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The Role of Building Information Modeling (BIM) in Sustainable Architectural Design

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Abstract
The construction industry significantly contributes to global energy consumption, carbon emissions, and material waste, creating an urgent need for more sustainable approaches to architectural design and building delivery. In this context, Building Information Modeling (BIM) has emerged as a transformative digital methodology that enables the integration of geometric, environmental, technical, and operational information within a centralized information model. Unlike traditional Computer-Aided Design (CAD) workflows, BIM supports data-driven decision-making throughout the entire building life cycle, from conceptual design and construction to operation and maintenance.
This paper investigates the role of BIM in supporting sustainable architectural design through a qualitative review of scientific literature and analysis of selected case studies. The research examines the contribution of BIM to key sustainability objectives, including energy performance optimization, life cycle assessment, material efficiency, interdisciplinary coordination, construction waste reduction, and facility management. Furthermore, the study critically evaluates the limitations of BIM implementation, including interoperability issues, high initial costs, lack of standardized workflows, and the need for specialized professional knowledge.
The findings indicate that BIM represents a valuable decision-support methodology for sustainable architecture; however, its effectiveness depends on the quality of information, integration with environmental assessment tools, and the ability of professionals to interpret and apply digital data within the design process. The paper concludes that future developments involving artificial intelligence, digital twins, and real-time building performance monitoring have significant potential to enhance BIM-based sustainable design strategies.
Keywords: *Building Information Modeling (BIM), sustainable architecture, sustainable design, energy efficiency, life cycle assessment, digital construction, building performance analysis.*

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I. Introduction

The construction industry is one of the largest contributors to global energy consumption, resource depletion, and greenhouse gas emissions. Buildings account for a significant proportion of environmental impacts throughout their life cycle, from material extraction and construction processes to operational energy consumption and eventual demolition. As climate change and resource limitations continue to influence the built environment, sustainable architectural design has become a central objective for contemporary architectural practice.

Sustainable architecture aims to reduce environmental impacts while maintaining functional, economic, and social quality of buildings. Achieving these objectives requires the integration of multiple factors, including energy efficiency, material selection, daylight optimization, thermal comfort, indoor environmental quality, and long-term operational performance. However, traditional design approaches based primarily on two-dimensional documentation often provide limited possibilities for evaluating complex environmental interactions and coordinating multidisciplinary information.

Building Information Modeling (BIM) has emerged as a significant digital methodology that transforms the way buildings are designed, constructed, and managed. Unlike conventional Computer-Aided Design (CAD), BIM provides an integrated digital representation of a building that contains both geometric and non-geometric information, including material properties, technical systems, performance data, and operational requirements. This allows architects, engineers, contractors, and facility managers to collaborate within a shared information environment throughout the building life cycle (Eastman et al., 2018).

One of the most important contributions of BIM to sustainable architecture is its ability to support performance-based design decisions during the early design stages. By integrating BIM models with simulation tools, designers can evaluate energy consumption, daylight availability, thermal performance, carbon emissions, and material impacts before construction begins. This enables comparison of different design alternatives and supports more informed decisions based on measurable environmental criteria rather than assumptions alone (Azhar, 2011).

Beyond environmental analysis, BIM contributes to sustainability by improving project coordination and reducing inefficiencies during construction. Centralized information management reduces inconsistencies between disciplines, while clash detection and accurate quantity extraction help minimize construction errors, material waste, and unnecessary resource consumption. Furthermore, BIM extends its value beyond project delivery by supporting facility management and improving the long-term operation of buildings through structured information about systems, components, and maintenance requirements (Becerik-Gerber et al., 2012).

Despite these advantages, the relationship between BIM and sustainability requires further critical examination. While BIM provides advanced capabilities for environmental assessment and optimization, its implementation does not automatically result in sustainable outcomes. The effectiveness of BIM-based sustainable design depends on factors such as data accuracy, software interoperability, professional expertise, organizational readiness, and the integration of sustainability criteria within the design workflow. In many practices, BIM is still primarily used for visualization and documentation rather than as a comprehensive sustainability analysis platform (Volk et al., 2014).

Furthermore, existing research often examines individual applications of BIM, such as energy simulation, life cycle assessment, or construction coordination, while fewer studies provide an integrated overview of how BIM contributes to sustainability throughout the entire building life cycle. This research gap highlights the need for a broader understanding of BIM as a decision-support methodology rather than solely a digital modeling technology.

Therefore, this paper aims to investigate the role of Building Information Modeling in sustainable architectural design by examining its applications, benefits, and limitations. The research focuses on five key areas: energy performance optimization, life cycle assessment, material efficiency, interdisciplinary collaboration, and facility management. Through a review of scientific literature and analysis of selected case studies, the paper evaluates how BIM contributes to more environmentally responsible and informed architectural decision-making.

Research Question

How does Building Information Modeling (BIM) contribute to sustainable architectural design throughout the building life cycle?

Research Objective

The objective of this paper is to analyze the role of BIM in supporting sustainable architectural design by examining its applications, benefits, challenges, and future potential, with particular emphasis on improving environmental performance and enabling informed decision-making throughout the building life cycle.

II. Literature Review

2.1 Building Information Modeling: Definition and Evolution

Building Information Modeling (BIM) represents a shift from traditional digital drafting methods toward an integrated approach to information management within the Architecture, Engineering, and Construction (AEC) industry. BIM is defined as a digital representation of physical and functional characteristics of a building, enabling the creation, exchange, and management of information throughout the entire building life cycle (Eastman et al., 2018).

Unlike conventional Computer-Aided Design (CAD), which primarily focuses on geometric representation, BIM incorporates additional information related to materials, technical systems, performance characteristics, and operational requirements. This allows different project stakeholders to work within a shared information environment and improves coordination between architectural, structural, and engineering disciplines (Succar, 2009).

The development of BIM has transformed its role from a visualization and documentation tool into a broader digital management methodology. Current BIM applications include design coordination, clash detection, quantity estimation, construction planning, facility management, and performance simulation. These capabilities have positioned BIM as an important component of digital transformation within the construction industry (Azhar, 2011).

However, the adoption of BIM has not been uniform across the industry. Research highlights that implementation is influenced by technological readiness, organizational structures, investment capacity, and professional expertise. Therefore, while BIM provides significant opportunities for improving building processes, its successful application requires appropriate workflows, standards, and knowledge development (Succar & Kassem, 2015).

2.2 Sustainable Architectural Design Principles

Sustainable architectural design focuses on reducing environmental impacts while improving the efficiency, durability, and quality of the built environment. It requires consideration of the entire building life cycle, including material extraction, construction, operation, maintenance, and end-of-life processes (Kibert, 2016).

Key principles of sustainable design include energy efficiency, responsible material selection, reduction of resource consumption, integration of renewable energy sources, and improvement of indoor environmental quality. Contemporary approaches increasingly emphasize life cycle thinking, recognizing that environmental impacts are generated not only during building operation but also through embodied energy and material production processes (Ding, 2008).

The complexity of sustainable design requires the integration of multiple performance criteria during the decision-making process. Traditional design methods often provide limited opportunities for evaluating the relationship between architectural decisions and environmental outcomes. Consequently, digital technologies such as BIM have become increasingly relevant by enabling performance analysis and evidence-based design strategies (Bryde et al., 2013).

Nevertheless, sustainability assessment remains challenging due to the complexity of environmental factors and the need for reliable data. BIM can support this process, but its effectiveness depends on the integration of accurate information and appropriate evaluation methods.

2.3 Applications of BIM in Sustainable Architectural Design

Research demonstrates that BIM supports sustainable architectural design through several interconnected applications, particularly in performance analysis, resource optimization, and life cycle management.

One of the most significant applications is **energy performance evaluation**. BIM models can be integrated with energy simulation tools to assess parameters such as building orientation, envelope performance, glazing ratios, and mechanical systems. These analyses allow designers to identify strategies for reducing operational energy demand during early design phases when modifications are most effective and economically feasible (Abanda & Byers, 2016).

BIM also contributes to **daylight analysis and indoor environmental quality assessment** by enabling evaluation of natural lighting conditions, solar exposure, and occupant comfort. Such analyses support decisions regarding façade design, openings, shading systems, and spatial organization (Azhar et al., 2015).

Another important application is the integration of BIM with **Life Cycle Assessment (LCA)** methodologies. By providing information about materials, quantities, and building components, BIM enables evaluation of environmental impacts throughout the building life cycle. This approach supports more informed material selection and contributes to reducing embodied carbon emissions associated with construction activities (Soust-Verdaguer et al., 2017).

Furthermore, BIM improves sustainable construction practices through accurate quantity estimation, improved coordination, and reduction of construction waste. Digital models allow early identification of conflicts between disciplines, reducing rework and unnecessary resource consumption during construction (Lu et al., 2017).

Beyond design and construction, BIM supports **facility management and operational sustainability** by providing structured information about building systems, equipment, and maintenance requirements. This enables more efficient operation, monitoring, and long-term management of buildings (Becerik-Gerber et al., 2012).

Although these applications demonstrate the potential of BIM, research indicates that the level of integration between BIM and sustainability analysis tools remains a significant challenge. In many cases, BIM models are developed primarily for documentation purposes, while advanced environmental assessment requires additional workflows and specialized expertise.

2.4 Benefits and Challenges of BIM Implementation for Sustainable Design

The integration of BIM into sustainable architectural practice provides several advantages, particularly through improved coordination, data accessibility, and performance-based decision-making. By creating a shared digital environment, BIM facilitates collaboration between different disciplines and reduces communication errors throughout the project process (Bryde et al., 2013).

A major benefit of BIM is the ability to evaluate sustainability strategies before construction begins. Early-stage simulations allow designers to compare alternatives related to energy efficiency, materials, and building systems, supporting decisions that can significantly influence long-term environmental performance (Azhar, 2011). However, the implementation of BIM also involves significant challenges. One of the primary barriers is the required investment in software, training, and organizational transformation. Smaller architectural practices may face difficulties adopting BIM due to financial limitations and lack of specialized personnel (GhaffarianHoseini et al., 2017). Interoperability between different software platforms represents another important limitation. Sustainable design workflows often require data exchange between BIM platforms and specialized environmental analysis tools, and inconsistencies in data formats may reduce efficiency and reliability (Sacks et al., 2020).

Additionally, BIM adoption requires changes in professional roles and collaboration methods. Without adequate training and clear project standards, BIM may remain limited to modeling and documentation rather than achieving its potential as a sustainability-supporting methodology (Volk et al., 2014). Therefore, BIM should not be viewed as an automatic solution for sustainable architecture but as an enabling framework. Its contribution depends on the integration of technology, professional expertise, reliable data, and sustainable design objectives.

III. Methodology

This research adopts a qualitative literature review methodology combined with case study analysis to investigate the role of Building Information Modeling (BIM) in sustainable architectural design. This approach was selected because the relationship between BIM and sustainability involves multiple interconnected aspects, including technological development, environmental assessment, design processes, and building performance evaluation.

The research was conducted through three main phases: (1) literature identification and selection, (2) thematic analysis of BIM applications in sustainable design, and (3) evaluation of practical implementation through selected case studies.

Scientific literature was collected from recognized academic databases, including Scopus, Web of Science, and ScienceDirect. The search strategy focused on publications related to BIM implementation, sustainable architecture, digital construction, environmental performance assessment, and life cycle approaches. The main keywords included *Building Information Modeling*, *BIM*, *sustainable architecture*, *energy efficiency*, *life cycle assessment*, *embodied carbon*, *digital construction*, and *building performance analysis*.

The selection criteria focused on studies that directly examined the relationship between BIM technologies and sustainability outcomes. Publications were included when they addressed BIM applications related to energy optimization, material efficiency, environmental assessment, construction coordination, or facility management. Studies focused exclusively on software development, visualization techniques, or BIM implementation without a sustainability perspective were excluded.

The reviewed literature was analyzed through thematic categorization to identify the main areas in which BIM contributes to sustainable architectural practice. Five key themes were established:

1. **Energy performance optimization** – application of BIM-based simulations for improving building energy efficiency.
2. **Material efficiency and Life Cycle Assessment (LCA)** – evaluation of environmental impacts and resource optimization.
3. **Interdisciplinary collaboration** – improvement of communication and coordination between project stakeholders.
4. **Construction waste reduction** – minimizing errors, rework, and unnecessary material consumption.
5. **Facility management and operational performance** – supporting efficient building operation throughout the life cycle.

In addition to the literature review, two contemporary architectural projects were selected as case studies. The selection was based on their significant use of BIM technologies, integration of sustainability strategies, and documented improvements in building performance. The case studies were analyzed according to BIM implementation, environmental objectives, and contribution to sustainable design outcomes.

The combination of literature analysis and case study evaluation enables a broader understanding of BIM as both a technological platform and a decision-support methodology for sustainable architectural practice.

Figure 1. Research methodology framework

Literature Identification

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Database Search (Scopus, Web of Science, ScienceDirect)

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Selection Criteria & Screening

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Thematic Analysis of BIM Applications

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Case Study Evaluation

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Synthesis of Findings and Discussion

IV. Case Studies: BIM Applications in Sustainable Architectural Projects

To examine the practical contribution of BIM to sustainable architectural design, two contemporary projects were selected as case studies. The selection criteria were based on the extensive integration of BIM technologies during the design and construction process, as well as the demonstrated focus on energy efficiency, resource optimization, and improved building performance. The selected examples illustrate different ways in which BIM supports sustainability, from early-stage design analysis to operational management.

4.1 The Edge, Amsterdam – BIM Integration for Energy Performance Optimization

The Edge, designed by PLP Architecture and completed in 2015, is widely recognized as one of the most sustainable office buildings due to its integration of digital technologies and energy-efficient strategies. BIM played an important role in coordinating architectural, structural, and building service systems during the design process.

The digital model enabled the analysis and optimization of important environmental factors, including daylight availability, building orientation, energy consumption, and system coordination. BIM-based workflows supported collaboration between different disciplines and reduced potential conflicts before construction.

In addition to design optimization, the project incorporates smart building technologies that collect and manage operational data. This integration between BIM and building management systems demonstrates how digital information can contribute to long-term energy efficiency and improved building performance.

4.2 One Angel Square, Manchester – BIM for Integrated Sustainable Design

One Angel Square, designed as the headquarters of the Co-operative Group, represents an example of BIM application in a complex large-scale commercial building. BIM was used to improve coordination between architectural, structural, and mechanical systems while supporting sustainable design decisions.

The digital model contributed to more accurate material quantities, improved construction planning, and better integration of energy-efficient systems. The project achieved high environmental performance through strategies such as optimized façade design, efficient mechanical systems, and reduced operational energy demand. This case demonstrates the value of BIM as a collaborative platform that supports sustainability not only through visualization but also through data management and performance evaluation.

4.3 Comparative Analysis of Case Studies

The selected projects demonstrate that BIM contributes to sustainable architecture in several key areas. In both cases, BIM improved interdisciplinary coordination, supported environmental analysis, and enabled more informed decision-making during the design process.

BIM Application	**The Edge**	**One Angel Square**
Energy performance analysis	✓	✓
Interdisciplinary coordination	✓	✓
Building system optimization	✓	✓
Material and construction management	✓	✓
Operational performance monitoring	✓	Limited

The case studies confirm that BIM functions as more than a digital modeling tool. When integrated with sustainability objectives, BIM becomes a decision-support system that enables architects and engineers to evaluate alternatives, reduce environmental impacts, and improve building performance throughout the life cycle.

V. Discussion and Findings

The analysis of the reviewed literature and selected case studies demonstrates that Building Information Modeling (BIM) has significant potential to support sustainable architectural design. However, the findings indicate that BIM should not be considered as a sustainability solution by itself, but rather as an enabling framework that supports more informed and evidence-based design decisions.

The contribution of BIM depends on the way digital information is integrated into the design process, the quality of available data, and the ability of professionals to interpret and apply this information effectively. Therefore, the relationship between BIM and sustainability is not purely technological but also involves organizational, educational, and methodological factors.

5.1 BIM as a Decision-Support Tool for Sustainable Design

One of the main findings of this research is that BIM enhances the capacity of architects and engineers to evaluate environmental performance during the early design stages. Since early decisions regarding building orientation, envelope configuration, material selection, and technical systems significantly influence long-term performance, the ability to simulate and compare alternatives provides an important advantage.

BIM-supported workflows enable integration with energy simulation, daylight analysis, and environmental assessment tools, allowing design teams to evaluate different solutions before construction begins. This shifts the design process from a primarily experience-based approach toward a more data-driven methodology. However, the effectiveness of BIM-based decision-making depends on the reliability of the information included in the model. A highly detailed BIM model does not automatically produce a sustainable building if environmental objectives are not clearly defined and integrated into the workflow. In many projects, BIM continues to be used mainly for visualization, documentation, and coordination, while advanced sustainability analyses remain separate processes requiring additional expertise.

This highlights an important distinction: BIM does not generate sustainable architecture; rather, it provides a platform through which sustainable strategies can be evaluated and optimized. The architect's role remains essential in interpreting digital information and balancing environmental objectives with functional, economic, and social requirements.

5.2 BIM and Life Cycle Sustainability

The reviewed literature emphasizes that one of BIM's greatest contributions is its ability to support a life cycle approach to building design. By maintaining information about materials, components, and building systems, BIM creates opportunities for evaluating environmental impacts from the initial design phase through operation and maintenance.

The integration of BIM with Life Cycle Assessment (LCA) represents a particularly important development in sustainable architecture. BIM can provide accurate information about quantities, material characteristics, and building components, enabling more comprehensive evaluation of embodied carbon and resource consumption.

Nevertheless, several limitations affect the wider implementation of BIM-based LCA approaches. These include inconsistent environmental databases, differences between software platforms, and difficulties in maintaining accurate information throughout the project life cycle. Therefore, while BIM provides the technical foundation for life cycle evaluation, additional improvements in interoperability and data standardization are necessary. The case studies confirm that BIM can contribute to long-term sustainability by improving coordination, supporting energy-efficient systems, and enabling better operational management. However, these examples also reveal that successful BIM implementation is often associated with large-scale projects supported by significant financial and technological resources.

5.3 Challenges and Future Development

Despite the growing adoption of BIM, several challenges continue to limit its full potential within sustainable architectural practice.

A major challenge is the gap between technological capabilities and professional implementation. Although modern BIM platforms provide advanced analytical possibilities, many professionals lack sufficient training in integrating environmental assessment methods into BIM workflows. As a result, BIM is frequently used at a basic level without exploiting its full sustainability potential.

Another important issue is interoperability. Sustainable design processes often require communication between BIM platforms and specialized tools for energy simulation, carbon assessment, daylight analysis, and facility management. The absence of standardized data exchange methods can reduce efficiency and limit the reliability of sustainability evaluations.

Organizational barriers also influence BIM adoption. Effective implementation requires changes in traditional working methods, stronger collaboration between disciplines, and clearly defined information management procedures. Without these changes, BIM may increase workflow complexity instead of improving project efficiency. Future developments involving artificial intelligence, digital twins, cloud-based collaboration, and real-time monitoring systems are expected to expand BIM capabilities. Artificial intelligence may support automated design optimization, while digital twins may enable continuous comparison between predicted and actual building performance. However, technological development should remain connected to architectural principles and human-centered design approaches.

5.4 Limitations of the Study

This research has several limitations that should be considered when interpreting the findings. First, the study is based on qualitative literature analysis and therefore depends on the availability, scope, and interpretation of existing academic research. A quantitative evaluation of BIM performance indicators was beyond the scope of this paper.

Second, the selected case studies represent internationally recognized projects with advanced technological integration and significant resources. Although they demonstrate the potential of BIM for sustainable design, their implementation strategies may not be directly transferable to smaller architectural practices or regions with limited digital infrastructure.

Finally, BIM technologies continue to evolve rapidly, meaning that future developments may introduce new possibilities and challenges not fully addressed within the current literature. Further research should investigate practical BIM implementation strategies across different project scales and explore measurable relationships between BIM adoption and sustainability performance.

VI. Conclusion

This paper investigated the role of Building Information Modeling (BIM) in sustainable architectural design through a qualitative review of existing literature and analysis of selected case studies. The findings demonstrate that BIM has become an important methodology for supporting sustainable decision-making by integrating digital information, environmental analysis, and interdisciplinary collaboration throughout the building life cycle.

The research indicates that BIM contributes to sustainable architecture through several key areas, including energy performance optimization, life cycle assessment, material efficiency, construction coordination, waste reduction, and facility management. By enabling architects and engineers to evaluate different design alternatives based on measurable performance criteria, BIM supports a transition toward more informed and data-driven design processes.

However, the study also highlights that BIM should not be considered as an inherently sustainable technology. Its contribution depends on the quality of information, integration with appropriate environmental assessment methods, professional expertise, and effective collaboration between project stakeholders. Without these conditions, BIM may remain limited to visualization and documentation rather than achieving its full potential as a sustainability-supporting methodology.

The case studies demonstrate that successful BIM implementation can improve building performance by supporting energy-efficient strategies, reducing coordination conflicts, and enhancing operational management. Nevertheless, current examples are primarily associated with large-scale projects with advanced technological resources, which highlights the need for further investigation into accessible BIM workflows for smaller architectural practices.

Future developments involving artificial intelligence, digital twins, cloud-based collaboration platforms, and real-time monitoring systems are expected to further expand the capabilities of BIM. These technologies have the potential to improve predictive analysis, optimize building performance, and support continuous adaptation throughout the operational phase.

In conclusion, BIM represents a valuable framework for advancing sustainable architectural practice. Its greatest contribution lies not in replacing architectural knowledge, but in strengthening the ability of designers to make informed decisions based on environmental data and integrated building information. The future of BIM-enabled sustainable architecture will depend on the successful combination of digital innovation, professional expertise, and responsible design approaches.

Further research should focus on developing standardized BIM-based sustainability workflows, improving interoperability between BIM and environmental assessment tools, and evaluating the measurable impact of BIM implementation on building performance across different project scales.

References

[1]. Abanda, F. H., & Byers, L. (2016). An investigation of the impact of building orientation on energy consumption in a BIM environment. *Advances in Engineering Software, 97*, 1–12. https://doi.org/10.1016/j.advengsoft.2016.02.005

[2]. Azhar, S. (2011). Building Information Modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and Management in Engineering, 11*(3), 241–252. https://doi.org/10.1061/(ASCE)LM.1943-5630.0000127

[3]. Becerik-Gerber, B., Jazizadeh, F., Li, N., & Calis, G. (2012). Application areas and data requirements for BIM-enabled facilities management. *Journal of Construction Engineering and Management, 138*(3), 431–442. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000433

[4]. Bryde, D., Broquetas, M., & Volm, J. M. (2013). The project benefits of Building Information Modelling (BIM). *International Journal of Project Management, 31*(7), 971–980. https://doi.org/10.1016/j.ijproman.2012.12.001

[5]. Ding, G. K. C. (2008). Sustainable construction—The role of environmental assessment tools. *Journal of Environmental Management, 86*(3), 451–464. https://doi.org/10.1016/j.jenvman.2006.12.025

[6]. Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2018). *BIM handbook: A guide to Building Information Modeling for owners, designers, engineers, contractors, and facility managers* (3rd ed.). Wiley.

[7]. GhaffarianHoseini, A., Tookey, J., GhaffarianHoseini, A., Naismith, N., Azhar, S., Efimova, O., & Raahemifar, K. (2017). Building Information Modelling (BIM) uptake: Clear benefits, understanding its implementation, risks and challenges. *Renewable and Sustainable Energy Reviews, 75*, 1046–1053. https://doi.org/10.1016/j.rser.2016.11.083

[8]. Ilhan, B., & Yaman, H. (2016). Green building assessment tool (GBAT) and its integration with BIM. *Automation in Construction, 70*, 37–48. https://doi.org/10.1016/j.autcon.2016.05.010

[9]. Kibert, C. J. (2016). *Sustainable construction: Green building design and delivery* (4th ed.). Wiley.

[10]. Lu, W., Chen, K., Xue, F., & Pan, W. (2017). Searching for an optimal level of detail in BIM-based construction waste management. *Waste Management, 65*, 20–30. https://doi.org/10.1016/j.wasman.2017.03.012

[11]. Miettinen, R., & Paavola, S. (2014). Beyond the BIM utopia: Approaches to the development and implementation of building information modeling. *Automation in Construction, 43*, 84–91. https://doi.org/10.1016/j.autcon.2014.03.009

[12]. Olawumi, T. O., & Chan, D. W. M. (2018). Identifying and prioritizing the benefits of integrating BIM and sustainability practices in construction projects. *Journal of Cleaner Production, 187*, 312–328. https://doi.org/10.1016/j.jclepro.2018.03.012

[13]. Sacks, R., Eastman, C., Lee, G., & Teicholz, P. (2020). *BIM handbook: A guide to Building Information Modeling for owners, designers, engineers, contractors, and facility managers* (3rd ed.). Wiley.

[14]. Soust-Verdaguer, B., Llatas, C., & García-Martínez, A. (2017). Critical review of BIM-based LCA method to support sustainable construction. *Energy and Buildings, 136*, 110–120. https://doi.org/10.1016/j.enbuild.2016.12.009

[15]. Succar, B. (2009). Building Information Modelling framework: A research and delivery foundation for industry stakeholders. *Automation in Construction, 18*(3), 357–375. https://doi.org/10.1016/j.autcon.2008.10.003

[16]. Succar, B., & Kassem, M. (2015). Macro-BIM adoption: Conceptual structures. *Automation in Construction, 57*, 64–79. https://doi.org/10.1016/j.autcon.2015.04.018

[17]. Volk, R., Stengel, J., & Schultmann, F. (2014). Building Information Modeling (BIM) for existing buildings—Literature review and future needs. *Automation in Construction, 38*, 109–127. https://doi.org/10.1016/j.autcon.2013.10.023

[18]. Wong, J. K. W., & Zhou, J. (2015). Enhancing environmental sustainability over building life cycles through green BIM: A review. *Automation in Construction, 57*, 156–165. https://doi.org/10.1016/j.autcon.2015.06.003

[19]. Wu, W., & Issa, R. R. A. (2015). BIM execution planning in green building projects: LEED as a use case. *Journal of Management in Engineering, 31*(1), A4014007. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000314

[20]. Zhang, X., Shen, L., & Zhang, L. (2013). Life cycle assessment of green buildings: A review. *Renewable and Sustainable Energy Reviews, 22*, 240–250.