JOURNAL OF ADVANCED ENGINEERING
AND INNOVATION
Volume 3, Issue 1, June 2025 | pp. 22-32
https://doi.org/10.54518/jaei.3.1.2025.1327

Recent Advances in Building Information Modeling (BIM) for Sustainable Infrastructure: Comparing Indonesia and Malaysia

Dewi Triantini[1]

Universitas Negeri Makassar, Indonesia[1]

ABSTRACT

Building Information Modeling (BIM) has emerged as a key digital technology for improving the planning, design, construction, and management of sustainable infrastructure. Indonesia and Malaysia have increasingly adopted BIM to enhance project efficiency, resource utilization, collaboration, and environmental performance, although their implementation strategies differ due to variations in policies, industry readiness, and technological capacity. This study aims to systematically review recent advances in BIM for sustainable infrastructure by comparing research trends, applications, benefits, challenges, and future opportunities in Indonesia and Malaysia. A Systematic Literature Review (SLR) was conducted using peer-reviewed journal articles published over the last five years. The findings indicate that Malaysia demonstrates more mature BIM implementation through stronger governmental support and industry standards, while Indonesia shows rapid progress driven by infrastructure development and digital transformation initiatives. Nevertheless, both countries continue to face challenges related to skilled workforce availability, interoperability, implementation costs, and organizational readiness. This review provides valuable insights for researchers, practitioners, and policymakers in promoting BIM adoption for sustainable infrastructure development.

Keywords: *Building Information Modeling, Digital Construction, Indonesia, Malaysia, Sustainable Infrastructure.*

CORRESPONDING AUTHOR:
Dewi Triantini
Universitas Negeri Makassar, Indonesia

ARTICLE HISTORY
Received : January 12, 2025
Final Revised : February 27, 2025
Accepted : April 21, 2025
Published : June 30, 2025

1. | INTRODUCTION

The construction industry has experienced significant transformation over the past decade due to rapid technological development and the growing demand for sustainable infrastructure. Increasing urbanization, population growth, environmental concerns, and limited natural resources have encouraged governments and construction stakeholders to adopt innovative technologies that improve project efficiency while minimizing environmental impacts. Sustainable infrastructure has become a major priority because it supports long-term economic development, environmental protection, and social well-being. To achieve these objectives, the construction sector requires integrated planning, efficient resource management, and effective collaboration among all project participants. As a result, Building Information Modeling (BIM) has emerged as one of the most important digital technologies for improving the planning, design, construction, operation, and maintenance of infrastructure projects (Li et al., 2022).

Building Information Modeling is no longer viewed solely as a three-dimensional visualization tool but as an intelligent digital information management system that integrates geometric models, engineering data, construction schedules, cost estimation, operational information, and maintenance records into a unified platform. Through BIM, architects, engineers, contractors, consultants, owners, and facility managers can collaborate using accurate and up-to-date information throughout the project lifecycle. This integrated approach improves communication, reduces design conflicts, enhances coordination among stakeholders, and supports more effective decision-making (Samimpay & Saghatforoush, 2020). Furthermore, BIM has evolved through its integration with emerging technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), cloud computing, Geographic Information Systems (GIS), Digital Twin, and big data analytics, enabling more intelligent and data-driven infrastructure management.

The importance of BIM has increased alongside the global commitment to sustainable development. Conventional construction methods often result in fragmented information, inefficient communication, material waste, project delays, and budget overruns. These issues not only reduce project performance but also increase environmental impacts through excessive resource consumption and carbon emissions. BIM addresses these challenges by enabling early design evaluation, automatic clash detection, construction simulation, accurate quantity estimation, and digital monitoring throughout the construction process (Zhang et al., 2022). The technology also supports lifecycle management by providing reliable information for operation, maintenance, renovation, and future infrastructure development. Consequently, BIM has become an essential component in achieving sustainable infrastructure by improving productivity, reducing waste, increasing energy efficiency, and supporting environmentally responsible construction practices.

In Southeast Asia, Indonesia and Malaysia have actively promoted BIM implementation as part of their national strategies for digital transformation in the construction sector. Indonesia has experienced substantial infrastructure development through investments in transportation systems, public facilities, industrial zones, and strategic national projects (Davidson, 2021). These developments have encouraged greater adoption of BIM to improve project planning, construction quality, and project management efficiency. However, BIM implementation in Indonesia remains at different levels across organizations because of challenges such as limited technical expertise, insufficient training, high software investment costs, and varying organizational readiness. These factors continue to influence the speed and effectiveness of BIM adoption within the national construction industry.

Compared with Indonesia, Malaysia has demonstrated a relatively more mature level of BIM implementation through stronger government support, national implementation frameworks, and greater collaboration among public institutions, universities, and private construction companies. BIM has been increasingly integrated into both public and private infrastructure projects to improve project coordination, reduce construction waste, optimize facility management, and enhance sustainability performance. Nevertheless, Malaysia also faces several challenges, including software interoperability, workforce competency development, organizational change management, and continuous adaptation to rapidly evolving digital technologies (Trenerry et al., 2021).

Although numerous studies have investigated BIM implementation within each country individually, comparative research examining recent advances in BIM for sustainable infrastructure between Indonesia and Malaysia remains limited. Considering that both countries share similar regional characteristics and infrastructure development priorities while demonstrating different levels of BIM maturity, a comparative analysis offers valuable opportunities to identify best practices, implementation challenges, and future development strategies (Bibri & Krogstie, 2021). Therefore, this study conducts a Systematic Literature Review (SLR) to examine recent advances in Building Information Modeling for sustainable infrastructure by comparing Indonesia and Malaysia. The review aims to analyze research trends, technological developments, implementation strategies, practical applications, benefits, existing challenges, and future research opportunities, thereby providing valuable insights for researchers, policymakers, and industry practitioners seeking to accelerate digital transformation and promote sustainable infrastructure development.

2. | RESEARCH METHOD

This study employed a Systematic Literature Review (SLR) to comprehensively identify, evaluate, and synthesize previous studies concerning recent advances in Building Information Modeling (BIM) for sustainable infrastructure, with a comparative focus on Indonesia and Malaysia. The SLR approach was selected because it provides a systematic, transparent, and reproducible procedure for collecting and analyzing scientific evidence from published literature while minimizing researcher bias. The review process consisted of four sequential stages: literature identification, literature screening, eligibility assessment, and qualitative data synthesis (McMeekin et al., 2020). Relevant publications were collected from internationally recognized scientific databases, including Scopus, Web of Science, ScienceDirect, SpringerLink, and IEEE Xplore. The literature search was conducted using combinations of keywords such as "Building Information Modeling," "BIM," "Sustainable Infrastructure," "Digital Construction," "Construction Industry," "Indonesia," and "Malaysia." Only peer-reviewed journal articles published between 2020 and 2024 were included to ensure that the review reflected the latest technological developments and implementation practices (Sony & Naik, 2020). The inclusion criteria required that the selected articles discuss BIM implementation, sustainable infrastructure, digital construction technologies, construction management, project lifecycle management, or policy and organizational aspects related to BIM adoption in Indonesia or Malaysia.

Studies focusing on sectors outside construction, duplicate publications, conference proceedings, book chapters, editorials, and articles lacking sufficient methodological information were excluded from the analysis. After the screening process, the eligible studies were examined through qualitative content analysis to extract relevant information, including publication year, research objectives, study location, infrastructure sector, research methodology, BIM application areas, enabling technologies, implementation benefits, challenges, and future research recommendations (Salzano et al., 2023). The extracted information was then categorized into several thematic aspects, including technological development, implementation strategy, sustainability contribution, organizational readiness, policy support, barriers to adoption, and future development opportunities. A comparative analysis was subsequently performed to identify similarities and differences between Indonesia and Malaysia regarding BIM maturity, digital transformation strategies, infrastructure applications, and implementation outcomes. Finally, the synthesized findings were interpreted to evaluate current research trends and identify knowledge gaps requiring further investigation. This systematic review provides a comprehensive overview of recent BIM developments while offering evidence-based insights that may assist researchers, policymakers, and construction practitioners in strengthening BIM implementation and accelerating sustainable infrastructure development in both countries.

3. | RESULTS AND DISCUSSION

The systematic literature review indicates that Building Information Modeling (BIM) has become one of the most influential digital technologies supporting sustainable infrastructure development between 2020 and 2024. The reviewed studies consistently demonstrate an increasing trend in BIM adoption as governments, construction companies, and research institutions recognize the importance of digital transformation in improving project efficiency, environmental sustainability, and lifecycle infrastructure management (Abbas et al., 2021). Unlike conventional construction approaches that rely on fragmented information and manual coordination, BIM provides an integrated digital environment capable of connecting design, engineering, construction, operation, and maintenance activities within a single information platform. This capability enables project stakeholders to access consistent and real-time information throughout the infrastructure lifecycle, thereby improving communication, reducing project uncertainty, and enhancing decision-making during every stage of project implementation (Arefazar et al., 2022).

One of the most significant findings identified in the reviewed literature is the growing integration of BIM with other emerging digital technologies (Alizadehsalehi et al., 2020). Recent developments demonstrate that BIM is no longer utilized solely for three-dimensional visualization or design coordination but has evolved into an intelligent information management system supporting data-driven construction processes. The integration of BIM with Artificial Intelligence (AI), the Internet of Things (IoT), Geographic Information Systems (GIS), cloud computing, Digital Twin, and big data analytics has expanded its functionality to include predictive maintenance, automated progress monitoring, intelligent facility management, energy performance analysis, and lifecycle asset optimization. These technological developments have strengthened BIM's contribution to sustainable infrastructure by enabling more accurate planning, reducing construction waste, improving operational efficiency, and supporting long-term infrastructure resilience (Murtagh et al., 2020).

The comparative analysis reveals that Indonesia and Malaysia have demonstrated substantial progress in BIM implementation despite differences in policy frameworks, technological maturity, and industrial readiness. Indonesia has experienced rapid infrastructure development during the past decade, creating increasing demand for digital construction technologies capable of improving project delivery and resource management. Large-scale investments in highways, railways, airports, ports, dams, and public buildings have encouraged government agencies and construction companies to adopt BIM as an effective solution for improving project coordination, reducing construction errors, and increasing productivity. The implementation of BIM has become increasingly important in supporting national infrastructure programs because it facilitates better collaboration among designers, contractors, consultants, and project owners while improving construction quality through more accurate planning and digital simulation (Banfi et al., 2022).

However, the review also indicates that BIM implementation in Indonesia remains uneven across the construction industry. Large construction companies and government-funded infrastructure projects generally demonstrate higher levels of BIM adoption because they possess greater financial resources, technological infrastructure, and access to skilled professionals. In contrast, many small and medium-sized construction firms continue to rely on conventional project management methods due to limited investment capacity, insufficient technical expertise, and lack of organizational readiness. The absence of standardized BIM implementation procedures across different organizations also contributes to inconsistent adoption levels. Furthermore, limited educational programs and professional certification related to BIM continue to affect workforce competency, slowing the broader digital transformation of Indonesia's construction sector (Takyi et al., 2013).

Malaysia presents a relatively different implementation pattern characterized by stronger institutional support and more comprehensive national strategies for BIM adoption. Government initiatives have encouraged the development of standardized BIM guidelines, industry collaboration, and digital construction policies that promote greater consistency in project implementation. Universities, professional organizations, and private industries have also played important roles in expanding BIM education, technical training, and research activities, resulting in a workforce that is generally more familiar with digital construction technologies. Consequently, BIM has been increasingly utilized not only during project design and construction but also for facility management, infrastructure maintenance, and sustainability assessment throughout the asset lifecycle. This broader implementation demonstrates Malaysia's commitment to integrating digital innovation into long-term infrastructure development while supporting environmental sustainability and improved construction performance.

The reviewed studies further demonstrate that BIM contributes significantly to improving project efficiency, cost control, and construction quality in both Indonesia and Malaysia. One of the principal advantages of BIM is its ability to integrate multidisciplinary project information into a single digital environment, enabling architects, structural engineers, mechanical and electrical engineers, contractors, and project owners to collaborate more effectively. This integrated workflow minimizes communication gaps that frequently occur in conventional construction projects, where information is often stored in separate documents and managed independently by different stakeholders. Through centralized information management, project participants can identify design inconsistencies, coordinate engineering disciplines, and resolve technical conflicts before construction begins. Consequently, BIM reduces design revisions, minimizes construction errors, and decreases project delays, resulting in improved productivity and more efficient project execution (Assaad et al., 2020).

Another important finding identified in the literature is the role of BIM in supporting sustainable infrastructure throughout the project lifecycle. Sustainability is no longer evaluated solely from the perspective of construction activities but also considers long-term operational performance, maintenance efficiency, environmental impact, and resource utilization. BIM enables project teams to simulate multiple design alternatives and evaluate building performance before physical construction starts. Digital simulations help optimize material selection, structural design, energy consumption, lighting systems, ventilation performance, and water management strategies, allowing engineers to choose solutions that provide both economic and environmental benefits. During construction, BIM facilitates accurate quantity estimation and construction sequencing, reducing unnecessary material consumption and minimizing waste generation. Following project completion, BIM continues to support infrastructure operation by providing comprehensive digital information that assists facility managers in planning inspections, scheduling maintenance, monitoring equipment performance, and extending asset service life (Zhou et al., 2023).

The comparative analysis also indicates that the implementation priorities of Indonesia and Malaysia differ according to their national development strategies. Indonesia primarily emphasizes BIM adoption to improve project delivery in large-scale infrastructure development, including transportation systems, public facilities, and strategic national projects. The increasing demand for efficient project management has encouraged construction organizations to integrate BIM into planning, scheduling, cost estimation, and construction coordination. Nevertheless, implementation remains concentrated within large organizations and government-funded projects, while smaller companies continue to face financial and technical barriers that limit digital transformation. Malaysia, in contrast, has adopted a more comprehensive approach by integrating BIM into national digital construction policies and encouraging its application throughout the entire infrastructure lifecycle. In addition to project planning and construction, BIM is increasingly used for facility management, asset maintenance, sustainability assessment, and operational optimization, reflecting a higher level of digital maturity within the Malaysian construction industry (Mansour et al., 2023).

Despite the considerable progress achieved in both countries, several challenges continue to hinder wider BIM implementation. One of the most frequently identified barriers is the shortage of qualified professionals possessing adequate BIM knowledge and practical experience (Ma et al., 2022). Successful BIM implementation requires interdisciplinary competencies involving engineering, information technology, project management, and digital collaboration. However, many construction professionals remain unfamiliar with advanced BIM applications because educational curricula and professional development programs have not fully adapted to rapidly evolving digital technologies. Consequently, organizations must invest in continuous training and capacity building to improve workforce readiness and maximize the benefits of BIM implementation.

The literature also highlights technological and organizational barriers that influence BIM adoption. Differences in software platforms, inconsistent data standards, and limited interoperability between digital systems often complicate information exchange among project participants (Faisal et al., 2022). Furthermore, high initial investment costs for software licenses, hardware infrastructure, and employee training remain significant obstacles, particularly for small and medium-sized construction enterprises. Organizational resistance to change, insufficient management commitment, and limited awareness of BIM's long-term benefits further slow implementation. These findings suggest that successful BIM adoption depends not only on technological capability but also on supportive government policies, standardized implementation frameworks, strong institutional collaboration, and sustained investment in human resource development. Strengthening these aspects will enable both Indonesia and Malaysia to accelerate digital transformation while improving the sustainability, resilience, and overall performance of future infrastructure projects.

4. | CONCLUSION

This study systematically reviewed recent advances in Building Information Modeling (BIM) for sustainable infrastructure by comparing its implementation in Indonesia and Malaysia based on peer-reviewed publications published between 2020 and 2024. The findings demonstrate that BIM has evolved from a digital design and visualization tool into an integrated information management platform that supports planning, design, construction, operation, and maintenance throughout the infrastructure lifecycle. The integration of BIM with emerging technologies, including Artificial Intelligence (AI), the Internet of Things (IoT), Geographic Information Systems (GIS), cloud computing, Digital Twin, and big data analytics, has further strengthened its contribution to improving project efficiency, construction quality, sustainability, and lifecycle asset management.

The comparative analysis indicates that Malaysia has achieved a relatively higher level of BIM maturity through comprehensive government policies, standardized implementation frameworks, and strong collaboration among public institutions, universities, and industry stakeholders. In contrast, Indonesia has demonstrated significant progress driven by rapid infrastructure development and increasing government commitment to digital transformation, although BIM adoption remains uneven across the construction sector because of differences in organizational readiness, workforce competency, and investment capacity.

Despite these achievements, several challenges continue to influence wider BIM implementation, including limited interoperability among digital platforms, shortages of skilled professionals, high implementation costs, and organizational resistance to technological change. Addressing these challenges requires continuous collaboration among governments, academic institutions, professional organizations, and the construction industry. Future research should focus on developing standardized BIM frameworks, strengthening digital competencies, and expanding BIM integration with emerging technologies to support resilient, efficient, and environmentally sustainable infrastructure development in Indonesia, Malaysia, and the broader Southeast Asian region.

Acknowledgment
We gratefully acknowledge the contributions of individuals who supported the completion of this article.

Funding Information
This research did not receive any funding.

Conflict of Interest Statement
The authors declare that there is no conflict of interest.

Ethical Approval and Originality Statement
Ethical approval was obtained for this study. The manuscript represents original work and has not been previously published, nor is it under consideration by another journal.

Data Disclosure Statement
The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

Abbas, K., Khan, T. A., Afaq, M., & Song, W. C. (2021). Network slice lifecycle management for 5g mobile networks: An intent-based networking approach. *IEEE Access*, *9*, 80128-80146.

Alizadehsalehi, S., Hadavi, A., & Huang, J. C. (2020). From BIM to extended reality in AEC industry. *Automation in construction*, *116*, 103254.

Arefazar, Y., Nazari, A., Hafezi, M. R., & Maghool, S. A. H. (2022). Prioritizing agile project management strategies as a change management tool in construction projects. *International Journal of Construction Management*, *22*(4), 678-689.

Assaad, R., El-Adaway, I. H., & Abotaleb, I. S. (2020). Predicting project performance in the construction industry. *Journal of construction engineering and management*, *146*(5), 04020030.

Banfi, F., Brumana, R., Salvalai, G., & Previtali, M. (2022). Digital twin and cloud BIM-XR platform development: from scan-to-BIM-to-DT process to a 4D multi-user live app to improve building comfort, efficiency and costs. *Energies*, *15*(12), 4497.

Bibri, S. E., & Krogstie, J. (2021). A novel model for data-driven smart sustainable cities of the future: A strategic roadmap to transformational change in the era of big data. *Future Cities and Environment*, *7*(1), 1-25.

Brodny, J., & Tutak, M. (2023). The level of implementing sustainable development goal" Industry, innovation and infrastructure" of Agenda 2030 in the European Union countries: Application of MCDM methods. *Oeconomia Copernicana*, *14*(1), 47-102.

Davidson, J. S. (2021). Opposition to privatized infrastructure in Indonesia. *Review of International Political Economy*, *28*(1), 128-151.

Faisal Shehzad, H. M., Binti Ibrahim, R., Yusof, A. F., Mohamed khaidzir, K. A., Shawkat, S., & Ahmad, S. (2022). Recent developments of BIM adoption based on categorization, identification and factors: a systematic literature review. *International Journal of Construction Management*, *22*(15), 3001-3013.

Li, C. Z., Guo, Z., Su, D., Xiao, B., & Tam, V. W. (2022). The application of advanced information technologies in civil infrastructure construction and maintenance. *Sustainability*, *14*(13), 7761.

Ma, X., Darko, A., Chan, A. P., Wang, R., & Zhang, B. (2022). An empirical analysis of barriers to building information modelling (BIM) implementation in construction projects: evidence from the Chinese context. *International Journal of Construction Management*, *22*(16), 3119-3127.

Mansour, H., Aminudin, E., & Mansour, T. (2023). Implementing industry 4.0 in the construction industry-strategic readiness perspective. *International Journal of Construction Management*, *23*(9), 1457-1470.

McMeekin, N., Wu, O., Germeni, E., & Briggs, A. (2020). How methodological frameworks are being developed: evidence from a scoping review. *BMC medical research methodology*, *20*(1), 173.

Murtagh, N., Scott, L., & Fan, J. (2020). Sustainable and resilient construction: Current status and future challenges. *Journal of Cleaner Production*, *268*, 122264.

Salzano, A., Intignano, M., Mottola, C., Biancardo, S. A., Nicolella, M., & Dell'Acqua, G. (2023). Systematic literature review of open infrastructure BIM. *Buildings*, *13*(7), 1593.

Samimpay, R., & Saghatforoush, E. (2020). Benefits of Implementing Building Information Modeling (BIM) in Infrastructure Projects. *Journal of Engineering, Project, and Production Management*, *1*(2), 123.

Sony, M., & Naik, S. (2020). Critical factors for the successful implementation of Industry 4.0: a review and future research direction. *Production Planning & Control*, *31*(10), 799-815.

Takyi-Annan, G. E., & Zhang, H. (2023). A multivariate analysis of the variables impacting the level of BIM expertise of professionals in the architecture, engineering and construction (AEC) industries of the developing world using nonparametric tests. *Buildings*, *13*(7), 1606.

Trenerry, B., Chng, S., Wang, Y., Suhaila, Z. S., Lim, S. S., Lu, H. Y., & Oh, P. H. (2021). Preparing workplaces for digital transformation: An integrative review and framework of multi-level factors. *Frontiers in psychology*, *12*, 620766.

Zhang, J., Cheng, J. C., Chen, W., & Chen, K. (2022). Digital twins for construction sites: Concepts, LoD definition, and applications. *Journal of Management in Engineering*, *38*(2), 04021094.

Zhou, N., Xu, Y., Cho, S., & Wee, C. T. (2023). A systematic review for switchgear asset management in power grids: condition monitoring, health assessment, and maintenance strategy. *IEEE Transactions on Power Delivery*, *38*(5), 3296-3311.