

Digital Transformation: Elevating Landscape Architecture through Building Information Modeling (BIM)

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Abstract

Building Information Modelling (BIM) is widely used in architecture and construction, particularly in building and structure design. However, BIM is imposed in landscape architecture design, which is still not much applied in landscape architecture, academically and practically. Therefore, this paper explores the benefits of BIM application in landscape architecture design. A methodology involves a systematic literature review (SLR) on BIM landscape architecture to explore the purposes and benefits of BIM's landscape architecture. The study found that the BIM application has contributed valuable benefits to the landscape architecture design process and the digital modeling of landscapes. Moreover, the study provides a solution software application and tool to generate a sustainable landscape design from the pre-design stage of landscape architecture projects. In short, successfully utilizing BIM depends on an operator's human skills to use the application in landscape architecture projects and enhance the multiple aspects of landscape visualization.

Keywords: Building Information Modelling (BIM); BIM Application; Landscape Architecture Design; Sustainability; Human Skills.

1. Introduction

The concept of computer modeling of structures arose in the early 1970s, and studies were published in the mid-1980s that looked at practical possibilities and applicable examples. "Building Information Models" was first used in a 1992 article. Nonetheless, it gained popularity in 2002 through an Autodesk White Paper, and Jerry Laiserin attributed it to coining the name BIM (Gobesz, 2020). For over 40 years, this digital technology has evolved and continues to grow, bringing significant change to the built environment and boosting efficiency and overall design outcomes. This program enables the effective and efficient design and construction of infrastructure.

The AEC/FM business has profited from the innovative integration of information technologies and industry-wide processes throughout the facility's lifecycle (Afara et al., 2024; Amen et al., 2024). Building Information Modeling (BIM) is one of the innovations swiftly emerging as a critical technique to virtually integrate the necessary information for facility design, construction, and management (Abdirad & Lin, 2015). Building Information Modeling (BIM) depicts a facility's physical and functional features. Furthermore, it establishes a shared knowledge resource to support the facility throughout its life cycle, from initial design to demolition, ensuring that everyone participating in the project can access all necessary information at all times. It has enabled improved consultant cooperation and real-time data interchange, resulting in more successful design processes and development.

BIM extends beyond 3D modeling and is commonly defined in dimensions such as 4D (time), 5D (cost), and 6D (as-built operation). These dimensions apply to the stages of information data, project planning, scheduling, cost management, and facilities management. Furthermore, dimensions are used to define a variety of BIM subsets, including 3D (object model), 4D (time), 5D (cost), 6D (operation), 7D (sustainability), and even 8D (safety). This multidimensional aspect of BIM is known as "nD" modeling because a nearly infinite number of dimensions can be added to the architectural model (Smith, 2014). Furthermore, BIM in China has shown a considerable advantage in resource integration and collaboration, completing multiple mega-engineering projects, and saving costs by minimizing errors and unanticipated modifications in the early phases of the project (Cao et al., 2021).

Landscape architecture is becoming more sophisticated as society evolves and the demands of the garden landscape increase. It includes large-scale landscape planning and small-scale designs for garden buildings, ornaments, plots, and construction plans. Using BIM to model the terrain and related structures of the landscape architecture design can realize the visual query of the relevant structures and the quality control of critical nodes, simplify the general layout optimization process, and complete the rapid and accurate calculation of the earthwork volume, so that engineering management and information technology are highly integrated, which is of excellent significance for improving the information rate of land (Suyu & Xiaogang, 2018).

Furthermore, BIM does not include all components of landscape-scale modeling, including projection and scenario testing (Larsen et al., 2016). However, Fritsch et al. (2019) observed that BIM might represent a notion for the information related to landscape elements, such as a terrain model, retaining walls, routes, and so on, via the Industry Foundation Classes (IFC) communication standard. This study investigates the role and benefits of BIM in landscape

architecture design, also known as landscape information modeling (LIM), in offering efficient and effective design solutions from the pre-design phase to the construction stage.

2. BIM and Landscape Architecture

Many landscape architects are captivated by BIM (Building Information Modeling) because it involves the word 'building.' However, BIM is the most recent technology advancement in the AEC industry. It progresses from making printed landscape drawings to creating and organizing data in a digital landscape model. In some ways, the transition to BIM is more complex than the transition to CAD since it necessitates a significant shift in methodologies that have been in use since hand drafting (Schmidt, 2016). Building Information Modeling (BIM) is a method for the digital collaborative design, construction, and operation of buildings. In the last few years, this method has become applicable in landscape architecture design as an overall visualization and impression of the project through real-world landscape objects like terrain, buildings, ways and paths, playgrounds and so on (Figure 1) (Amen, 2021; Amen et al., 2023; Barone, 2023). Urban landscape construction is becoming more popular, and landscape architecture is becoming more complex, ensuring that capturing landscape information within a BIM model is feasible and must be disseminated in academic and professional fields to strengthen its use. Furthermore, standardizing the BIM approach will enable each landscaper to develop catalogs of vegetation families by geographical region, providing access to a wide range of catalogs shortly. It can help with project communication, time management, cost control, and interoperability (Garcia, 2022).



Figure 1. Visualization of a public park (Developed by Author).

Trisyanti et al. (2019) also noted that vegetation modeling is essential for several fields, particularly landscape architecture, where it can be used to visualize and evaluate tools like urban greening, energy conservation, and flood prevention simulations. Moreover, Trisyanti et al. stated that vegetation models are visualized at different levels of detail (LoD), as shown in Table 1, which can be broken down into (i) LoD 1, which only provides information on appearance because it has only two polygons with texture, and (ii) LoD 2, which provides information on appearance and geometry. Additionally, on LoD 1, the form of a 3D model follows the geometry of an object, but in a simplified form; (iii) LoD 3 consists of the 3D model of the tree that already contains semantic information, such as root, trunk, and crown. The semantic information adheres to the tree's hierarchy level, and (iv) LoD 4. It is the highest level and provides all the information aspects of a 3D model. There are three types of appearance: geometry, semantics, and topology. The topological aspect of the model involves the relationship between each part of the tree.

Regardless of the pros and cons, the BIM workflow was intended to help architects complete projects more successfully by utilizing digital collaborative design tools, and information flow is a crucial feature of the BIM workflow. Furthermore, a comprehensive database is required to help the designer understand the design environment, including topography, sunlight, soil, and hydrology, which must be meticulously collected and classified in BIM software before being linked to the generation of an accurate digital terrain model (Cao et al., 2021). Furthermore, from a BIM perspective, planning may be the primary gateway via which BIM data and visualizations can inform building processes and enhance landscape planning (Nikologianni et al., 2022).

Table 1. Level of Detail (LoD) of vegetation

			
LoD 1	LoD 2	LoD 3	LoD 4

Moreover, Building Information Modeling (BIM) within the context of Revit software possesses extensive sun and shade settings (Figure 2), enabling the adaptation of these settings within the project following the requirements. The natural lighting settings allow the analysis to be carried out for a precisely defined location using geographical coordinates and the sun's position. According to Borkowski and Luczkiewicz (2023), the findings can aid in strategic planning and managing space within the landscape design. Furthermore, Figure 3 shows the results of sun and shade setting hourly and its implications for shading analysis of through landscape components.

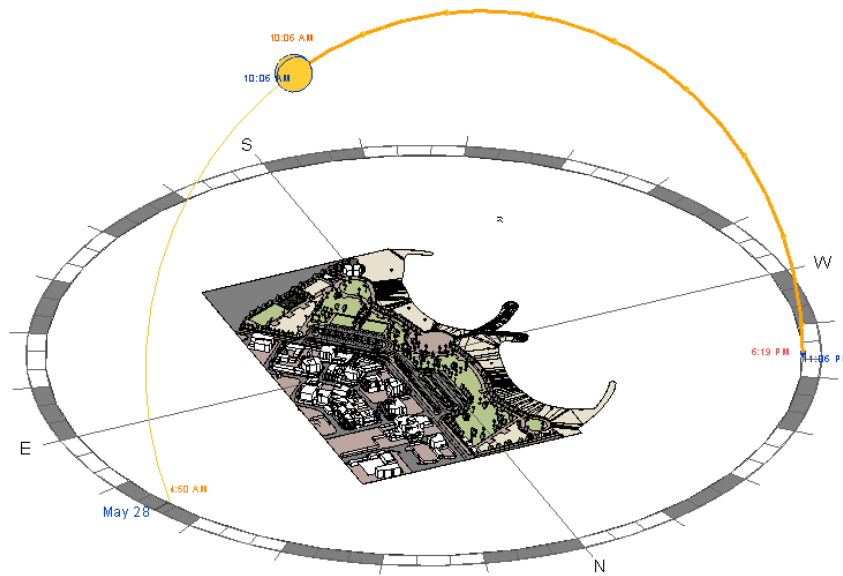


Figure 2. The sun and shade settings are in Revit software (Developed by the author).

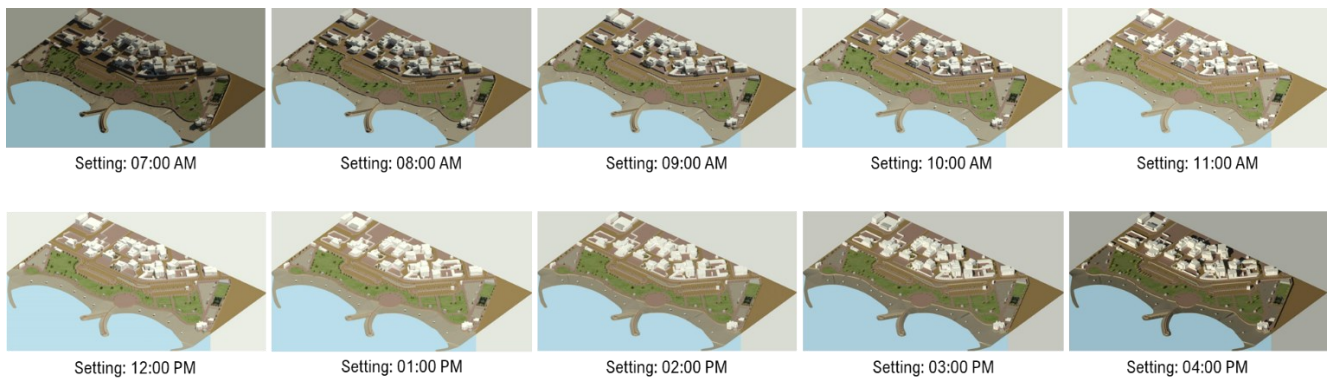


Figure 3. The result of sun and shade settings hourly (Developed by the author).

Furthermore, Nikologianni et al. (2022) revealed that only specific ties between BIM and landscape have been established thus far, as evidenced by an emphasis on three critical areas of the landscape: planning, urban design, and climate change. Furthermore, BIM and digitalization transformation technologies can help to improve the landscape by giving accurate data, increasing landscape comprehension, and highlighting climatic challenges and environmental solutions. Additionally, sustainable cities require comprehensive plans to deal with climate calamities, but digital tools may greatly assist with visualization and carbon calculation to improve these outcomes. Finally, using

BIM in landscape design allows architects to pursue a more ecological and integrated design solution, emphasizing the link between humans and the environment (Cao et al., 2021).

3. Methodology

The study's approach is an examination of pertinent literature, including the keywords "digital landscape," "landscape information modeling," "BIM in the landscape," and "history of BIM." This method was repeatedly utilized to find pertinent content before the review. Google Scholar and Scopus were used to search for this data. Since the titles likely included relevant terms, the search was expanded to include additional keywords like "BIM implementation" and "BIM benefit".

Screening and filtration were performed manually by reading the titles and abstracts to check whether the articles were within the scope of the review. Some studies focusing on BIM in landscape architecture design have been conducted. The study varied based on the implementation of BIM in landscape architecture design, 3D landscape objects in BIM, landscape modeling for visualization in BIM, etc. The following constraints of this review form the basis of the selection criteria: (i) The research was done on BIM in landscape architecture, and (ii) papers published in the last ten years, between 2014 and 2024.

4. Result

Although BIM is commonly used in AEC (Architectural, Engineering, and Construction) projects, its implementation in landscape architecture design needs to be improved. However, BIM implementation has some purposes in landscape design. First, BIM is a digital tool for visualizing landscape design through the 3D image impression and providing the construction documents for landscape construction. This purpose is to produce a final landscape design impression and exchange knowledge amongst the stakeholders involved in the landscape project. The decision was made at the beginning of the project to minimize errors in the landscape construction. Moreover, this stage consists of generating a level of detail of the landscape component and a database as part of the design solution in the landscape project.

Secondly, BIM provides a sun and shade analysis that can assist designers in deciding the placement of landscape components to generate heat mitigation solutions for sustainable landscape design. This tool (solar study) can also help determine the type of shading and modify its size to produce a sufficient shaded area.

Lastly, generating a model and construction document will not maximize BIM's purposes. Moreover, the end of all BIM processes should be connected to project management. This function is related to the bill for the quantity of landscape projects. However, this stage needs to be explored more in the context of BIM for landscape projects.

5. Discussion

BIM is a platform for coordinating design, budgeting, construction, and management activities. Thus, consultants, contractors, and site managers share a centralized database with the client, in which each component has a wealth of information attached. Moreover, BIM is not a specific brand of software but a process that involves multidiscipline and knowledge to provide a better solution for the built environment.

The transformation terminology from BIM to LIM will likely aid landscape architects in utilizing information modeling software to represent physical objects in a landscape design. The digital representation of physical objects allows for the simulation of phenomena and the prediction of behaviors of components inside the modeling to provide sufficient design solutions. The present digital model will facilitate the execution of analyses, furnishing crucial details regarding managing a landscape setting, its components, or entire areas. Furthermore, a comprehensive description of numerous aspects of land use is presented in the topography, land cover, materials used to construct pavements or paths, and landscaping, including high, medium, and low vegetation. The chaque site component is of great value and should be presented in as much detail and accuracy when creating a digital representation of landscape design.

6. Conclusion

This work examined the application of Building Information Modeling (BIM) in landscape architectural design. The emphasis on landscape architecture research stems from the expansion and enhancement of BIM's application in the built environment, both academically and practically, intending to establish a sustainable environment. Furthermore, since landscape architecture has a direct impact on climate change, the topic of climate change promotes sustainability in the built environment.

BIM applications are used for more than just rendering output; they convey landscape design concepts and convince clients. Furthermore, BIM deployment impacts landscape architecture design solutions, beginning with the early design stage. It is demonstrated that the landscape architect and client could identify difficulties before beginning landscape work. Furthermore, including a plug-in, such as the Environment plug-in, into BIM software gives an essential answer to the landscape architecture design process. However, the implementation of computer software is dependent on the person operating the software. As a result, the growth and improvement of human capital are critical issues that must be explored further.

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Conflict of Interests

The Authors declare that there is no conflict of interest.

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