P-ISSN: 2790-6795	Annals of Human and Social Sciences	Apr-June 2024,Vol. 5, No. 2
O-ISSN:2790-6809	http://doi.org/10.35484/ahss.2024(5-II)02	[14-25]

Annals of Human and Social Sciences
www.ahss.org.pk

RESEARCH PAPER

Exploring the Role of BIM In Supporting Sustainable Design and Construction of Green Buildings

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ABSTRACT

Sustainable design and construction have amassed outstanding recognition in the construction of green buildings, resulting in revolutionary improvements to authenticate these aspirations. Building information modeling (BIM) achieving momentum as a potent software for enhancing sustainability in construction. This research explores BIM's input to support sustainable design and construction in green buildings, trying to analyze its acknowledgment, improvement, and benefits among professionals. It explores BIM's implication on sustainable design principles, cooperation, and project efficacy, and emphasizes factors like energy effectiveness, selection of material, sustainable indoor air quality, and resource streamlining. Through a mixed-method strategy, this research emphasizes BIM's assurance to enhance sustainable design principles and improve project delivery. Findings share insight and guidance for practitioners and participators, supporting wider BIM collaboration to achieve sustainable construction targets competently. Integration of BIM's software with laboratory concrete tests to achieve high-quality construction and continuous monitoring of the project.

Keywords: BIM, Green Buildings, Revit, Sustainable Design

Introduction

As time passed by escalating technological innovations and worldwide integration, the domain of sustainability has manifested as both an urgent requirement and a bold ambition. The essential requirement to coordinate human evolution with environmental stability represents a crucial obstacle of our era. In this fundamental structure, the agreement amongst sustainable design principles and building information modeling (BIM) has evolved as a leading principle of innovation, inspiring not only to achieve sustainability milestones but to go beyond.

The construction industry, a foundation of world economies and nations, structures entirety from magnificent tall buildings to simple homes (Othman, 2011). Yet, it struggles with ineffectiveness and disintegration, requiring a transformation in the direction of coordinated operations and technological remedies (Kymmell, 2008),(Hergunsel, 2011). An innovative tool revolutionizing construction by promoting cooperation and persistent progress (Ghaffarianhoseini et al., 2017).

BIM generates thorough computerized models refined with essential building details, improving design, execution, and operational supervision (Lu et al., 2014). Its range surpasses 3D modeling, covering lifecycle guidance, coordination, and expense management (Lu et al., 2017). As sustainability attains importance amongst global warming issues, green building standards have transformed vital for establishing sustainable and green buildings (Chi et al., 2020),(Hossain, 2018).

The amalgamation of BIM with green building standards maintains remarkable commitments to endorsing sustainability in construction (Fadeyi, 2017). By enhancing design, evaluating energy efficiency, and advising material alternatives, BIM promotes sustainable construction approaches (Ohueri et al., 2022). Moreover, it streamlines the executions of frameworks like LEED and BREEAM, incorporating sustainability into the design approaches (Arayici, 2017).

As BIM evolves, it delves into new features such as 4D, 5D, 6D, and 7D BIM, providing advanced energy improvements and project achievement awareness (Fadeyi, 2017). Web-based BIM databases improve cooperation and clarity between stakeholders, and encourage actual decision-making and environmental consequences evaluation (Edwards et al., 2015).

Despite its potential, the incorporation of BIM in green buildings deals with difficulties such as acknowledgement and appreciation slots (Zhang et al., 2020). Controlling these obstructions obliges revolutionary incorporation of BIM in smaller projects to open important ecological gains (Ferdosi et al., 2023).

Our expedition throughout these innovative surroundings is directed by the endeavor for the revolution, accuracy, and environmental responsibility. This research initiates an investigation of BIM's significant role in supporting sustainable design and construction in the framework of green buildings. The aim is not only to archive the influence of BIM on sustainability; instead, it's focus on to explain the significant and broad consequences that arise when technological innovation and sustainable cognizance are merge.

The importance of this study broadens surpassing the domains of execution and academia. As our world community struggles with the repercussions of resource scarcity, global warming, and urban expansion, the construction of green buildings signifies a real and flexible approach. Nonetheless, the track to sustainability is filled with difficulties, incorporating vary material prices, unstable energy trades, and complicated legal systems. It is here that BIM arises as a powerful partner, encouraging stakeholders to guide these difficulties with accuracy and predictions.

This study aims to motivate architects, engineers, legislators, and entrepreneurs by contribution a thorough analysis of the agile collaboration amongst BIM and sustainable design. It Assists as evidence to the revolutionary prospect of innovation, going beyond the conventional frameworks of construction. Furthermore, it emphasizes the pragmatic imperative of sustainability in an era where environmental stability is not a luxury but a fundamental requirement for our collective destiny.

As we commence on this research, we realize that we are at the threshold of a new era, where the integration of technological advancement and sustainable obligation has the potency to transform the urban panorama of our towns and the blueprint of our society. Our research starts here, in the cooperation of sustainability and innovation, where the alternatives are as infinites as our dreams for a sustainable, more eco-friendly world.

Literature Review

BIM has emerged as the foundation of the construction industry. It helps throughout the life cycle of the project phase: initiating, planning, execution, monitoring and controlling, and closing. BIM and green building standards have open digital way to attain sustainability objectives and reduce the ecological impact of the engineered environment, especially in small projects (Cao et al., 2022a).

From enhancing HVAC (heating, ventilation, and air conditioning) arrangements to optimizing lighting design, BIM's energy analysis competences are revolutionary for eco-friendly construction. This systematic technique helps to find and solve deficiencies, and

make provision for the sustainable buildings that have constructive footprints on the world (Olanrewaju et al., 2022).

BIM transitioned into a digital guide for exposing the veiled routes to sustainable in green building projects. In this way spectacular decrease in utilization and a remarkable improvement in productivity (Ismaeel & Kassim, 2023).

Utilizing BIM's statistically informed observations, engineers and architects precisely choose materials that incorporate minimum carbon and paramount reuse fulfilment, providing considerable depletion in the building's sustainable footprints (Mohammed, 2020).

Transcending energy analysis, currently BIM escorts eco-friendly material chosen by giving statistically informed observations and supports analysis of sustainable footprints (Waqar, Othman, & González-Lezcano, 2023).

Transcendent to a fundamental analysis, LCA investigate thoroughly into the statistical experiences of a building's sustainable footprints, enabling decisions approaching sustainable design and construction of green buildings. Some convincing researchers put light on BIM's information-laden environment as a powerful coordinator for organizing resilient LCA on buildings, preparing the grounds for more sustainable construction standards (Roggeri et al., 2021). Utilizing BIM for LCA enables stakeholders to understand the complicated network of a building's sustainable impact, opening the door for more reliable construction execution (Solla et al., 2019).

Sustainability achieving momentum in the construction industry, BIM appear as a promoter of clarity, delivering comprehensive knowledge regarding materials and their life cycle footprints. BIM endorsed sustainability enhanced accessibility and responsibility in sustainable construction projects (Ekasanti et al., 2021).

The amalgamation of BIM software with the preconstruction approach confines enormous potentialities to reduce waste and smooth the construction execution, leading toward more structured and eco-friendly projects (Morsi et al., 2022).

BIM power technique that is amalgamated with preconstruction approach is not just about expedite the process and productivity: it is about accuracy and sustainability. Using BIM software, we can adjust our work by using the clash detection method. This radical method gives new heights to the construction industry to move towards green buildings and this led to superior specifications eco-friendly reliable green construction (Liu & Wang, 2022).

Models drafting by BIM software and preconstruction approach is the technique for versatile buildings that encourage the future. Leading minimum waste and maximum sustainability (Cao et al., 2022b). Although improving sustainable design practices in preconstruction process is essential for the buildings, but focal point is large-scale projects that ignore the capability of BIM to encourage the practitioners of small-scale projects to make enlightened and sustainable decisions. This research intends to narrow the knowledge disparity and how BIM software is ingeniously modified to tackle the distinctive difficulties and chances of sustainable design in small-scale projects (Roggeri et al., 2021; Rathnasiri et al., 2020 &Huang et al., 2021).

Architects and engineers to stakeholders and environmentalists, BIM authorizes stakeholders to dynamically shape green building expectations. Its powerful proficiency in energy analysis instructs knowledgeable design options that lead to minimizing carbon impact. Accurate material alternatives improve reserves employed, although LCA put light on ecological footprints across a building life. Preconstruction additionally increases proficiency, minimizing waste and maximizing efficiency. This dependent amalgamation of

BIM and sustainable techniques led toward reliable responsibility, cost savings, and standards transitions into the direction of ecological cognizant construction (Waqar, Othman, Almujibah, et al., 2023 &Waqar, Othman, & Pomares, 2023).

Incorporation of BIM inside green building assessment can optimize the approach and bestow precious observations for efficiency enhancement. This method analyzes critical elements modifying green building efficiency using modeling software, then compute the results and proposed refined standards. A Case study of a school building in China illustrates the potency of this technique, demonstrating how different refurbishment plans can notably increase the green performance of buildings even though also enhance residents' convenience, Although obstacles subsist and more research is required, initiate the capabilities of BIM centered analysis as a potent tool for maximizing green buildings and advocating sustainable improvements (Guo et al., 2021).

Motivated by the vitality of sustainable improvements, green buildings address primary obstacles like scarcity of resources, energy inefficacy, and ecological repercussion, striving for the equilibrium and sustainable future (Dwaikat & Ali, 2018).

The emergence of 4D (duration), 5D (expense), 6D (Performance), and 7D (Sustainability) BIM symbol a significant move in design application. By incorporating these aspects, BIM assists increase energy streamlining and provide complete cognizance of projects productivity throughout their whole lifespan (Fadeyi, 2017). In Table no. 1, showing that the aspects of BIM and revealing the level of project intelligence

Table 1
BIM aspects: revealing the levels of Project Intelligence

Aspects	Description	Key Benefits
3D	Length, Width, & Height	Rendering, geometric understanding, clash detection
4D	Construction Plan	planning, resource allocation, Order efficiency
5D	Cost Calculation	exact budgeting, cost control, business suitability study
6D	Site Integration (GIS)	Terrain study, infrastructure factors, informed site improvements
7D	Facilities Management	Effective maintenance, active planning, persistent asset management

The rising collaboration of BIM-BPS tools like green building studio (GBS) and Revit, (Abanda & Byers, 2016) open a new era by examining the effect of building directions on energy using in the buildings of United Kingdon. The outcomes provide important observations for architects and engineers to design energy-optimal buildings with the help of enlightened direction preferences.

In his research built traditional and non-traditional building models with the help of BIM software such as Revit 2019 and EDGE app. These models were precisely investigated with the perspective of energy, water and low-carbon materials. Moreover, this research also sheds light on the differentiating of incorporated energy and carbon footprint in both models. (Uddin 2018),

Architecture is being transforming by sustainable design, stipulating innovative investigation tools. BIM software such as Revit elevates to solve disputes before and during construction. This data-saturated, BIM, network amalgamates with tools like green building studio (GBS), enhancing building efficiency from solar to carbon impacts. BIM authorize architects to build sustainable buildings that radiate proficiency and productivity (Ebrahim & Wayal, 2020).

Material and Methods

A mixed-method strategy was utilized: questionnaire and assessment of existing studies. This strategy permitted for a thorough investigation of the function of BIM in supporting sustainable design and construction of green buildings.

From an academic point of view, the methodology compatible with the method of triangulation, surpassing easily authenticated results. This theory helps to comprehend objects superiorly such as books, group discussions, surveys, and interviews. Triangulation assists researcher by employing diverse origins and asking people promptly, and motivate peers to carry out corresponding. It also proposes a diverse method to interpret objects as opposed to ordinary ones. But there are also some difficulties with this novel method. Employing enhanced knowledge and diverse strategies of cognizance assist research to be superior and more helpful (Vivek et al., 2023). By merging of survey responses with the observations of existing studies, obtain a significant insight into the theme.

Moreover, the methodology emulated components of constructivism. (Schwandt, 1994) recognized the opinionated essence of information and pursued to develop significance with the help of analysis of statistics compiled from contributors and existing studies. This acknowledges the understandings and experiences of shareholders in construction sector designed their comprehension of BIM's function in sustainable design and construction of green buildings.

Comprehensively, the methodology was based in the standards of methodological pluralism, which broadly employed the resources integrates different qualitative data analysis approaches, emphasizing the advantageous and restrictions of every individual (Miles & Huberman, 1994).

Questionnaire Fills for Acquiring Data

An organized survey form was created to collect information from professionals in the construction sector, incorporating architects, project managers, engineers and BIM practitioners. The questionnaire was thoroughly created to extract perceptions into attendees' knowledge, use, and recognized benefits of BIM in the framework of sustainable design and construction strategies. Questionnaire were drafted to assess attendee's understandings with BIM software, their familiarity with incorporating BIM into green building projects, and they experience with obstacles. The questionnaire also delves into detailed components of sustainable design, including indoor air quality, material picking, and sustainable energy use, to comprehend how BIM assist to these sections. Information gathered from the questionnaire shall be evaluated by applying statistical approaches to determine developments, design and correlation. In figure 1, detail of stages, how the survey was conduct to accumulate the information from participants.

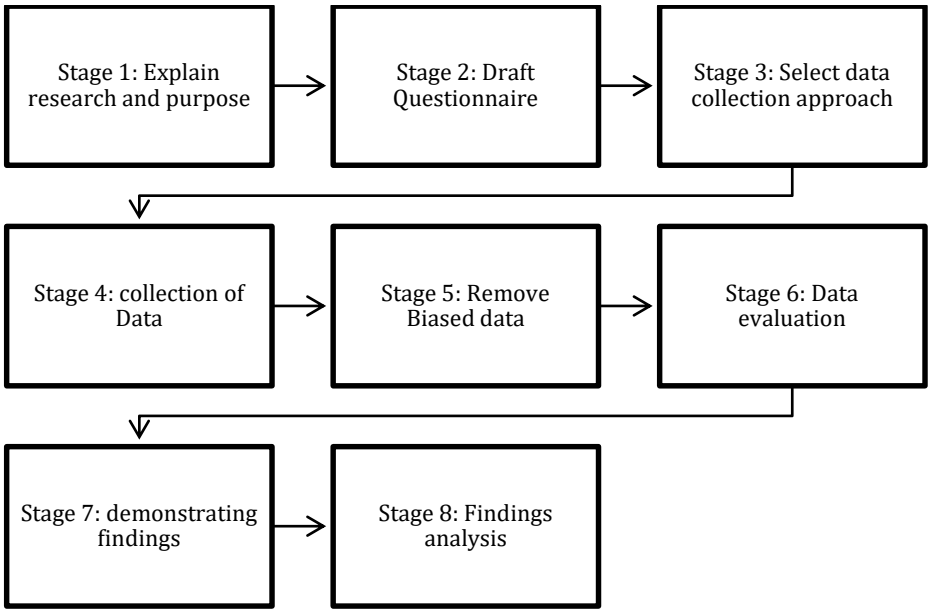

Fig.1. Stages for conducting the survey to accumulate information.

Exploring the Existing Studies

An exhaustive analysis of existing studies was carried out to stimulate the research inside the limit of academic conversation on BIM, sustainable design, and construction of green buildings. Related contemporary critique journals, conference papers, reports, and case studies were structurally investigated and examined. The analysis included studies targeting on the practice of BIM in green construction, its effect on sustainability achievements, and the difficulties and possibilities related with its executions. Important motifs and outcomes from literature review were integrated to offer a strong academic framework for the study. This combination enlightened the drafting of questionnaires, the analyses of observable results, and the conversation of results and proposals.

Results and Discussion

This study has explained the substantial influence of BIM within the construction sector, highlighting its universal acceptance and special focus on sustainability.

Questionnaire Results

Architects' prominence as the principal patron of BIM, emphasizes its critical function in project implementations, though a considerable mass illustrates basic awareness with the innovation. Table 2 shows statistics on the awareness of BIM in the circumstances of sustainable design and construction of green buildings. Table 3 demonstrate the appreciated advantages of BIM in sustainable design and construction, emphasizing its use beyond design within construction approaches praised for oversight decline and process improvement. Table 4 shows the appreciated benefits of BIM in sustainable design, imputing declines in ecological effect and improvements in energy efficient to its execution. Table 5 demonstrates the obstacles of adopting BIM in green building projects, and Table 6 summarizes tendencies in BIM for sustainable design and construction. Table 7 shows obstacles in incorporating BIM engaged in green building projects. However, obstacles such as software price are costly and a shortfall of practitioners endure, suggesting the demand for persistent sector endeavors to enhance approachability and uniform procedures. Foreseeing, predicted shifts incorporate enhanced BIM acceptance, incorporation with associated tools, and the entity of resilient data criteria, assuring additional innovations in sustainable construction methods and sector-wide productivity.

Table 2
Awareness of BIM in sustainable Design and Construction

Stage of awareness	Percentage of contributors
Expert	5.2%
Moderate	23.4%
Fundamental	50.2%
Beginner	1.2%

Table 3
Advantages of BIM in Sustainable Design and Construction

Advantages of BIM	Percentage of contributors
Assure the precision and cooperation of building information	44.6%
Minimize the environmental effect	25.3%
Enhance the energy utilization	22.2%
Enhance the paper work and delivery	7.9%

Table 4
Benefits of BIM in Sustainable Design

Benefits of BIM	Percentage of contributors
Increased cooperation	35%
Enhances project performance	28%
Improve decision forming	20%
Enhance sustainability effects	17%

Table 5
Obstacles to adopting BIM in Green Building Projects

Obstacles	Percentage of contributors
Complicated and costly software	32.6%
Advance cooperation among stakeholders	39.3%
Hard to find BIM professional	28.1%

Table 6
Tendencies in BIM for Sustainable Design and Construction

Tendencies	Percentage of contributors
Utilizing BIM for Design and Construction	71.4%
Cooperation of BIM with other software	54.3%
Innovations of new BIM Principles	32.8%

Table 7
Obstacles in incorporating BIM into Green Building Projects

Obstacles	Frequency
Absence of guidance	29
Refusal to transformation	28
Suitability problem	18
Price of software	25

Study of Existing Studies

BIM (Building Information Modeling) has arisen as a keystone innovation in construction, transforming project strategizing, implementation, and supervision. Its incorporation with green building procedures has opened inventive ways to attain sustainability aims, especially in smaller projects. BIM's energy evaluation ability, assisted

by software named Revit, allow thorough enhancement of frameworks by lighting design and air condition, resulting in prominent energy-productive buildings and encouraging ecological effect. Utilizing BIM's analytics-based perceptions, architects and engineers precisely chose material with less incorporated carbon and maximum reuseable material, assisting to important decreases in a building's natural effect. Moreover, BIM dynamically advises eco-friendly material selection and assists Life Cycle Assessment (LCA), enabling stakeholders to make enlightened choices toward sustainable design and construction. Furthermore, the incorporation of BIM with preconstruction approaches, assisted by software such as Revit, supports enormous capability for waste reduction and simplification of construction methods, in this way we can get more effective and sustainable design. Table 8 shows the quantity of research articles that had been studied for this study. Generally, these results highlight the revolutionary function of BIM, notably with tool like Revit, in sustainable design and construction, featuring its abilities in energy improvement, waste reduction, material selection, ecological management through the complete lifecycle of projects.

Table 8
Read number of articles by Publication category

Publication category	Read number of research article
Journals	89
Academic Papers	11
Reports	3
Case Studies	9

Discussions

We are exploring the thrilling potentials and difficulties confronting building information modeling (BIM) in sustainable construction. Initially, the cost of AUTODESK software's are very high, which is main hurdle to adopt (Abanda & Byers, 2016). To address this, supporting cost-effective possibilities and internet-based registration could help to the practitioners to make the mark.

Moreover, progressive sustainability evaluation in BIM could transform how we design and construct buildings (Olanrewaju et al., 2022). By incorporating life cycle assessment (LCA) software and energy modeling, we can improve buildings for nominal ecological effect from construction to procedures. Ultimately, regulation works like openBIM norms are essential for assuring data suitability and smooth cooperation (Fadeyi, 2017). These steps can lead us to future where BIM authorizes sustainable construction techniques and motivates optimistic transition in the construction industry.

Conclusion

A three-dimension model of an existing site project is modeled in Autodesk Revit program and IFC is imported and shared with all stakeholders for cross checking. An outcome is observed, that the cost of materials is reduced by five percent when using a BIM approach. As a result of identifying collisions and clashes during the pre-construction phase, the design accuracy was improved. Most of our crew members practice a traditional construction method, so the BIM method reduces errors and simultaneously improves virtual mistakes, for example in staircase with a fraction of millimeters slab thickness increased or decreased results virtual error in risers and trends which impacts a lot on time and cost.

Moreover, study reinforces the innovative dominance of BIM in crafting a sustainable, more effective, and constructed environment. Construction efficiency and productivity could be improved by incorporating this BIM-based system into design and planning processes. At this time, stakeholders must invest in learning BIM methodology and

investing in education and training so that they can motivate constructive change and facilitate a more sustainable future for the construction industry.

Recommendations

Concrete is widely used as a construction material which requires sufficient strength and durability. Different structural components such as foundation, beams, walls, slabs, and columns have different strengths and durability. BIM is capable of integrating all stages of construction into a single digital model, achieving high-quality construction, accurate performance as well as continuous monitoring (7 days, 14 days, and 28 days) and then controlling site parameters.

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