

Research Article

The Role of Building Information Modeling (BIM) in Reducing the Environmental Impacts of the Construction Industry

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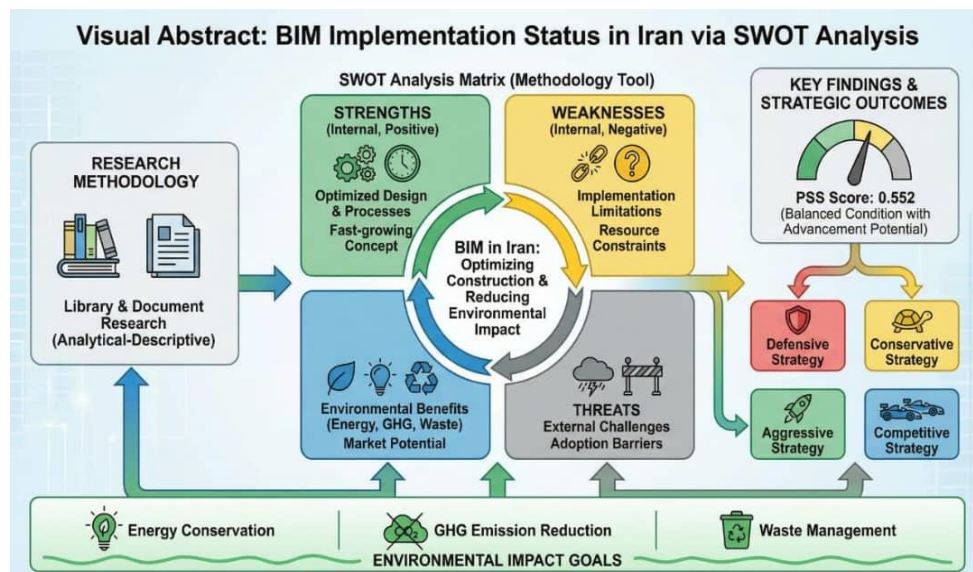
Abstract

The aim of this study is to examine the status and implementation of Building Information Modeling (BIM) in Iran using the SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis model. BIM represents the fastest-growing concept in construction management and plays a significant role in reducing the negative environmental impacts associated with the construction industry. Accordingly, this research addresses two central questions: How can a meaningful connection be found between BIM performance and environmental process improvement? How can a SWOT framework be used to turn weaknesses into strengths and threats into opportunities? Additionally, this study explores the environmental impacts of BIM, highlighting its potential to contribute meaningfully to energy conservation, reduction of greenhouse gas emissions, and waste management in the construction sector. The research methodology employed is analytical-descriptive, relying on library research and document analysis, with SWOT matrix analysis as the primary tool. SWOT provides a simple yet powerful framework to assess an organization's internal resources and limitations, market opportunities, and external threats. This analysis facilitated the identification of strengths, weaknesses, opportunities, and threats associated with BIM implementation in the Iranian context. Based on the SWOT analysis, the level of BIM adoption in Iran was evaluated, and its internal (S, W) and external (O, T) factors were identified. The results show that the Probability of Strategic Success (PSS) score is 0.552, which is supported by 4 strategies, namely conservative, defensive, aggressive, and competitive: high cost of BIM implementation in engineering firms is linked with the environmental benefits of contributing to architectural design standards, suggesting that greater attention be paid to sustainability in future designs (Conservative strategy), Lack of improvement in waste management correlates with the increasing volume of construction debris in the environment (Defensive strategy), Implementation of BIM in Iran can reduce material waste, enhance project quality, and automate drawing production, thereby motivating students in the construction field (Aggressive strategy), Reduction of construction costs through BIM technology can incentivize contractors and stakeholders to adopt the system more widely (Aggressive strategy).

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Keywords: BIM; SWOT Matrix; Architecture; Environmental Impacts; Strategic Planning; Iran

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1. Introduction

Building Information Modeling (BIM), as an emerging technology, has revolutionized the construction industry and is rapidly becoming a global standard. By providing a comprehensive digital representation of a building, BIM enables efficient information management, reduces errors, and enhances overall productivity. In Iran, this technology has also garnered attention as a means to improve construction quality and mitigate the negative environmental impacts of the industry. One of the most significant advantages of BIM lies in its potential to reduce the environmental footprint of the construction sector. By optimizing design and implementation processes, BIM allows for reduced resource consumption, minimized waste generation, and improved energy efficiency. Consequently, its application can contribute to lowering greenhouse gas emissions, conserving natural resources, and decreasing environmental pollution. Despite these numerous advantages, the implementation of BIM in Iran faces several challenges. The purpose of this paper is to assess the current state of BIM adoption in Iran through a SWOT (Strengths, Weaknesses, Opportunities and, Threats) analysis and to propose strategies for enhancing its implementation, with a particular emphasis on reducing its environmental impacts.

2. Theoretical Foundations and Literature Review

In recent years, many leading construction companies have recognized major transformations in their operational domains driven by information technology.

One of the most revolutionary advancements in this context is the application of Building Information Modeling (BIM) in construction, known as Building Information Modeling (Gal & Jensen, 2008). According to its standard model, BIM is an advanced process concerning the planning, design, construction, operation, and management of facilities using standardized, machine-readable information models that are compatible with both new and existing software. These models contain all relevant information produced or collected about the facility in a format usable by all stakeholders (Smyth, 2005). In another definition, BIM is described as a novel technology and an integrated collection of all processes in construction, including the generation, communication, and analysis of building models (Eastman, 2011). Rafiyan and colleagues, in their study, introduced the advanced capabilities of BIM by collecting data through questionnaires and expert interviews. They examined the growth trends and assessed the maturity level of BIM implementation. Their findings indicated that the primary barriers to BIM adoption in Iran include a shortage of skilled professionals and the high cost of training and implementation (Rafieian & Shafiei, 2014). Manghasarian and colleagues, in a study titled "Investigation and Analysis of Building Information Modeling and the Assessment of Its Non-Implementation in Iran", utilized questionnaires to examine BIM adoption. Their results revealed that technical, financial, human resource, and time-related issues were the main barriers to BIM implementation in Iranian infrastructure projects (Manghasarian & Nekooie, 2016). Najjar et al. investigated Life Cycle Assessment (LCA) methodology from a building perspective and examined the integration of BIM with LCA for evaluating the environmental

impacts of construction materials. Their study emphasized the importance of this integration in supporting better design decisions that are more efficient and cost-effective. They concluded that the most significant environmental impacts occur during the material production and building operation phases (Najjar et al., 2017). Abedini and colleagues focused on establishing a successful project management system and emphasized timely access to information as a key component. This accessibility aids project specialists in making better decisions when needed. The types of information include materials, assembly instructions, warranty services, maintenance details, pricing, and installation procedures. BIM serves as a shared reference among stakeholders—client, designer, and builder—improving coordination, reducing errors and waste, and enhancing quality (Abedini & Shakri, 2013). Soust and colleagues developed a BIM-based life cycle assessment method during the early design stages. They validated their framework by evaluating the environmental impacts of a single-family residence in Uruguay. The proposed method supports decision-making regarding material selection, construction techniques, and transportation distances throughout the building's life cycle. It also aimed to reduce data input volumes and optimize the design process for environmental performance (Soust et al., 2018). Feridonzadeh and colleagues explored cost control in construction projects using the fourth and fifth dimensions of BIM. Their review of previous studies demonstrated that BIM can significantly reduce costs, optimize time management, improve stakeholder relationships, and increase profitability. Specifically, BIM adoption resulted in a 7% reduction in project duration, an 80% decrease in cost estimation time, improved quality, and a return on investment in BIM-related expenses (Feridonzadeh & Shahabi Jou, 2021). Major institutions such as McGraw Hill (U.S.) and NBS (U.K.) regularly publish comparative BIM adoption reports. According to McGraw Hill, BIM adoption increased from 28% in 2007 to 49% in 2009 and reached 71% by 2012 (East, 2007). Mamter et al. examined the root causes of low BIM adoption in Malaysia using a systems dynamics approach. Their causal model analysis showed that increased building productivity requires support from all sectors, including government, private industry, and NGOs (Mamter et al., 2017). Ngowtanasuwan and Hadikusumo conducted a study on BIM adoption in Thailand's engineering and design sector through a case analysis of four companies. They simulated four policy scenarios—status quo, training, hiring new staff, and incentive schemes—over a two-month period. Results indicated that training was the most effective policy for enhancing BIM efficiency and implementation (Ngowtanasuwan &

Hadikusumo, 2017). Hosseini and colleagues identified barriers to BIM adoption in Iran using expert questionnaires. Their findings showed that construction professionals generally lack interest and experience with BIM. Additionally, a lack of governmental support and motivation from policymakers, insufficient awareness and education, unavailability of training materials, resistance to abandoning traditional methods, high implementation costs, poor internet speed, and lack of infrastructure were the main barriers (Hosseini et al., 2016). Doumbouya examined BIM adoption for improving project effectiveness in China. The study aimed to analyze BIM acceptance and understand the benefits across a project's life cycle. Findings indicated BIM improves quality, reduces costs and design errors, and shortens construction duration. Key factors influencing adoption included strong management support, subjective norms, automation, and system compatibility, while technical complexity, scheduling, and financial constraints were the primary challenges (Doumbouya et al., 2016). Bui et al. studied BIM usage among construction workers in Norway involved in structural and terminal installations at Oslo Airport. Workers reported that BIM was easy to use and suitable for complex systems and expressed willingness to use it in future projects (Bui et al., 2016). Mehran evaluated BIM adoption in the United Arab Emirates through surveys of experts. The study revealed that a lack of standards, resistance to change, and insufficient awareness were the main reasons for BIM's limited adoption in the UAE (Mehran, 2016). Manghasarian and Nekooie reiterated in another study that technical, financial, human resource, and time constraints are the main factors preventing BIM realization in Iran's construction projects (Manghasarian & Nekooie, 2016). Finally, Rogers and colleagues investigated the dynamic adoption process of BIM in Malaysia's construction sector. Their results identified lack of trained personnel and insufficient government guidance and support as the most critical barriers to BIM adoption in the country (Rogers et al., 2015). A close examination of the aforementioned studies reveals that Building Information Modeling (BIM) technology has, in recent years, been extensively utilized in developed countries to support the quantitative expansion of construction projects. As a result of this widespread adoption, a notable improvement in the qualitative performance of construction projects has been observed. Given this trend of qualitative growth in developed nations, it raises the question of why BIM—despite its critical importance—has not received the same level of serious attention in Iran, a country with significant geographic size and population, especially when compared to many leading countries in this field. This

paper seeks to address this gap by identifying both the barriers and facilitators of BIM implementation in Iran. As previously mentioned, existing studies often lack a comprehensive analytical framework that simultaneously considers the four dimensions of the SWOT model (Strengths, Weaknesses, Opportunities, and Threats). Therefore, this study aims to fill that gap by applying the SWOT approach to the context of BIM, thereby offering a more holistic analysis of the BIM implementation framework in Iran, in contrast to the more limited scope of prior research.

3. Research Questions

Given that the key evaluation criteria for Building Information Modeling (BIM) technology involve identifying its strengths and weaknesses and clarifying its role within the Iranian context, the following research questions are proposed:

- How can a meaningful connection be found between BIM performance and environmental process improvement?
- How can a SWOT framework be used to turn weaknesses into strengths and threats into opportunities?

4. Research Hypotheses

Based on the aforementioned research questions and considering the total population of Iran and the scale of construction activities across the country, the following hypothesis is formulated:

By accurately identifying the strengths, weaknesses, opportunities, and threats (SWOT) of the construction industry in Iran and developing integrated strategies based on these elements, it is possible to enhance environmental conditions through the implementation and advancement of Building Information Modeling (BIM) technology.

5. Research Methodology

The methodology employed in this study is of a descriptive-analytical nature, with a primary focus on the SWOT matrix technique. SWOT analysis is commonly used in strategic management and serves as a diagnostic tool frequently applied at the initial stages of strategic planning. It is a simple yet powerful method for assessing an organization's resource capabilities and deficiencies, market opportunities, and external threats to its future development (Thompson et al., 2007). SWOT is an acronym that represents the organization's internal and external environmental characteristics. The analysis consists of two dimensions: internal and external. The

namely strengths and weaknesses, while the external dimension pertains to environmental factors, such as opportunities and threats (Gurel & Tat, 2017). SWOT analysis enables the identification of internal strengths and weaknesses to leverage the opportunities available in the external environment. Strengths and weaknesses are derived from internal organizational conditions, whereas opportunities and threats stem from the external environment. These two dimensions give rise to four categories of factors:

1. External Positives (Opportunities): Developments within the external environment that can be leveraged
2. Internal Positives (Strengths): Organizational capabilities that provide a competitive edge
3. External Negatives (Threats): Environmental risks that may hinder progress
4. Internal Negatives (Weaknesses): Internal limitations that may impair performance

6. Literature Review

Building Information Modeling (BIM)

BIM, an acronym for Building Information Modeling, refers to a model that incorporates all construction-related data within a unified digital environment. It serves as a platform through which all activities occurring throughout a structure's life cycle can be interconnected and effectively managed. These activities include conceptual design, architectural design, structural analysis and design, construction documentation, and building operations (East, 2007). A Building Information Model is an integration of software models combined with various engineering indicators, merged into a coherent system. Although there is no universally agreed-upon or rigid definition of BIM, it has been interpreted in multiple ways. In this study, BIM is defined according to the U.S. National BIM Standard as a digital representation of the physical and functional characteristics of a building. It serves as a shared knowledge resource for building information, providing a reliable basis for decision-making throughout the project's life cycle—from initial planning to demolition (East, 2007). What must be emphasized is that compared to traditional construction workflows, BIM not only changes the method of presenting geometric data (e.g., 3D visualizations) and integrating essential information, but also requires a shift in the mindset and approach of participants in the construction process. For example, cost analysis, when leveraging BIM, benefits from rapid data extraction, allowing for advanced development of predictive cost models using accurate and timely inputs (Juszczak et al., 2019).

Table 1. Summary of research background

Tools	Purpose	Title	Year	The Author
Questionnaire and expert survey	The Growing Trend of This Technology: Assessing the Maturity Level of Building Information Modeling (BIM)	Advanced Capabilities of BIM Technology	2014	Rafeian
Questionnaire	Reasons for the Underachievement of Building Information Modeling (BIM) in Iranian Construction Projects	A Scientific Review and Analysis of Building Information Modeling (BIM) and the Assessment of Its Underachievement in Iran	2016	Mangasarian and Partners
Questionnaire	Providing a Common Reference Framework Among the Client, Designer, and Contractor	Developing a Successful Project Management System	2014	Abedini and Partners
Review of the theoretical foundations and causal diagram	An Investigation into the Key Underlying Factors Contributing to the Decline in Technology Adoption	The Scientific Roots of the Low Adoption of Building Information Modeling (BIM) in Malaysia	2017	Memter and AbdolAziz
Review of the theoretical foundations and descriptive analysis	Analysis and Evaluation of Successful Case Studies Implemented Using the BIM System	Cost Control of Construction Projects Using the Fourth and Fifth Dimensions of BIM	2021	Feridonzadeh and Partners
Review of the theoretical foundations and system dynamics	Definition, Comparison, and Analysis of Technology Adoption Policies	System Dynamics for BIM Adoption in Thailand	2017	Negotanasomoan and Hadikusomoa
Survey with questionnaire and analysis	Identification of Barriers to the Adoption of Building Information Modeling (BIM)	A Preliminary Assessment of the Current Status of Building Information Modeling (BIM) in Iran	2016	Hosseini and Partners
Survey with questionnaire and analysis	An Analysis for a Better Understanding of the Benefits of Technology Throughout the Project Lifecycle	Adoption of Building Information Modeling (BIM) for Enhancing the Effectiveness of Construction Projects in China	2016	Doumbouya and partners
Interview, survey, and analysis	Evaluation of the Effectiveness of Building Information Modeling (BIM) in Construction Projects	The Status of Building Information Modeling (BIM) Adoption Among Norwegian Construction Workers	2016	Bui and Partners
Survey and analysis	Identification of Barriers to the Adoption of Building Information Modeling (BIM)	The Status of Building Information Modeling (BIM) Adoption in the United Arab Emirates	2016	Mehran
Questionnaire and comparison of key criteria	Investigation and Evaluation of the Barriers to Building Information Modeling (BIM) in Iran	An Examination and Analysis of Construction Information Modeling and the Assessment of Its Lack of Implementation in Iran	2016	Mangasarian and Nekoei
Evaluation	Assisting in Decision-Making, Data Reduction, and Design Optimization for Environmental Impact Assessment	Environmental Impact Assessment for a Single-Family Residential Building in Uruguay	2018	Soust and Partners
Questionnaire, interview, and analysis	Removing Barriers and Creating Incentives for the Adoption of This Technology in Malaysia	An Investigation into the Evolution of Building Information Modeling (BIM) Technology in the Construction Sector	2015	Rogers and Partners
Evaluation	Supporting Decision-Making for Improved Design Standards	An Analysis of the Evolution of Building Information Modeling (BIM) Technology in the Construction Sector	2017	Najar and Partners

Table 2. Comparison of BIM and CAD Software Capabilities

CAD System	BIM Technology
There is no linkage between the models, and any changes need to be manually corrected	Parametric design and automatic model modification capability
Two-dimensional view, without visualization of the third and fourth dimensions...	3D, 4D, 5D, ... , ND
A CAD model is merely recognized as a model or object and lacks any embedded information	The BIM model has a realistic structural and engineering representation and provides capabilities such as quantity takeoff, cost estimation, energy analysis, and more
To describe the properties or information contained in a drawing, manual annotation is required	The properties of existing elements are easily embedded within the drawing and can be viewed with a single click
Documentation should be generated separately	The BIM model is an automated and shared data source
Interferences are detected during the construction stage	During the design phase, clashes are resolved using software

Table 3. Weighting of the four indicators: strengths and weaknesses, opportunities and threats of BIM technology implementation in Iranian construction projects; (Interviews with university professors)

Strengths (S)	Indicator weight	Weaknesses (W)	Indicator weight
Improvement of energy efficiency	5	Insufficient progress in waste management practices"	2
Reduction of infrastructure project costs	5	Limited awareness of the environmental advantages of Building Information Modeling (BIM)	5
Environmental impacts on the building life cycle	3	Resistance to the transition from traditional construction methods	4
Automation of drawing execution Possibility to evaluate different alternatives	4	High implementation costs of BIM in a company Lack of employee training in BIM technology	1
Total	17	Total	12
Opportunities (O)	Indicator weight	Threats (T)	Indicator weight
The BIM digital model can be effective in renovation, restoration, and damage assessment	4	Insufficient institutional support from governmental and private sectors for advancing the adoption of BIM	5
Environmental impacts in supporting architectural design standards	3	Shortage of skilled and specialized personnel in the BIM industry	5
Reduction of waste and rework	5	Increase in construction waste in the natural environment	3
Planning for recycling	2	Absence of legal frameworks and regulations governing the use of BIM in construction projects	-
Total	14	Total	13

Source: Authors, 2025

Moreover, each stakeholder in a construction project gains access to relevant data and actively contributes throughout the construction cycle. As a result, cost data can be continually adjusted, verified, or updated—for instance, enabling real-time modifications and validations of sample cost analyses. Another notable advantage of BIM

is the ability to examine both geometry and embedded data, which significantly facilitates the detection and resolution of potential clashes. This allows for the discussion and implementation of alternative solutions and the elimination of design errors before the construction phase begins—an essential benefit of BIM

technology (Nawari & Ravindram, 2019). The Architecture, Engineering, and Construction (AEC) industry is at the forefront of BIM-driven digital transformation, addressing critical issues such as speed, cybersecurity, and the integrity of data exchange. In light of the points mentioned regarding BIM and its application in construction, a comparative overview of BIM and traditional CAD systems is summarized in 2 methods.

It can be concluded that over the past decade, research in the field of Building Information Modeling (BIM) has continuously advanced, fundamentally transforming traditional operational practices within the AEC (Architecture, Engineering, and Construction) industry. This ongoing development has increasingly captured the attention of researchers worldwide.

7. BIM Technology Analysis Using the SWOT Matrix in Iran

The subsequent steps of the SWOT analysis, as described in the Research Methodology section, are presented below. This analysis evaluates the strategic use of BIM in Iran's construction industry. Table 4 presents the strengths, weaknesses, opportunities, and threats associated with the implementation of BIM technology in Iranian construction projects. The table also includes a numerical weighting scale for each indicator within the SWOT matrix, ranging from 1 to 5, where a score of 1 indicates a very weak impact and a score of 5 indicates a very strong impact. This assessment was conducted subjectively by the authors, based on market data, industry reports, their own professional experience, and consultations with university professors actively engaged in construction-related fields who possess comprehensive knowledge of the current shortcomings in this domain. SWOT Matrix Elements: Strengths and Opportunities, the components of the SWOT matrix qualified for each category are summarized below.

8. Strengths and Opportunities

According to the contents of Table 3, the key elements that position the BIM system as a superior solution in mitigating negative environmental impacts are the strengths outlined in the same table.

Environmental Impacts of BIM

Building Information Modeling (BIM) enables precise simulation of a structure prior to the commencement of construction. This allows for the early detection and resolution of design conflicts, thereby reducing costly

rework and construction waste. Through accurate 3D visualization of the project, detailed evaluation and analysis of architectural and engineering plans become possible, minimizing human errors and optimizing material usage. Consequently, with reduced construction waste, the demand for new material production decreases, leading to lower greenhouse gas emissions (Salgin et al., 2017). BIM facilitates energy performance analysis during the design phase of buildings. Utilizing these analyses, energy efficiency can be optimized and consumption reduced. BIM enables early-stage energy modeling, empowering architects and engineers to assess how materials, systems, and building orientation affect energy use (Salgin et al., 2017).

BIM supports the design of sustainable and environmentally responsible buildings. Through this model, the incorporation of sustainable materials and renewable energy systems becomes feasible (Wong & Fan, 2013). This study further shows that integrating BIM with Life Cycle Assessment (LCA) offers multiple advantages for enhancing sustainability and minimizing environmental impacts in the construction industry. These include improved building design and construction processes, optimized material usage, and more informed decision-making for carbon reduction. The review identified several common BIM and LCA tools, explored a range of BIM-LCA integration applications, and presented various case studies illustrating their benefits. However, it also recognized several limitations in BIM-LCA integration, including technical challenges, the need for more real-world projects, best practices for integration, and barriers to adoption in Thailand's construction sector (Samnang et al., 2017). BIM enables effective life cycle management of buildings, assisting in evaluating environmental impacts across the building's lifespan and supporting informed decisions for mitigating those impacts. Additionally, BIM facilitates planning for the recycling of construction materials during the demolition phase. Through this model, recyclable materials can be identified and separated accordingly (Schamne et al., 2024). By minimizing errors and reducing the need for rework, BIM significantly lowers the volume of construction debris. Furthermore, BIM enhances communication and coordination among various project teams, contributing to reduced errors, fewer revisions, and consequently, a lower environmental footprint.

9. Weaknesses and Threats

One of the major challenges preventing the full implementation of Building Information Modeling (BIM)

in Iran is the construction industry's heavy reliance on individuals.

Project owners—who provide the financial capital—are often unwilling to abandon traditional systems, which appear less costly compared to BIM. Another significant weakness in the Iranian context is the lack of familiarity among experienced engineers with BIM technology, which represents a serious barrier that must be addressed through training programs provided by governmental agencies or public institutions. Most architecture and construction firms in Iran continue to rely on two-dimensional CAD systems, which require less powerful hardware. However, implementing BIM in engineering and technical offices necessitates upgrading to more advanced systems and hardware. Considering current market conditions and the high cost of such equipment, this requirement itself poses a substantial obstacle. Moreover, due to insufficient knowledge regarding the full implementation of BIM, and the resulting shortage of skilled personnel, the number of BIM service providers remains limited—leading to higher service costs. Another critical weakness, as identified by the authors, is the lack of copyright enforcement in Iran. While users in many countries are expected to pay for licensed BIM software, in Iran such software is often used without cost. This widespread access to free software may disincentives professionals from pursuing proprietary or specialized BIM tools (Authors, 2025).

10. Discussion

At this stage of the research, the traditional approach is compared with the Building Information Modeling (BIM) approach for project delivery, which is increasingly being adopted in the construction industry. The implementation of the BIM process for building design begins with the creation of coordinated and reliable information for project design. This information is represented within an intelligent three-dimensional model of the building, in which design components are dynamically interconnected and enriched with comprehensive data. Through this method, BIM facilitates the evaluation of a greater number of design alternatives. As part of the design process, engineers can utilize the building information model to perform simulations and analyses that support the optimization of the design in terms of constructability, sustainability, and building safety. Furthermore, the BIM process enables the direct generation of deliverables from the building information model. These deliverables are not limited to two-dimensional construction drawings; they include the model itself and all the valuable embedded data, which can be used for quantity take-off,

material and labor estimates, construction sequencing, drawing comparisons, and even building operation and maintenance. What, then, differentiates the BIM approach? Modeling, 3D visualization, and model analysis are not entirely new concepts in building design. The distinction lies in the integration: in traditional approaches, design, analysis, and construction documentation are treated as separate processes, often leading to inefficiencies and high costs when exploring alternative design scenarios. As illustrated in [Figure 1](#) below, BIM fosters effective integration between the stages of design, analysis, and documentation. Consequently, a larger portion of the design effort is shifted to the earlier phase of the project life cycle—detailed design—where the potential to influence project execution is greater, and the cost of implementing design changes is significantly lower. Under these conditions, engineers can allocate more time to exploring optimized design scenarios and less time on the preparation of construction drawings.

According to [Table 3](#), the total scores for each of the four elements of the SWOT matrix are presented. It is essential to mention the following formula:

$$S = \sum_{i=1}^4 S = 17 > W = \sum_{i=1}^4 W = 12 \quad (1)$$

$$O = \sum_{k=1}^4 O = 14 > T = \sum_{l=1}^4 T = 13 \quad (2)$$

This indicates a strategic position in which the superiority of strengths over weaknesses and opportunities over threats grants BIM a competitive advantage in the market. The strategic course of action regarding BIM technology in Iran's construction industry should therefore focus on maintaining its current advantageous position. Moreover, by utilizing the data from [Table 3](#) for the SWOT analysis, the effectiveness of the BIM technology's external environment (AS environment) can be assessed.

This is a function of opportunities and threats and is calculated using the following formula:

$$AS = \frac{O}{O + T} + \frac{14}{14 + 13} = 0.519$$

The market position of BIM technology can also be determined using the following two formulas: the first relates to internal strength (SP), and the second pertains to the probability of strategic success (PSS):

$$SP = \frac{S}{S+W} + \frac{17}{17+12} = 0.586$$

$$PSS = \frac{SP+AS}{2} + \frac{0.586+0.519}{2} = 0.552$$

$$PSS = 0.552$$

Given that the implementation level of the Building Information Modeling (BIM) process is considered as a single value ranging from 0 to 1, and the Probability of Strategic Success (PSS) has been calculated as PSS = 0.552 based on the aforementioned formula. It can be concluded that the adoption of BIM is currently in a moderate position, with potential for further advancement. However, it should be noted that this progress is not without challenges.

11. Findings and Conclusion

The aforementioned analysis, based on the components of strengths and weaknesses of BIM technology implementation in Iran, as well as the opportunities and threats arising from the external environment, expresses a specific framework for a particular problem. In order to address and explore solutions further, the use of the SWOT matrix and its corresponding strategies is recommended. The matching technique may involve exploratory methods such as brainstorming, or the use of direct or symbolic analogies. The combination of strengths and weaknesses with opportunities and threats, aimed at maximizing the potential of the BIM approach, is presented in Table 5. The strategic options are categorized using the labels of aggressive (strength–opportunity match), competitive (strength–threat match), defensive (weakness–threat match), and conservative (weakness–opportunity match) strategies. However, it must be emphasized that matrices themselves do not generate strategies. The output of the SWOT matrix is limited to a set of strategic options, which can be considered as inputs for the formulation and selection of final strategies. The arrangement of strategies based on alignments or oppositions among opportunities, threats, weaknesses, and strengths, as demonstrated in Table 5, results in the identification of matrix-based strategies. This matrix incorporates data from both internal and external environmental analyses and enhances their interpretability. Table 5 illustrates a matrix of strategic tasks and activities, where the combination of internal and external components may facilitate the positioning of BIM technology in Iran. Applying exploratory methods to interpret the data derived from this table contributes to

strengthening the proposed strategic actions being undertaken in the country. For instance, combinations such as S1 with O3, S2 with O1, and W2 with O4 serve as proposals for implementing strategic actions, including the following:

Conservative Strategy (W4–O2: Weakness–Opportunity match):

The high cost of BIM implementation in engineering firms is linked with the environmental benefits of contributing to architectural design standards, suggesting that greater attention be paid to sustainability in future designs.

Defensive Strategy (W2–T3: Weakness–Threat match):

The lack of improvement in waste management correlates with the increasing volume of construction debris in the environment. Similarly (W1–T1: Resistance to changing traditional construction methods): combined with insufficient support from public and private organizations for promoting BIM indicates a critical barrier to adoption.

Aggressive Strategy (S3–O2: Strength–Opportunity match):

The implementation of BIM in Iran can reduce material waste, enhance project quality, and automate drawing production, thereby motivating students in the construction field.

Competitive Strategy (S2–T3: Strength–Threat match):

The reduction of construction costs through BIM technology can incentivize contractors and stakeholders to adopt the system more widely. It appears that the most suitable strategic approach for the implementation of BIM is an aggressive development strategy, typically recommended for high-potential contexts. This strategy aims to maximize the utilization of strengths and opportunities to simplify BIM adoption in day-to-day construction practices. When the external environment provides the necessary conditions, the strengths of BIM should be fully leveraged. The SWOT analysis indicates that BIM implementation currently holds a favorable position in the Iranian market, due to the predominance of strengths over weaknesses and opportunities over threats. Nonetheless, it is challenging to rely on the rapid dynamics of change in BIM execution across Iran. A closer analysis of the contents of Table 5 suggests that by focusing on the combined results of the four core SWOT components (strengths, weaknesses, opportunities, and threats), It is possible to overcome negative elements by harnessing the latent potential of strengths and opportunities.

Accordingly, it can be concluded that enhancing the position of BIM technology in Iran requires the fulfillment of the following critical components:

Need for skilled and specialized personnel in BIM technology, the need for adequate hardware and infrastructure, Governmental support and the establishment of national-level implementation regulations. With the realization of these prerequisites, it is likely that, in the near future, the Iranian construction sector will witness improvements in construction quality, cost reductions, and the prevention of rework—issues that have historically caused considerable and often irreparable damage in the industry. Additionally, the introduction of specialized academic programs in BIM within universities will, over time, help bridge the existing skills gap among professionals, enabling a greater number of personnel to competently utilize various BIM applications. Contribution of the Study - Compared to the findings of prior research referenced in this study, which primarily focused on the technical details of BIM and potential challenges in various countries, the contribution of this article lies in providing a comprehensive overview

of the BIM process and clarifying its strategic position in Iran. This was achieved through the use of the SWOT matrix (as illustrated in the corresponding table). A closer examination of the research hypothesis—which posits that accurate identification of strengths, weaknesses, opportunities, and threats (as outlined in Table 4), along with the development of four strategic orientations: conservative, defensive, aggressive, and competitive—confirms the validity of the hypothesis. The alignment of the four strategic categories with the four SWOT dimensions demonstrated that it is possible to leverage strengths and opportunities to overcome the gaps created by weaknesses and threats. This outcome contributes to the development of a growth cycle for advanced technologies in Iran’s construction industry. Iran, as one of the most populous countries in the region, simultaneously faces a pressing need for reconstruction and modernization in its building sector. Furthermore, the findings of this study suggest that the SWOT matrix model applied to BIM technology can also be extended to assess and implement other technologies within the national industrial framework.

Table 4. Comparison of BIM and CAD from an Environmental Perspective

CAD	BIM	Feature
Inability to accurately simulate More human errors	Accurate simulation and clash detection	Waste Reduction
Inability to perform energy analysis Traditional design	Precise material management Building energy analysis	Energy Efficiency
Higher energy consumption and waste	Sustainable design Reduced energy consumption and waste	Greenhouse Gas Emissions
Inability to plan for recycling More construction debris	Planning for recycling Reduction of construction debris	Waste Management

Source: Authors; 2025

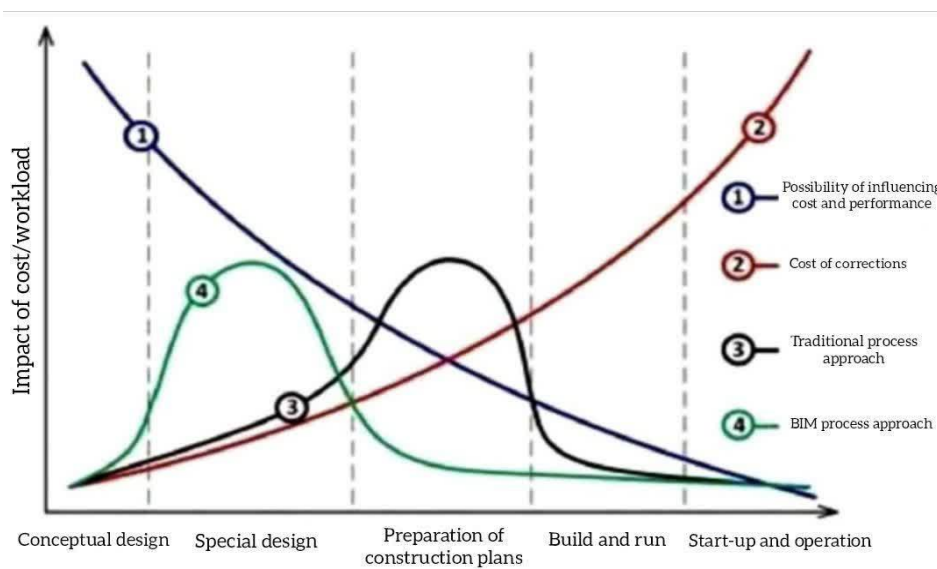


Figure 1. Preparation, processing and packaging of vermicompost prepared using *Parthenium hysterophorus* and cattle dung at Bihar Agricultural University, Sabour, Bhagalpur, India

Table 5. Strategic Tasks and Activities Matrix

	Strengths (S)	Weaknesses (W)
	1. Delivering high-quality projects 3w2. Improving energy efficiency 3. Environmental impacts on the building life cycle 4. Automation of drawing generation	1. Resistance to changing traditional construction methods 2. Lack of improvement in waste management 3. Lack of awareness regarding the environmental benefits of BIM 4. High implementation cost of BIM technology in engineering firms
Opportunities (O)		
1. High interest from construction industry experts in using BIM	S2 with O1: The environmental impacts supporting architectural design standards align with the strong interest of industry experts in adopting BIM	W1 with O1: Resistance to changing traditional construction methods contrasts with the growing interest of industry experts in BIM
2. Environmental impacts supporting architectural design standards	S3 with W1: Lack of awareness regarding the environmental benefits of BIM is related to resistance against changing traditional methods	W4 with O2: The high cost of BIM implementation in engineering firms is relevant to the environmental benefits in architectural standardization
3. Reduction of waste and rework	S1 with O3: Delivering high-quality projects can contribute to reducing construction waste in the environment	-
4. Planning for recycling	S4 with O4: Automation of drawings can support precise planning for the recycling phase	W2 with O4: Accurate recycling planning can help resolve the issue of unprocessed construction waste
Threats (T)		
1. Insufficient support from governmental and private organizations for promoting BIM	S1 with W3: Developing high-quality, standardized projects can help reduce the use of environmentally harmful materials	W1 with T1: Resistance to changing traditional methods is related to the lack of sufficient institutional support for BIM promotion
2. Shortage of skilled and experienced workforce in BIM	S4 with T2: Automated drawing generation requires users proficient in BIM systems	W4 with T2: Due to the high implementation cost and lack of skilled personnel, BIM adoption remains limited
3. Increase in construction debris in the environment	S2: Improving energy efficiency can help reduce waste and encourage clients to adopt BIM	W2 with T3: Inefficient waste management is directly linked to the increase in construction debris in nature

Source: Authors, 2025

Authors Contribution

All authors have contributed equally to prepare the paper.

Availability of data and materials

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

Conflict of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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