to tackle systemic challenges. However, this may also imply diffused focus, as few studies address multiple axes in tandem, stressing the scarcity of integrated frameworks, despite the need for holistic construction digitalization strategies.

The Research and Methods section appears overly generic (Fig. 6). This advocates a scarcity of empirical, simulation, data-driven, or case study methodological approaches, that would clarify how robust and applicable the field’s findings truly are, appealing for further validation research work.

5. Conclusions

The construction industry is acknowledged for complex and dynamic processes throughout life cycle stages. Despite the independent maturity of BIM and AI, their combined application within the construction domain remains relatively nascent. This convergence promises to revolutionize construction project delivery. Through a scientometric review, this study presents a comprehensive exploration of the evolving research nexus between BIM and AI, i.e., BIM 11D, in the construction industry.

The findings show a marked increase in scholarly attention from 2021 onward, with a peak in 2024. Four countries emerged as the most active contributors, with China leading at 18 papers, followed by the UK and Italy, and Australia, outpacing the total contributions of other countries in their respective continents. This high inequality stresses the important regional disproportion of national construction digitation strategies including standardization efforts, implementation incentives, infrastructures and invested funds. Besides, the analysis of types and temporal evolution of shared studies revealed that BIM-AI nexus is contemporary with a focus on original studies in applied research.

Keyword and term co-occurrence analyses independently revealed a clustered thematic landscape, with dominant research efforts spanning modeling, information theory, system integration, data processes, and real-world applications in design, construction, and project management. Central concepts such as "Architectural design" "Machine Learning," "process," "model," and "integration" emerged as high-frequency terms. Over time, the literature has evolved from foundational modeling and system development toward more complex concerns including challenges and impact assessment, suggesting a maturing field coping with deployment realities.

The cross-analysis of keyword and title/abstract clusters revealed a semantic and functional alignment in BIM-AI (BIM 11D) research, structured around six thematic dimensions: Technologies, Application, Benefits, Applied Outputs, Implementation Axes, and Research Methods. This implies that BIM-AI studies utilize diverse AI techniques, modeling types, and data-driven technologies across all project phases, aiming to enhance accuracy, efficiency, and integration. The studies outputs are mostly applied outputs including systems and processes. The implementation axes represents individual efforts and span managerial, technical, and sustainability concerns, stressing the fragmented BIM-AI implementation.

This fragmentation indicates a promising yet scattered research landscape, with limited interdisciplinary integration and a lack of unified frameworks necessary for holistic digital transformation in construction. The adoption of generic research methods instead of robust approaches advocates the need for further validation research work. Besides these BIM-AI research limitations, the critical analysis of the study results exhibited noticeable gaps. First, noticeable lack of empirical validation of claimed benefits. Second, there is a strong need for inclusive global collaboration, especially engaging underrepresented regions. Third, current studies often isolate implementation axes, indicating the need for holistic approaches that remain necessary for systemic construction innovation. Fourth, while technical advancements dominate, deeper exploration of socio-technical challenges such as user adoption, policy integration, and ethical AI use remains sparse. Lastly, longitudinal and impact-oriented studies are needed to move from proof-of-concept to measurable transformation.

Overall, this scientometric study brings a strong contribution to the body of knowledge. It provides scholars, professionals and policymakers with consistent metrics and well-founded insights of key aspects of BIM-AI nexus in the construction industry as well as existing gaps. This would pave the path for more established studies, innovative BIM-AI solutions, and well-based strategic approaches. However, the North America's underrepresentation, despite the global tech leadership of its countries, may imply that relevant studies are framed outside the BIM-AI integration scope, allied to other databases, or do not fall under the search criteria. This represents a key limitation of the study, highlighting the need for reviews that are more region-specific or incorporate wider keywords and databases.

References

Bassir, D., Lodge, H., Chang, H., Majak, J., & Chen, G. (2023). Application of artificial intelligence and machine learning for BIM: Review. *International Journal for Simulation and Multidisciplinary Design Optimization*, *14*, 5. https://doi.org/10.1051/smdo/2023005

Bouhmoud, H., & Alzarrad, A. (2025). Leveraging nD BIM Scalability for Sustainable Construction: Challenges, Opportunities, and Strategic Frameworks for Carbon Emission Mitigation. *2025 IEEE Conference on Technologies for Sustainability (SusTech)*, 1–8. https://doi.org/10.1109/SusTech63138.2025.11025623

Edirisinghe, R., & London, K. (2015). Comparative analysis of international and national level BIM standardization efforts and BIM adoption. *CIB W78 Conference 2015, CIB*, 149–158.

Khan, A., Bello, A., Arqam, M., & Ullah, F. (2024). Integrating Building Information Modelling and Artificial Intelligence in Construction Projects: A Review of Challenges and Mitigation Strategies. *TECHNOLOGIES*, *12*(10). https://doi.org/10.3390/technologies12100185

Li, J., Liu, Z., Han, G., Demian, P., & Osmani, M. (2024). The Relationship Between Artificial Intelligence (AI) and Building Information Modeling (BIM) Technologies for Sustainable Building in the Context of Smart Cities. *SUSTAINABILITY*, *16*(24). https://doi.org/10.3390/su162410848

Li, J., Shirowzhan, S., Pignatta, G., & Sepasgozar, S. (2024). Data-Driven Net-Zero Carbon Monitoring: Applications of Geographic Information Systems, Building Information Modelling, Remote Sensing, and Artificial Intelligence for Sustainable and Resilient Cities. *SUSTAINABILITY*, *16*(15). https://doi.org/10.3390/su16156285

Meisels, M., Nikulin, M., Hardin, K., Sloane, M., & Dwivedi, K. (2024, November 4). *2025 Engineering and Construction Industry Outlook*. Deloitte Insights. https://www.deloitte.com/us/en/insights/industry/engineering-and-construction/engineering-and-construction-industry-outlook.html

Omotayo, T., Tanyer, A., Deng, J., Kaima, A., Akponeware, A., Pekericli, M., Shikder, S., & Ogunnusi, M. (2025). Advancing AI-Powered BIM for Circularity in Construction in the UK and Turkiye: State-of-the-Art Review and Capability Maturity Modelling. *BUILDINGS*, *15*(8). https://doi.org/10.3390/buildings15081224

Pan, Y., & Zhang, L. (2023). Integrating BIM and AI for Smart Construction Management: Current Status and Future Directions. *ARCHIVES OF COMPUTATIONAL METHODS IN ENGINEERING*, *30*(2), 1081–1110. https://doi.org/10.1007/s11831-022-09830-8

Porubcinova, M., Gajniak, O., & Heriban, R. (2025). Expert Estimates of the Potential of AR, VR, BIM and AI Technologies to Support Sustainable Construction 4.0 in Slovak Construction Sector. *SLOVAK JOURNAL OF CIVIL ENGINEERING*, *33*(1), 55–63. https://doi.org/10.2478/sjce-2025-0006

Singer, D., Bügler, M., & Borrmann, A. (2016). *Knowledge based bridge engineering—Artificial intelligence meets building information modeling*. 23rd International Workshop of the European Group for Intelligent Computing in Engineering, EG-ICE 2016. Scopus. https://www.researchgate.net/publication/304245260_Knowledge_based_Bridge_Engineering_-_Artificial_Intelligence_meets_Building_Information_Modeling