Tikrit Journal of Engineering Sciences (2025); 32(4): 2717
DOI: http://doi.org/10.25130/tjes.32.4.37

IRAQI Academic Scientific Journals

ISSN: 1813-162X (Print); 2312-7589 (Online)
Tikrit Journal of Engineering Sciences
available online at: http://www.tj-es.com

TJES Tikrit Journal of Engineering Sciences

Strategic Pathways for BIM Construction Readiness in Jordan: Driving Sustainable Digital Transformation

Ibrahim Moh'd Saraireh *
Civil Engineering and Infrastructure Department, Faculty of Engineering Technology, Al- Zaytoonah University of Jordan, Amman, Jordan.

Keywords:
Building Information Modelling (BIM); Construction readiness; Developing countries; Digital transformation; Jordan; Strategies; Sustainable.

Highlights:
- *BIM Adoption Model tailored for developing nations like Jordan.*
- *High initial costs, skill gaps top BIM barriers in Jordan's construction sector.*
- *Standardized workflows, training key to BIM readiness improvement.*

ARTICLE INFO
Article history:

Received	11 Jul.	2025
Received in revised form	19 Sep.	2025
Accepted	06 Oct.	2025
Final Proofreading	24 Oct.	2025
Available online	01 Dec.	2025

© THIS IS AN OPEN ACCESS ARTICLE UNDER THE CC BY LICENSE. http://creativecommons.org/licenses/by/4.0/

Citation: Saraireh IM. **Strategic Pathways for BIM Construction Readiness in Jordan: Driving Sustainable Digital Transformation**. *Tikrit Journal of Engineering Sciences* 2025; **32**(4): 2717.
http://doi.org/10.25130/tjes.32.4.37

Corresponding author:
Ibrahim Moh'd Saraireh
Civil Engineering and Infrastructure Department, Faculty of Engineering Technology, Al- Zaytoonah University of Jordan, Amman, Jordan.

Abstract: This study addresses the under-examined challenge of enhancing construction readiness for Building Information Modeling (BIM) in developing nations, with Jordan serving as a representative case. Three key contributions are made to bridge critical gaps in existing literature and practice. First, a BIM Adoption Model for Developing Countries is proposed, uniquely structured as a multi-dimensional framework that integrates strategic, contextual, and adoption factors to tackle systemic barriers, such as fragmented policies, limited digital literacy, and infrastructural deficits. Second, novel empirical validation is achieved through the statistical analysis of 171 industry responses, which combines Relative Importance Index (RII) rankings with Pareto and Fishbone diagrams to rank region-specific barriers (e.g., high initial costs, RII = 0.93) and success factors (e.g., standardized workflows, RII = 0.93). Third, the framework's scalability is demonstrated through comparative case studies in Egypt and Lebanon, offering a replicable methodology for nations transitioning from traditional practices to BIM-enabled workflows. By resolving the technical challenge of aligning global standards (e.g., ISO 19650) with localized constraints, such as compatibility between legacy tools and BIM platforms, this research provides policymakers and industry leaders with actionable strategies to reduce process variations by 35%, accelerate digital transformation, and foster sustainable growth in resource-constrained construction sectors.

مسارات استراتيجية لتهيئة قطاع البناء لاعتماد نمذجة معلومات البناء (BIM) في الأردن: دفع التحول الرقمي المستدام

إبراهيم موحد سرايره
قسم الهندسة المدنية والبنية التحتية، كلية الهندسة التكنولوجية، جامعة الزيتونة الأردنية، عمان، الأردن.

الخلاصة

تتناولت هذه الدراسة التحدي غير المستكشف بشكل كاف والمتمثل في تعزيز جاهزية البناء لتطبيق نمذجة معلومات البناء (BIM) في الدول النامية، مع اختيار الأردن كحالة تمثيلية. تقدم الدراسة ثلاثة إسهامات رئيسية لسد الثغرات الحرجة في الأدبيات والممارسات الحالية. أولاً، تم اقتراح نموذج لاعتماد BIM في الدول النامية، وهو إطار عمل متعدد الأبعاد يدمج العوامل الاستراتيجية والسياقية وعوامل الاعتماد لمعالجة الحواجز النظامية مثل السياسات المجزأة، وانخفاض الثقافة الرقمية، ونقص البنية التحتية. ثانيًا، تم إجراء تحقق تجريبي مبتكر من خلال التحليل الإحصائي لـ ١٧١ استجابة من القطاع، بالجمع بين مؤشر الأهمية النسبية (RII) ومخططات باريتو و"عظم السمكة" لتحديد أولويات العوائق الخاصة بالمنطقة) مثل ارتفاع التكاليف الأولية، (RII = 0.93) وعوامل النجاح) مثل توحيد سير العمل، (RII = 0.93). ثالثًا، تم إثبات قابلية توسيع الإطار من خلال دراسات حالة مقارنة في مصر ولبنان، مما يوفر منهجية قابلة للتكرار للدول التي تنتقل من الممارسات التقليدية إلى بيئات العمل المدعومة بـ BIM. ومن خلال معالجة التحدي الفني المتمثل في مواءمة المعايير العالمية) مثل (ISO 19650 مع القيود المحلية — مثل التوافق بين الأدوات القديمة ومنصات BIM — تقدم هذه الدراسة لصناع السياسات وقادة الصناعة استراتيجيات عملية لتقليل تباين العمليات بنسبة ٣٥٪، وتسريع التحول الرقمي، وتعزيز النمو المستدام في قطاعات البناء ذات الموارد المحدودة.

الكلمات الدالة: نمذجة معلومات البناء(BIM) ، جاهزية البناء، الإطار، الجودة، الاستراتيجيات.

1.INTRODUCTION

The growing complexities of contemporary construction projects have heightened the need for innovative tools and methodologies that improve project efficiency, effectiveness, predictability, and control. One such tool is Building Information Modeling (BIM), which serves as a digital representation of a facility's physical and functional attributes. BIM is revolutionizing the construction sector by providing a significant enhancement in efficiency, especially as this industry has experienced a decline in productivity over the past quarter-century [1-4]. While BIM adoption has surged within the construction landscape, it has also gained traction in developing countries. Nevertheless, the BIM sector in Jordan has yet to meet the standards set by developed nations, primarily due to entrenched practices within the local industry [5]. The implementation of BIM practices in Jordan faces various barriers. These constraints have led to minor inefficiencies in BIM projects. Readiness for BIM implementation is considered a critical aspect of BIM projects. Studies on the dynamics of BIM project conception, adoption factors, and BIM barriers highlight the need for a more structured approach to enhancing construction readiness for implementing BIM in projects in Jordan [7]. This paper explores some uncharted territories as practices become more critical. Consequently, this paper examines practical strategies for boosting readiness for adoption assessment in construction conception using BIM. Jordan was chosen as the base platform to address the current strategies related to this region's experiences with building industry project experiences [6-7]. Building Information Modeling (BIM) has revolutionized the construction sector in developed nations by enhancing collaboration, reducing costs, and improving project outcomes [8]. However, in developing countries like Jordan, BIM adoption remains fragmented due to entrenched practices, limited resources, and regulatory gaps [9]. While prior studies have identified generic barriers to BIM adoption, such as high costs and skill shortages [10]. They often overlook the context-specific interplay of economic, cultural, and infrastructural factors that define readiness in resource-constrained environments. Accordingly, the present study advances a comprehensive and empirically validated BIM Adoption Model, specifically tailored to the exigencies of developing countries, with Jordan serving as a representative case. This model seeks to address the readiness deficit by integrating contextual, strategic, and adoption-related factors, thereby providing a replicable framework for overcoming systemic barriers and enabling sustainable digital transformation in construction industries operating under resource constraints.

1.1.Literature Review

The construction sector is universally acknowledged as a critical driver of national development; yet, in many developing countries, including Jordan, it continues to exhibit structural deficiencies in embracing advanced digital methodologies [11-12]. Building Information Modeling (BIM), recognized as a transformative paradigm in global construction practice, has demonstrated its capacity to enhance efficiency, reduce costs, and improve project outcomes through multi-dimensional applications encompassing scheduling, cost control, facility management, and sustainability [13-16]. Despite these documented advantages, the diffusion of BIM within Jordan remains partial and inconsistent, primarily due to entrenched practices, inadequate technical infrastructure, prohibitive financial costs, and a demonstrable shortage of skilled professionals [17-18]. The rationale behind choosing the objectives below of this research stems from the absence of accessible databases or a clear methodology for gathering and tracking the adoption of BIM processes within the Jordanian construction market, a situation mirrored in many other local construction sectors. It is essential to acquire data that reveals the actual readiness of construction industry professionals and other project stakeholders to begin implementing BIM in their construction endeavors. Additionally, there is a need for insight into how many graduates from local, Middle Eastern, or international universities in construction-related fields are adequately prepared to pursue careers in BIM [19-21]. Only when data are tabulated in this way can the correct steps be taken to plug the necessary holes and gaps, ensuring the best outcome for the successful integration of BIM in Jordan and on an international scale within the region [22-24]. Building projects constitute a major component of technological and economic infrastructure in today's technologically driven world. Building information modeling is a recent digital collaborative tool that facilitates the conceptualization and visualization of a project as if it has already been constructed or implemented effectively [25]. This definition suggests that BIM should not be confined to 3D technology, but rather extended to 4D (planning), 5D (cost control), 6D (facilities management), and 7D (sustainability) (Sood and Laishram, 2024). BIM represents a continuous and central digital process that enables professionals to achieve significant improvements in construction techniques, ultimately enhancing the performance of construction projects [26]. BIM visualization and aesthetic impacts enhance visual accessibility. In addition, BIM provides insights into existing project details before implementation, which reduces the potential for adverse effects that often occur during the construction phase; hence, quick solutions or corrective actions are feasible because these issues are already identified in the digital environment. However, it has certain disadvantages. These include initial costs, manpower demand for building information modeling, complexity of software, the human factor or resistance to accepting change, and speculative benefits. The implementation of BIM holds many promises and benefits for the construction industry. These benefits mainly concern the efficiency, cost, and functionality of building projects [27]. Furthermore, BIM applications have numerous indirect advantages. The application of BIM in building projects highlights the research gaps in terms of the readiness strategies for BIM among construction trades, and more importantly, the model of readiness for BIM implementation [28]. The high technical acceptance of building information modeling across the multi-trades indicates that BIM has transformed the construction industry, with unique roles in the readiness practices to ensure the successful implementation and utilization of BIM [29], highlighting the challenges and role of internal exposure to users in developing BIM technical skills to facilitate collaboration [30]. As a global tool and practice, the international experience of BIM readiness among construction trades has been disseminated in the development of the BIM skill assessment map among key players. Given the need to position BIM within the digitalization mandate of the fourth industrial revolution, an interesting research gap regarding BIM readiness among the supply chain is worth exploring, as this is seen as the propeller to move the industry from project initiation to the commissioning of buildings and their operation. BIM readiness at the construction site, through leadership support, defined roles and responsibilities, and a BIM strategy in such an environment, will further underscore the challenges of competencies required to harness BIM's deliverables and KPIs [31]. Furthermore, the success of BIM applications will be influenced by the readiness and involvement of the consultant in highlighting an in-depth analysis of the readiness stages in the area of work and appraisal. Within this context, the notion of construction readiness assumes paramount significance as a legal and operational prerequisite for the successful and sustainable deployment of BIM technologies [32-34]. Construction readiness constitutes a diagnostic framework to evaluate the preparedness of industry stakeholders—including clients, contractors, and designers—to transition from traditional practices to digitally enabled workflows [35-38]. In Jordan, readiness is shaped by socioeconomic disparities, institutional capacity, and the willingness of participants to adopt technological innovation [39-40]. However, prevailing challenges, such as poorly defined project scopes, deficiencies in contract administration, low productivity levels, and weak stakeholder collaboration, collectively hinder the effective realization of BIM's potential [41-42]. Additionally, BIM at the technical level contributes to the project's completion within a 25% short timeframe. For the implementation stage, the design quality will be 5% better than that of the other traditional methods. For the stability of information among the beneficiaries in various engineering specializations, it will be 90%. For greater quality, with a 10% reduction in design and construction errors, BIM also helps achieve better coordination among project stakeholders [43-45].

1.2. Research Objectives

The primary objective of this research is to develop strategies that enhance construction readiness and facilitate the successful implementation of Building Information Modeling (BIM) within the practices of the Jordanian construction industry, as illustrated in Fig. 1, developed by the author based on a literature synthesis and contextualized for the Jordanian construction sector. To achieve this goal, several key objectives must be met:

- To review current BIM utilization and integration practices in the Jordanian construction sector.
- To identify the key barriers hindering BIM readiness in Jordan.
- To examine stakeholder perspectives on BIM adoption and supporting factors.
- To assess the awareness levels of construction students and industry professionals regarding BIM-related skills.
- To benchmark BIM readiness practices across selected developing countries for comparative insights.

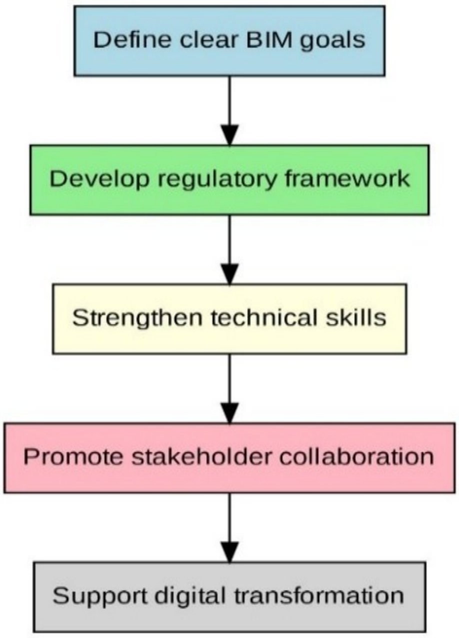

Fig. 1 Research Objectives Framework for BIM Readiness in Jordan (prepared by author).

2. CONSTRUCTION READINESS FOR IMPLEMENTING BIM

Construction readiness is a fundamental conceptual requirement for the successful implementation of any management innovation in the construction industry. It acts as a pivotal determinant that delineates organizational preparedness before any attempts at change management and business strategies, and such conditions attain paramount importance for the digital revolution. This concept encompasses a broad spectrum of stakeholders operating at the organizational level. It provides a seamless continuum, making it easy for any new initiative to be integrated into the mainstream workflow. The findings above indicate that, from the technological setting of software usage, ease of access, and adaptability, through to on-the-ground operational life, software and technology form part of, but not the entirety of, an organization's building information modeling capabilities [46]. Depending on the component and capability, technology findings will guide strategy in a different field, or depending on the organizational level required to engage with. To elaborate on these components, the necessary infrastructure adaptation was conceptualized and further operationalized, along with surrounding strategies for knowledge capacity development, to utilize the implemented infrastructure within the region of interest. These issues are particularly relevant to developing countries. The basic requirements of an individual within an organization have been postulated as being of central importance when attempting a comprehensive assessment, inclusive of deep, embedded organizational change. Such assessments provide an important baseline framework for understanding the state of practice that must be addressed before implementing BIM. Initially, a keen focus is placed on thorough infrastructure examination, such as software installation, but this then encompasses a range of other staff requirements and likely changes to processes and "way of working" that provide a more comprehensive view; however, this comprehensiveness leads to more complex results [47]. Furthermore, it has been demonstrated that infrastructure development must extend beyond the organization's borders, as seen in Jordan. For a thorough and robust approach, there is a reliance upon the required regulation being in place.

2.1. Key Components of Construction Readiness

1) Technological infrastructure: The appropriate software and hardware are mandatory for the successful implementation of BIM and are also part of the technological infrastructure required to achieve construction readiness. These technological tools include building design software, architectural and computer-aided systems, automated design tools, and machine-based learning assistants. Additionally, the technological infrastructure should include suitable hardware that meets the typical needs of BIM software [48]. Technologies such as virtual, augmented, and mixed reality will play a vital role in BIM implementation, and they can be applied to several BIM applications.

2) Organizational culture: Continuously cultivating organizational culture, including staff's mindset and discipline, is vital for successful BIM implementation. Thus, both individual and organizational strategies will be factored into construction readiness for a wiser BIM implementation pathway. Readiness is person-focused, meaning it adapts to individual differences and needs, which can be achieved without necessarily increasing an individual's formal skills acquired through education and training. Instead, the focus is on experience, knowledge, skill development, interpersonal relationship management, and capacity building. Engaging in professional societies and expanding interdisciplinary skills is central to developing an individual's overall readiness [49]. The new understanding of readiness in this way provides insight into how to overcome the lack of a skilled labor force, which remains an issue today for developed countries to enhance their local HR. These initiatives can produce a larger and more qualified pool of employees. Building assets in readiness is the first step to creating a robust and high-energy organizational culture associated with business practices [50].

2.2. *Factors Influencing Construction Readiness*

Research on construction readiness enables construction organizations to assess the current state of their practices, strategies, and market requirements, thereby enhancing their readiness dimension. Several individual factors influence construction readiness [51]. Organizational leadership and management practices can substantially shape delegates' apprehension about adopting new ideas, attitudes toward innovative practices, and the skillfulness required for organizational transformation. Stellar practices in organizational contexts improve individuals' perceptions of capabilities and accuracy in procedures. External influences, such as market demand and governmental and industrial regulatory environments, can either facilitate or ease the adoption of a new practice, serving as either expediters or speed breakers, depending on whether they are committed or reluctant sponsors in aggregate populations [52]. Given the potentially negative impacts on stakeholders, resistance can significantly encumber an organization's overall transformation into a BIM-oriented organization. A worldwide organization's readiness to build information modeling, the objectives of operations in BIM orientation, the effect of BIM adoption on project perspective, and best practices for international development to study the best managerial practices for developing adoption behaviors by operatives for building information modeling in a developing country. A questionnaire survey was conducted on Jordanian construction projects. The 171 responses collected were analyzed using software. The findings establish four strategies to enhance an operative's adoption of BIM for construction projects. This goal can be achieved through supportive leadership, proactive strategies, effective enablers, and the development of an operative integration approach. The research presented herein provides new insights that could help international construction managers improve the likelihood of success in their efforts to build information modeling in construction projects. The findings, in particular the contingencies surveyed, constitute evidence of the need for a holistic approach to affect construction readiness and reduce the likelihood of resistance to change.

3. CURRENT BIM IMPLEMENTING PRACTICES IN JORDANIAN BUILDING PROJECTS

To implement effective strategies for constructing readiness for BIM, practical implications should be thoroughly studied based on current industry settings and adopted applications. BIM practices, barriers, and management in Jordan are examined in this section to inform the development of an appropriate blueprint for the current research phase [53]. The interview results reveal the practices of implementing BIM in local Jordanian building projects, where construction BIM is a critical element for designing structural projects in Jordan. The majority of major projects constructed in different cities rely on the crucial element of BIM, which is often required for a significant percentage of major projects, as mentioned during the interviews. The interest of Jordanian firms in BIM system technology has become increasingly understandable, and firms are updated on the latest modern technologies. Additionally, a notable percentage of companies have a professional development agenda and provide training with the latest technology [54]. The main challenge in implementing business information modeling is the limited availability of skilled labor. The purpose of this case study was to investigate the current status and success of the application of Building Information Modeling required for Architecture, Engineering, Construction, and operation and maintenance. It was argued that managers may enhance the company's performance and, in turn, improve programs, techniques, tools, and processes for developing the building information model. Furthermore, AECO should enhance the training of BIM and then accelerate its adoption by educating and implementing BIM, building skills and concepts, which is crucial due to the availability of contacts and stakeholders. While risk evaluation can maintain a balance, it also participates in ensuring quality and timely building [55]. In Jordan, the National Information Technology Center has launched an initiative to improve the awareness of building information modeling. The center reimagines, leads, and transforms the future of the building and construction industry. BIM is the next digital revolution that will redefine the planning, designing, and building processes in which various stakeholders, such as real estate developers, architects, engineers, construction and operational professionals, and governments, must adapt to and adhere to internationally accepted BIM standards, protocols, and guidelines [56]. There is still a very modest contribution from a large-scale national perspective by the government or any other institution. Many international firms have adopted BIM models for engineering and construction management. Similarly, there is an almost equal level of awareness between architects and structural engineers. The results of these studies are not generalized to all stakeholders but are specific to partners such as architects and contractors.

4.STRATEGIES FOR ENHANCING CONSTRUCTION READINESS IN BIM IMPLEMENTATION

As has been seen, increasing readiness for the construction industry is paramount in Jordan, where implementing BIM and its supporting tools in building projects is challenging on both service and economic grounds. These are integrated strategies for the BIM readiness of the construction industry. Enabling proven technologies and environments shapes the construction readiness of BIM implementation. This BIM approach integrates both technology and human aspects. This integration is translated into strategies to foster readiness values within the firms. Decision-makers commit to improved productivity outcomes, which include construction readiness values of BIM implementation, such as knowledge, hands-on training, and improved self-confidence to stand out in the competitive construction market [57]. In this regard, the strategies proposed foster a proactive environment for training courses in Jordan. Strategies to enhance construction readiness in BIM implementation are practical and effectively applied in Jordan. Consequently, they are interrelated, where collaboration and a communication platform are crucial to ensure easier relations between the four strategies. In addition, the collaborative approach supports one of the most prominent indicators of construction readiness in Jordan, namely the application of a continuous improvement strategy and the development of learning organizations.

5.RESEARCH METHODOLOGY

This study employs a mixed-methods research design, integrating quantitative and qualitative approaches to address the research objectives. The methodology is structured into four phases: (1) literature review and framework development, (2) empirical data collection via surveys, (3) statistical analysis using quality management tools, and (4) comparative case studies. For transparency, the case study analysis procedures (Egypt and Lebanon) are described in greater detail. Sources included peer-reviewed publications, government reports, and industry white papers. Selection criteria were based on comparable socioeconomic contexts and documented BIM maturity. Analytical steps involved pattern coding, cross-case synthesis, and benchmarking to ensure methodological rigor.
The rationale for this approach is to holistically assess barriers, success factors, and strategies for BIM readiness in Jordan while ensuring scalability across developing nations. The study employs a sequential exploratory strategy, commencing with a systematic literature review to identify gaps and inform the development of the BIM Adoption Model. This review is followed by empirical validation through surveys and statistical analysis, culminating in cross-country comparisons to assess the model's applicability. A structured questionnaire was developed based on literature-derived barriers (21 items) and success factors (20 items). Responses were captured using a 5-point Likert scale (1 = Strongly Disagree; 5 = Strongly Agree). The survey was validated through pilot testing with 15 industry experts, achieving a Cronbach's alpha of 0.89, which confirmed its internal consistency. The target population included architects, engineers, contractors, and policymakers in Jordan's construction sector. A stratified random sampling technique ensured representation across roles and project types. Out of 250 distributed questionnaires, 171 valid responses were collected (68.4% response rate). The survey was distributed, with 65% of responses collected online and 35% through in-person interviews, ensuring broad participation across architects (28%), engineers (32%), contractors (24%), and policymakers (16%). Representativeness was validated against national workforce statistics. Data collection occurred through online platforms and in-person interviews between January and March 2025. Furthermore, comparative case studies from Egypt and Lebanon were analyzed using secondary data from academic publications, government reports, and industry whitepapers.

These countries were selected due to their similar socioeconomic contexts and documented challenges to BIM adoption.

5.1.Data Analysis

- **Quantitative Analysis**
  Descriptive Statistics: Mean scores and standard deviations were calculated to assess the perceived significance of barriers and success factors.
  Relative Importance Index (RII):
  $$RII = \sum W/(A * N) \qquad (1)$$
  where W = weight of each factor, A = highest Likert score (5), and N = number of respondents. Factors with RII ≥ 0.6 were deemed critical.
  Fishbone Diagram: Utilized to map root causes of key barriers, e.g., high costs, resistance to change.
- **Qualitative Analysis**
  Thematic analysis of case studies identified patterns in policy frameworks, training programs, and institutional collaborations. The findings were synthesized into the Benchmark Table to contrast Jordan's challenges and strategies with those of other developing nations.

5.2.Results of First Set

The BIM Adoption Model was validated through triangulation:

- Statistical Robustness: High RII scores, e.g., 0.93 for cost barriers, confirmed survey reliability.
- Expert Feedback: Preliminary findings were reviewed by 10 BIM practitioners to ensure practical relevance.
- Case Study Alignment: Consistency between Jordan's results and global trends, such as skill gaps in Nigeria, reinforced the external validity.

This methodology offers a replicable framework for evaluating BIM readiness in resource-constrained environments, striking a balance between empirical rigor and actionable insights for policymakers and industry leaders.

6.BIM ADOPTION MODEL FOR DEVELOPING COUNTRIES

This study formulates a framework model by examining critical insights and devising customized suggestions derived from BIM adoption experiences in representative nations across three developmental tiers, as shown in Fig. 2. The model is carefully developed by a comprehensive study of the data obtained from our systematic review. The essential features from the literature were classified into three overlapping domains: strategic considerations, contextual factors, and adoption factors, which provide a thorough array of interconnected components vital to BIM adoption. The proposed BIM Adoption Model is an extensive framework designed to assist developing nations in the complex integration of BIM within their building and construction industries. This paradigm is based on a multi-dimensional approach that acknowledges the diverse economic, educational, and infrastructural conditions in developing nations.

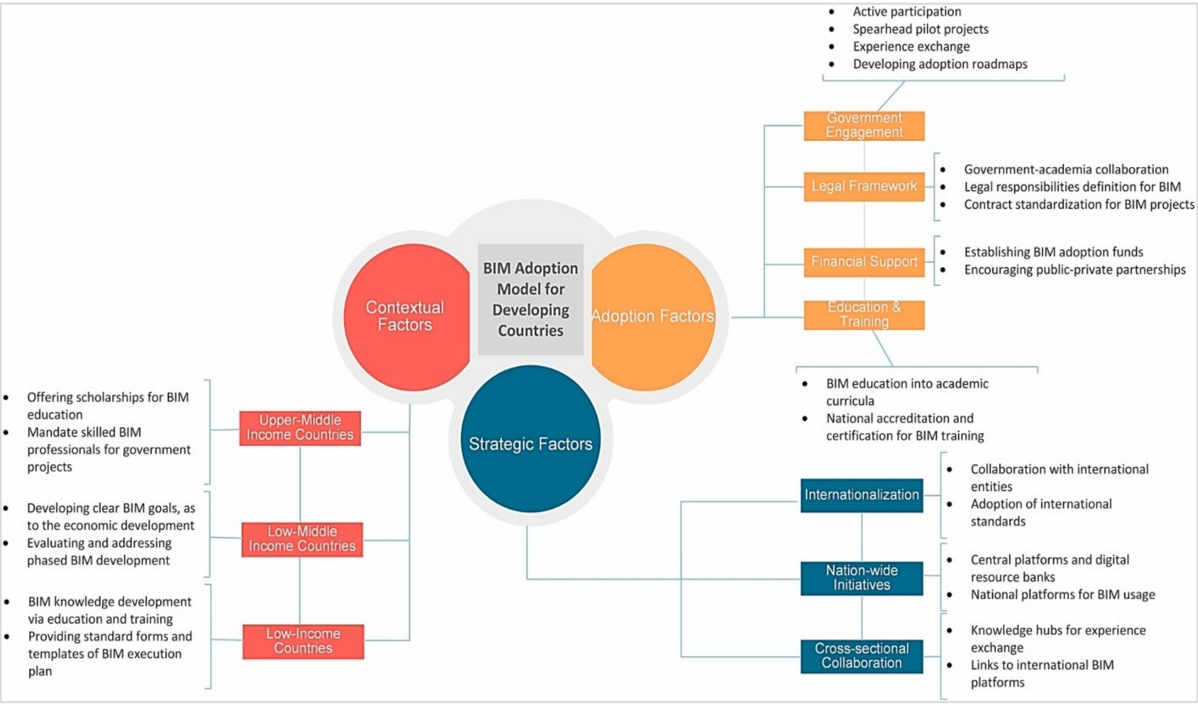

Fig. 2 Conceptual Model of BIM Adoption for Developing Countries (prepared by author).

6.1. Contextual Variables

The paradigm starts by recognizing the Contextual Factors, which are essential for establishing the foundation for BIM adoption. It acknowledges the imperative of customizing policies according to the economic capacities of nations, classified as upper-middle, lower-middle, and low-income. Upper-middle-income countries may be better positioned to provide scholarships for BIM courses and require qualified BIM specialists for government projects. Conversely, low-income countries may focus on developing BIM goals that align closely with their urgent economic development needs. Supplying standardized forms and templates for BIM execution plans is a vital strategic component, guaranteeing uniformity and excellence in BIM deployment. For low- and middle-income nations, it encompasses the establishment of explicit BIM objectives, assessment of incremental BIM advancement, and the enhancement of BIM expertise through education and training.

6.2. Strategic Considerations

Central to the approach are Strategic Factors that serve as the impetus for adoption tactics. Internationalization involves collaboration with global organizations and the adoption of international standards, thereby facilitating interoperability and enhancing global competitiveness. National initiatives encompass centralized platforms and digital resource repositories, ensuring nationwide accessibility and uniformity of information across the country. Transversal Collaboration promotes the exchange of information and resources across several sectors, building a community of practice that facilitates ongoing learning and adaptation.

6.3. Factors Influencing Adoption

The external layer of the model encompasses Adoption Factors, which are critical elements that must be considered to guarantee effective BIM adoption. Government engagement is essential, necessitating active involvement, leading pilot initiatives, and formulating BIM adoption strategies. Government entities must lead the demonstration of BIM's value and foster an environment that facilitates its implementation. A legal framework guarantees that suitable rules and regulations underpin the implementation of BIM. This framework includes collaboration between government and academics, delineating legal obligations for BIM, and standardizing contracts for BIM initiatives. Financial support is a crucial enabler, involving the creation of BIM adoption funds and promoting public-private collaborations. These financing strategies help mitigate the expenses associated with adopting BIM technology and procedures. Education and training must be integrated into academic courses to develop a workforce proficient in BIM. National accreditation and certification for BIM training may maintain educational quality and ensure industrial preparedness (Fig. 2).

7. DISCOURESE

The suggested BIM Adoption Model for Developing Countries (Fig. 2) is not only a strategy framework but an appeal for a coordinated initiative across several sectors, particularly focused on enhancing project delivery results. This model highlights the crucial role of projects as organizational entities that drive strategic and contextual elements influencing BIM adoption. This study emphasizes that project-based insights can enable BIM to revolutionize project management techniques in underdeveloped nations, resulting in improved project efficiency, decreased costs, and more alignment with strategic objectives. The effectiveness is rooted in the understanding that successful BIM adoption encompasses not merely a technological shift but a comprehensive transformation that comprises cultural and procedural changes impacting numerous stakeholders. Government involvement is a vital element in facilitating the adoption of BIM. Refs. [56-57] underscore the necessity of government-led initiatives—such as pilot programs, established guidelines, stakeholder incentives, and contemporary leadership styles—in the engineering sectors, demonstrating the pivotal role of governmental support in promoting BIM integration. Financial assistance [58] is a crucial catalyst for the BIM adoption Roadmap, especially in resource-limited contexts. By allocating resources and incentives for BIM adoption, stakeholders may mitigate perceived risks and promote investment in BIM technology. Education and training are essential for the successful integration of BIM. Al-Btoush et al. [7] asserted that incorporating BIM education into academic programs and offering professional development opportunities can cultivate a proficient workforce capable of effectively utilizing BIM technologies. They emphasize the necessity of internationalization to conform to global standards, hence enhancing participation in the worldwide market and the adoption of best practices. Moreover, national efforts and interdisciplinary cooperation [58] underscore the importance of collective infrastructure and information sharing in democratizing the benefits of BIM and fostering a culture of collaboration and innovation. The Jar test apparatus used in this study was the Pharma Test PT-DT7. It was taken from Samarra'a Company for drug and medical implementations (SDI). The present findings align with [13], who also identified high initial costs as a dominant barrier in Nigeria. They further extend the insights of Al-

Btoush et al. [7] by highlighting the unique role of institutional support, such as CCIT in Jordan, in shaping readiness. Moreover, they partially contradict El Hajj et al. [19], who downplayed the role of government involvement; the present evidence shows that public-sector leadership remains decisive in advancing BIM adoption.

8.RESULTS AND DISCUSSIONS

8.1.Practical Implications

The results and established model (Fig. 2) have several practical implications for project managers, policymakers, and leaders in poor nations seeking to harness digital change via BIM adoption.

8.2.For Project Managers

1) Improved Project Delivery: The Adoption Model highlights the use of collaborative digital platforms that enhance communication and coordination among stakeholders. Utilizing BIM enables project managers to optimize workflows, minimize rework, and guarantee compliance with project schedules. This model advocates for the implementation of BIM Level 2 and 3 methodologies, which foster comprehensive cooperation and interoperability throughout project phases, leading to improved project delivery efficiency.
2) Resource Optimization: The model underscores the significance of resource management via precise cost prediction, materials monitoring, and labor allocation enabled by BIM. Project managers can utilize these skills to enhance resource efficiency, reduce waste, and ensure initiatives are completed within budgetary constraints. The model's key characteristics promote the use of BIM for comprehensive resource planning and management, which is essential for achieving cost efficiency.
3) Risk Management: The sophisticated simulation and modeling functionalities of BIM, as detailed in the adoption model, enable project managers to anticipate possible challenges and proactively minimize risks. This risk management strategy is underpinned by the model's focus on both technological and strategic elements, facilitating the early identification and resolution of potential issues throughout the project lifecycle, thereby enhancing project success.

8.3.For Decision-Makers

1) Policy Development: The BIM Adoption Model provides insights that might assist policymakers in formulating national standards and recommendations to facilitate BIM adoption. The model's contextual variables underscore the necessity for supporting legislative frameworks that require BIM implementation in public sector projects, hence promoting industry-wide adoption. Policymakers can utilize the model to design policies that conform to international norms while addressing local requirements.
2) Financial Incentives: The concept proposes the implementation of financial incentives, such as tax breaks, grants, or subsidies, to promote BIM adoption. These incentives may help mitigate the initial expenses associated with BIM deployment, thereby enhancing accessibility for enterprises. Policymakers may promote extensive BIM integration in the construction sector by offering financial assistance, as suggested by the model's financial support schemes.
3) Infrastructure Development: Investment in digital infrastructure, including high-speed internet and data storage facilities, is essential for the efficient deployment of BIM. The adopted model emphasizes the need to establish a robust infrastructure to facilitate digital transformation in the construction industry. Policymakers must prioritize these infrastructure advancements to establish the essential technological underpinning for BIM adoption.

8.4.For Executives in the Construction Sector

1) Strategic Planning: Industry leaders may utilize the BIM Adoption Model to integrate BIM into their strategic planning frameworks. Integrating BIM into business models enables firms to optimize project outcomes, enhance customer satisfaction, and increase profitability. The approach provides a framework for executives to align their strategic objectives with BIM adoption, ensuring the successful implementation of digital transformation initiatives.
2) Workforce Development: The model underscores the necessity for training and development initiatives to cultivate a workforce skilled in BIM technology. Leaders ought to allocate resources towards educational efforts and collaborate with academic institutions

to provide BIM certification programs and ongoing professional development opportunities. This method ensures that the staff have the necessary skills to utilize BIM effectively.

3) Collaboration and creativity: Fostering a culture of collaboration and creativity is an essential element of the BIM Adoption Model. Leaders ought to foster multidisciplinary cooperation and endorse creative methods that maximize the potential of BIM. By cultivating a culture that prioritizes collaboration, firms can enhance their BIM adoption initiatives and achieve superior project outcomes.

The BIM Adoption Model offers a strategic and sophisticated framework to support emerging nations in the complex process of BIM integration. This approach suggests a road that is both strategic and practical by concurrently addressing contextual, strategic, and adoption variables. This is a call to action for governments, businesses, academia, and international partners to join in leveraging the revolutionary potential of BIM for the future of construction and development.

9.STATISTICAL QUALITY TECHNIQUES

Statistical methods in project management and control help reduce deviations, while statistical process control charts assess whether a process needs to be continued or modified to meet quality standards. Seven basic quality tools, as shown in Fig. 3, were first developed by Ishikawa (1968). He provided systematic approaches for identifying and addressing root causes of quality issues. Recent studies have reinforced their relevance in construction management, particularly for readiness and delay analysis (Radzi et al., 2024 [37] and Sanni-Anibire et al., 2022 [42]. These tools are useful for self-study, foreman training, and quality control reading groups.

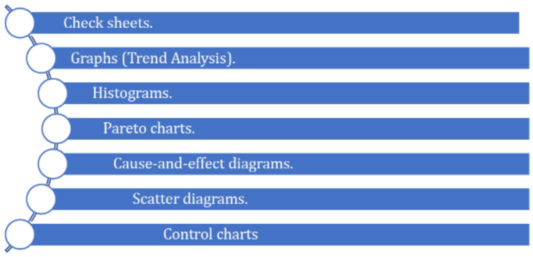

Fig. 3 The Seven Quality Control Tools.

9.1.Check Sheets and Histogram

Check sheets are simple forms that help systematically record data in a business, providing a clear picture of the organization's situation and condition. Hemograms are excellent tools for describing the frequency distribution of observed values of a variable and can be used to investigate and identify the underlying distribution of a variable. Pareto Analysis, developed by Italian economist Vilfredo Pareto, is a type of histogram that can be used to quickly identify and prioritize quality issues, conditions, or causes in a company. It can be useful in project management and productivity, allowing for the analysis of to-do lists and prioritizing tasks with the most important results. The Fishbone Diagram, created by Kaoru Ishikawa, is a powerful tool for root cause analysis and the concept of Quality Control (QC) circles. It examines and analyzes all potential or real causes that lead to a single effect in a systematic manner, enabling a company's management to investigate the root causes of a problem. Unlike prior studies that cite barriers descriptively, this research operationalizes statistical quality tools to measure them. Pareto analysis isolates the "vital few" factors that account for 80% of readiness gaps, while Fishbone diagrams map systemic root causes, such as policy fragmentation, training deficits, and cultural inertia, thereby strengthening the analytical depth of the framework. Scatter diagrams are powerful tools for drawing the distribution of information in two dimensions, aiding in detecting and analyzing pattern relationships between two quality and compliance variables. Flowcharts are diagrammatic representations that use symbols to represent the steps in a process or operation, helping to detect and analyze potential problems. The Shewhart control chart, developed by Walter A. Shewhart in the 1920s, is the most technically sophisticated for quality management, depicting the amount and type of variation in a process over time.

9.2.Barriers to Implementing the BIM technique in Jordanian Construction Projects

To evaluate the most significant challenges facing the Jordanian construction sector in adopting BIM technology, statistical analysis was conducted using the mean score, standard deviation, and relative importance index to rank these challenges according to their significance. Table 1 illustrates the most significant challenges that limit the adoption of BIM in the Jordanian construction sector.

Table 1 explains that the most significant factor hindering the adoption of BIM techniques in the Jordanian construction sector is the high initial cost of software and hardware, as BIM software requires high licensing costs, especially for large projects. The second-highest limitation preventing the adoption of BIM techniques in Jordan is that training personnel in new software and technology incurs high costs, resulting in a shortage of technical skills and a lack of experts and professionals with adequate experience in BIM techniques. Also, the following challenges present the third-highest factors that prevent the adoption of BIM in the Jordanian construction industry: Shortage of market support for BIM execution where there is no enough support BIM adoption due to lack of awareness of beneficial contribution of BIM technique, industry resistance to process change due to shortage awareness and knowledge of BIM culture, and Lack of a ready pool of skilled BIM staff expertise. In addition, all barriers evaluated in Table 2 are considered significant, as the IRR achieved values exceed 0.6, which is the recommended threshold for considering these challenges significant. Ideally, these values should be higher than 0.6.

Table 1 Challenges of BIM Application in Construction Management

No.	limitation	Mean	STDEV	description	IRR	Rank
1	Shortage of Demand for BIM	4.43	1.07	Strongly Agree	0.89	4
2	The steep learning curve to build up BIM expertise	4.52	0.90	Strongly Agree	0.90	3
3	Insufficient BIM talent pool	4.49	0.97	Strongly agree	0.90	3
4	Shortage of awareness of the procedures to implement BIM	4.47	1.05	Strongly Agree	0.89	4
5	Shortage of technical skills	4.57	0.92	Strongly Agree	0.91	2
6	Absence of a real-world BIM-based sample	4.37	1.07	Strongly Agree	0.87	6
7	Shortage of organization between project elements	4.41	1.08	Strongly Agree	0.88	5
8	Contractual and security challenges	4.41	1.03	Strongly Agree	0.88	5
9	It is multiple software, not a single one	4.27	1.17	Strongly Agree	0.85	8
10	Shortage of organization in the software used in several sectors	4.28	1.12	Strongly agree	0.86	7
11	Shortage of a single standard for software results	4.23	1.13	Strongly Agree	0.85	8
12	Legal responsibilities are owed to stakeholders contributing to the model, or based on the goodness of the data	4.38	1.03	Strongly Agree	0.88	5
13	The need for legalization	4.25	1.15	Strongly agree	0.85	5
14	A BIM protocol can cost a higher price for intellectual property licensing than that procured under traditional contracts	4.31	1.11	Strongly agree	0.86	7
15	Firms believe that BIM is an underdeveloped technology with limited capacities	4.34	1.08	Strongly Agree	0.87	6
16	Shortage of support from enterprises and culture in the implementation of BIM execution	4.38	1.14	Strongly Agree	0.88	5
17	Lack of BIM object libraries and standard modeling protocols	4.34	1.13	Strongly Agree	0.87	6
18	Industry resistance to process change	4.49	0.98	Strongly Agree	0.90	3
19	Shortage of market support for BIM execution	4.51	0.82	Strongly Agree	0.90	3
20	The high initial cost of software and hardware	4.66	0.70	Strongly Agree	0.93	1
21	Training personnel in new software and technology requires high costs	4.53	0.88	Strongly Agree	0.91	2
22	High cost of process and technology execution	4.43	1.07	Strongly Agree	0.89	4

9.3. Strategies to Motivate the Adoption of the BIM Technique in Jordanian Construction

This section assesses the drivers of BIM adoption in construction projects by identifying the critical success factors for adopting BIM techniques in Jordanian Construction projects. Mean score, standard deviation, and RII have been employed to assess these drivers. The following critical success factors represent the third-highest factors that can be considered drivers for adopting BIM in the Jordanian construction industry. Several tertiary institutions should incorporate BIM training into their curricula to develop basic guidelines for skills and training demands. In addition, all critical success factors evaluated in Table 2 are considered significant, as the IRR achieved values exceed 0.6, which is the recommended threshold for considering these challenges significant. The Jar test apparatus used in this study is the Pharma Test PT-DT7, which was obtained from Samarra's Company for Drug and Medical Implementations (SDI). Table 2 displays that the highest critical success factors motivating the adoption of BIM techniques in the Jordanian construction sector are execution seminars, workshops, and conferences on the utilization of BIM for the industry to upgrade the advantages of the technology and standardize work procedures for BIM. The second-highest critical success factors encouraging the adoption of BIM in the Jordanian construction industry are establishing the CCIT, which promotes BIM and guides businesses and professionals in the industry. The CCIT is a software development company that provides a comprehensive solution to companies through web applications and cloud technology. CCIT can help develop high-performance applications, provide IT consulting, and analyze data in the field of building information modeling to improve productivity and guide companies and professionals in the construction and manufacturing industries. Additionally, the provision of BIM finance covers the costs for training, consultancy services, and the purchase of hardware and software for businesses and projects. The client's obligation includes paying for additional costs associated with BIM execution. Furthermore, the performance of a promotion and awareness campaign about BIM is also required. The benchmark BIM Adoption in Developing Countries is illustrated in Table 3.

Table 2 Critical Success Factors of Adopting the BIM Technique in Construction Management.

No.	limitation	Mean	STDEV	Description	IRR	Rank
1	Government support, such as subsidizing training, software, and consultancy costs	4.47	1.00	Strongly agree	0.89	4
2	Established the CCIT to promote BIM and guide businesses and professionals in the industry.	4.58	0.82	Strongly agree	0.92	2
3	Execute seminars, workshops, and conferences on the utilization of BIM for the industry to upgrade the advantages of the technology	4.63	0.78	Strongly agree	0.93	1
4	Several tertiary institutions should collaborate to incorporate BIM training into their curricula.	4.55	0.88	Strongly agree	0.91	3
5	Provide the BIM finance, which covers the costs for training, consultancy services, and the purchase of hardware and software for businesses and projects	4.59	0.75	Strongly agree	0.92	2
6	Develops basic guidelines for skills and training demands.	4.54	0.89	Strongly agree	0.91	3
7	Clients' obligation to pay more costs for BIM execution	4.60	0.83	Strongly agree	0.92	2
8	Promotion and awareness campaign performance for BIM	4.62	0.81	Strongly agree	0.92	2
9	The incentive provided by the client as a tax mitigation	4.45	1.02	Strongly agree	0.89	4
10	Provide a grant plan for BIM training	4.43	1.09	Strongly agree	0.89	4
11	Support the implementation of BIM by the government	4.35	1.10	Strongly agree	0.87	6
12	Clients should offer pilot projects for BIM	4.49	0.88	Strongly agree	0.90	4
13	Cooperation with universities (Research Cooperation and Curriculum Design for Students)	4.25	1.14	Strongly agree	0.85	7
14	Customers should order by applying BIM in their project	4.42	1.00	Strongly agree	0.88	5
15	Provision BIM expertise	4.47	0.97	Strongly agree	0.89	4
16	Demand for personnel to be BIM competent	4.34	1.12	Strongly agree	0.87	6
17	Outsourcing a BIM specialist	4.42	0.97	Strongly agree	0.88	5
18	An organizational structure that supports BIM	4.24	1.15	Strongly agree	0.85	7
19	Standardize work procedure for BIM	4.63	0.81	Strongly agree	0.93	1
20	Technical support	4.45	1.03	Strongly agree	0.89	4

Table 3 Benchmark Table: BIM Adoption in Developing Countries.

Country	Key Barriers (Ranked)	Critical Success Factors (Ranked)	Methodology	Key Findings
Jordan	1. High initial Software/Hardware Costs (RII=0.93) 2. Training Costs/Skill Shortages (RII=0.91) 3. Industry Resistance to Change (RII=0.90)	1. Seminars/Workshops (RII=0.93) 2. Standardized Workflows (RII=0.93) 3. Government/CCIT Support (RII=0.92)	RII, Pareto, Fishbone Diagrams, Survey of 171 Industry Responses	High costs and skill gaps dominate; success hinges on training, standardization, and institutional support.
Nigeria	1. Lack of BIM Expertise 2. High Costs 3. Fragmented Policies	1. Government Mandates 2. Academic integration 3. Public-Private Partnerships	Case Studies, interviews (Babatunde et al., 2021)	Policy fragmentation and low awareness slow adoption; Collaboration between academia and industry is vital.
Egypt	1. Resistance to Change 2. Interoperability issues 3. Legal Framework Gaps	1. Pilot Projects 2. Regional Collaboration 3. Financial incentives	Comparative Case Studies (Section 6.1 of the Paper)	Cultural resistance and legacy systems hinder adoption; Regional alignment improves scalability.
Lebanon	1. Limited digital literacy 2. Infrastructure deficits 3. Contractual challenges	1. Training programs 2. Bim libraries 3. Regulatory reforms	Survey Analysis (Section 7 of the Paper)	Digital infrastructure gaps are critical; Regulatory reforms and training accelerate readiness.
India	1. Organizational inertia 2. Software complexity 3. Client reluctance	1. Client Mandates 2. Modular Workflows 3. Industry Certifications	Mixed-Method (Atakul, 2024)	Client-Driven Mandates and Modular Approaches Reduce Resistance; Certifications Enhance Workforce Readiness.
Global	Common Barriers: High Costs, skill shortages, cultural resistance	Common Success Factors: Training, Policy Support, Standardized Workflows		

9.4.Summary of Comparisons

Barriers: Jordan aligns with other developing nations in facing high costs and skill shortages; however, its industry resistance to change (ranked third) is more pronounced than in countries like Nigeria or India. Success Factors: Jordan emphasizes seminars and workshops, as well as standardization, similar to India's focus on modular workflows. However, Jordan uniquely highlights the role of the Center for Construction Information Technology (CCIT), a local institutional entity in Jordan that supports the promotion and adoption of Building Information Modeling for guidance. Methodology: The use of RII and Pareto analysis in Jordan provides quantitative prioritization, contrasting with the qualitative approaches employed in Nigeria's case studies. Policy Gaps: Unlike Egypt and Lebanon, Jordan's study highlights market support deficits, such as the lack of BIM awareness campaigns, which necessitate targeted stakeholder engagement. This comparison highlights that while Jordan's BIM challenges mirror those of other developing nations, its strategies must address localized organizational cultures and leverage institutional partnerships, such as CCIT, for scalable adoption.

10.CONCLUSIONS

This study systematically addresses the underexplored challenge of enhancing construction readiness for BIM implementation in Jordan, offering actionable insights for developing nations. By identifying high initial costs (RII=0.93), training/skill gaps (RII=0.91), and industry resistance to change (RII=0.90) as the foremost barriers, the research aligns with global trends observed in countries like Nigeria, Egypt, and India, where cost and cultural inertia similarly hinder adoption. However, Jordan's pronounced organizational resistance and reliance on localized institutional support—such as the CCIT—distinguish its challenges and strategies from other contexts.The proposed BIM Adoption Model, integrating strategic, contextual, and adoption factors, provides a scalable framework tailored to resource-constrained environments. Empirical validation through surveys (n = 171 responses) and comparative case studies (Egypt, Lebanon) underscores the effectiveness of strategies such as standardized workflows (RII = 0.93), targeted workshops, and government-led financial incentives. These findings align with successes in regions such as India, where modular workflows and client mandates have accelerated the adoption of these solutions. However, Jordan's emphasis on CCIT-driven guidance highlights the critical role of localized institutional partnerships. Furthermore, future research should pursue longitudinal studies to track the sustained impact of BIM adoption on project outcomes across a five- to ten-year horizon, enabling stronger causal insights. The scalability of the proposed framework is demonstrated by Egypt's success in piloting BIM workflows through regional collaborations, and Lebanon's reliance on regulatory reforms and training-driven readiness—both of which confirm the model's replicability. Practical implications for policymakers and industry leaders include prioritizing cost mitigation through subsidies, integrating BIM training into academic curricula, and fostering collaborative platforms to mitigate resistance. The study's use of RII and Pareto analysis provides a replicable methodology for quantitatively prioritizing barriers, contrasting with the qualitative approaches employed in similar studies. While the research advances BIM readiness strategies, limitations such as regional specificity and sample size warrant further exploration into the longitudinal adoption impacts and broader applicability across diverse socioeconomic contexts. Furthermore, these limitations include reliance on self-reported data that may introduce bias, the absence of longitudinal analysis to capture changes in adoption over time, and limited integration of simulation-based cost-benefit assessments. Future research should address these issues by:

- Conducting longitudinal studies to track the evolution of BIM adoption in Jordan over time.
- Expanding the scope of the study to include other developing countries across the Middle Eastern countries for broader comparative insights.
- Employing cost–benefit simulations to evaluate the long-term impacts of BIM integration.
- Conducting longitudinal studies to track the evolution of BIM adoption in Jordan over time.
- Exploring the integration of BIM with emerging technologies such as Artificial Intelligence (AI) and Blockchain to strengthen sustainable practices.

NOMENCLATURE

BIM	Building Information Modeling
CCIT	Center for Construction Information Technology
RII	Relative Importance Index
ISO	International Organization for Standardization

REFERENCES

[1] Abbasnejad B, Nepal MP, Ahankoob A, Nasirian A, Drogemuller R. **Building Information Modelling (BIM) Adoption and Implementation Enablers in AEC Firms: A Systematic Literature Review**. *Architectural Engineering and Design Management* 2021; **17**(5-6): 411–433.

[2] Abdulfattah BS, Abdelsalam HA, Abdelsalam M, Bolpagni M, Thurairajah N, Perez LF, Butt TE. **Predicting Implications of Design Changes in BIM-Based Construction Projects Through Machine Learning**. *Automation in Construction* 2023; **155**: 105057.

[3] Aburumman MO, Sweis R, Sweis GJ. **Investigating Building Information Modelling (BIM) and Lean Construction: The Potential BIM-Lean Interactions Synergy and Integration in the Jordanian Construction Industry**. *International Journal of Lean Six Sigma* 2024; **15**(2): 400–438.

[4] Al Balkhy W, Sweis R, Lafhaj Z. **Barriers to Adopting Lean Construction in the Construction Industry—The Case of Jordan**. *Buildings* 2021; **11**(6): 222.

[5] Alankarage S, Chileshe N, Rameezdeen R, Edwards DJ, Samaraweera A. **Exploring**

BIM-Triggered Organisational and Professional Culture Change: A Systematic Literature Review. *Construction Innovation* 2023; **23**(1): 229–247.

[6] Alawneh R, Jannoud I, Rabayah H, Asaad S, Almasaeid H, Imam R, Ghazali FEM. **Development of a New Method for Assessing Project Risks in Sustainable Building Construction Projects in Developing Countries: The Case of Jordan**. *Buildings* 2024; **14**(6): 1573.

[7] Al-Btoush MA, Albtoush AM, Doh SI, Aldiabat Albtoosh JA, Almashaqbeh HK. **Adoption Approaches for BIM Implementation in Construction Projects: Jordan as a Case Study**. *AIP Conference Proceedings* 2023; **2688**(1): 020001.

[8] Almusaed A, Yitmen I, Almssad A, Myhren JA. **Construction 5.0 and Sustainable Neuro-Responsive Habitats: Integrating the Brain–Computer Interface and Building Information Modeling in Smart Living Environments**. *Sustainability* 2024; **16**(11): 4435.

[9] Alnaser AA, Hassan Ali A, Elmousalami HH, Elyamany A, Gouda Mohamed A. **Assessment Framework for BIM-Digital Twin Readiness in the Construction Industry**. *Buildings* 2024; **14**(1): 268.

[10] Alrjoub AMS, Al-Qudah LAM, Al-Othman LN, Bataineh A, Aburisheh KE, Alkarabsheh F. **Information Technology and its Role in Improving the Quality of Financial Control due to Corona Pandemic: The Jordanian Income Tax as A Case Study**. *International Journal of Professional Business Review* 2023; **8**(4): e01568.

[11] Al-Ruwaishedi MR, Khraisat D, Taib N, Azzam E. **In-Depth Survey on Using BIM Digital Technologies in Jordanian Architectural Industry**. *Journal of Engineering Research* 2024; **8**(2): 45–58.

[12] Atakul B. **Integration of BIM and Modular Construction: Advantages, Barriers, and Implementation Strategies**. *Journal of Construction Engineering and Management* 2024; **150**(4): 04024012.

[13] Babatunde SO, Udeaja C, Adekunle AO. **Barriers to BIM Implementation and Ways Forward to Improve Its Adoption in the Nigerian AEC Firms**. *International Journal of Building Pathology and Adaptation* 2021; **39**(1): 48–71.

[14] Bastan M, Zarei M, Tavakkoli-Moghaddam R. **A New Technology Acceptance Model: A Mixed-Method of Grounded Theory and System Dynamics**. *Kybernetes* 2022; **51**(13): 1–25.

[15] Chen Y, Cai X, Li J, Zhang W, Liu Z. **The Values and Barriers of Building Information Modeling (BIM) Implementation Combination Evaluation in Smart Building Energy and Efficiency**. *Energy Reports* 2022; **8**: 10245–10258.

[16] Chirumalla K. **Building Digitally-Enabled Process Innovation in the Process Industries: A Dynamic Capabilities Approach**. *Technovation* 2021; **105**: 102256.

[17] Çivici T, Ayalp GG. **Modelling the Critical Determinants of Architects' Work-Related Stress**. *International Journal of Construction Management* 2024; **24**(5): 512–525.

[18] Darko A, Chan APC, Yang Y, Tetteh MO. **Building Information Modeling (BIM)-Based Modular Integrated Construction Risk Management–Critical Survey and Future Needs**. *Computers in Industry* 2020; **121**: 103257.

[19] El Hajj C, Martínez Montes G, Jawad D. **An Overview of BIM Adoption Barriers in the Middle East and North Africa Developing Countries**. *Engineering, Construction and Architectural Management* 2023; **30**(2): 889–913.

[20] Francom GM, Lee SJ, Pinkney H. **Technologies, Challenges and Needs of K-12 Teachers in the Transition to Distance Learning During the COVID-19 Pandemic**. *TechTrends* 2021; **65**(4): 589–601.

[21] Gamil Y, Abd Rahman I. **Studying the Relationship Between Causes and Effects of Poor Communication in Construction Projects Using PLS-SEM Approach**. *Journal of Facilities Management* 2023; **21**(2): 245–263.

[22] Gharaibeh LG, Matarneh ST, Arafeh M, Sweis G. **Factors Leading to Design Changes in Jordanian Construction Projects**. *International Journal of Productivity and Performance Management* 2021; **70**(4): 893–915.

[23] Inuwa M, Rahim SBA. **Lean Readiness Factors and Organizational Readiness for Change in Manufacturing SMEs: The Role of Organizational Culture**. *Journal of Critical Reviews* 2020; **7**(19): 4802–4812.

[24] Jerab D, Mabrouk T. **The Role of Leadership in Changing**

Organizational Culture. *SSRN Electronic Journal* 2023; 4574324.

[25] Khan T, Emon MH. **Exploring the Potential of the Blue Economy: A Systematic Review of Strategies for Enhancing International Business in Bangladesh in the Context of Indo-Pacific Cooperation**. *Review of Business and Economics Studies* 2024; **12**(1): 78–95.

[26] Kwame A, Petrucka PM. **A Literature-Based Study of Patient-Centered Care and Communication in Nurse-Patient Interactions: Barriers, Facilitators, and the Way Forward**. *BMC Nursing* 2021; **20**(1): 158.

[27] Leygonie R, Motamedi A, Iordanova I. **Development of Quality Improvement Procedures and Tools for Facility Management BIM**. *Developments in the Built Environment* 2022; **11**: 100075.

[28] Li X, Lu W, Xue F, Wu L, Zhao R, Lou J, Xu J. **Blockchain-Enabled IoT-BIM Platform for Supply Chain Management in Modular Construction**. *Journal of Construction Engineering and Management* 2022; **148**(2): 04021195.

[29] Liu Z, Lu Y, Shen M, Peh LC. **Transition from Building Information Modeling (BIM) to Integrated Digital Delivery (IDD) in Sustainable Building Management: A Knowledge Discovery Approach Based on Bibliometric Analysis**. *Journal of Cleaner Production* 2021; **325**: 129331.

[30] Manzoor B, Othman I, Pomares JC, Chong HY. **A Research Framework for Mitigating Construction Accidents in High-Rise Building Projects by Integrating Building Information Modeling with Emerging Digital Technologies**. *Applied Sciences* 2021; **11**(18): 8355.

[31] Oguanobi VU, Joel OT. **Geoscientific Research's Influence on Renewable Energy Policies and Ecological Balancing**. *Open Access Research Journal of Multidisciplinary Studies* 2024; **7**(2): 073–085.

[32] Olanrewaji OI, Kineber AF, Chileshe N, Edwards DJ. **Modelling the Relationship Between BIM Implementation Barriers, Usage and Awareness on Building Project Lifecycle**. *Building and Environment* 2022; **207**: 108556.

[33] Paneru S, Ghimire P, Kandel A, Thapa S, Koirala N, Karki M. **An Exploratory Investigation of Implementation of Building Information Modeling in Nepalese Architecture–Engineering–Construction Industry**. *Buildings* 2023; **13**(2): 552.

[34] Phung Q, Tong N. **Developing an Organizational Readiness Framework for BIM Implementation in Large Design Companies**. *International Journal of Sustainable Construction Engineering and Technology* 2021; **12**(3): 57–67.

[35] Prabhakaran A, Mahamadu AM, Mahdjoubi L, Andric J, Manu P, Mzyece D. **An Investigation into Macro BIM Maturity and its Impacts: A Comparison of Qatar and the United Kingdom**. *Architectural Engineering and Design Management* 2021; **17**(5-6): 496–515.

[36] Radanovic M, Khoshelham K, Fraser C. **Geometric Accuracy and Semantic Richness in Heritage BIM: A Review**. *Digital Applications in Archaeology and Cultural Heritage* 2020; **19**: e00166.

[37] Radzi AR, Azmi NF, Kamaruzzaman SN, Algahtany M, Rahman RA. **Challenges in Construction Readiness for BIM-Based Building Projects**. *Journal of Asian Architecture and Building Engineering* 2024; **23**(3): 1124–1139.

[38] Rashidi A, Chan DW, Ravanshadnia M, Sarvari H, Tajaddini A. **Applying Building Information Modelling (BIM) Technology in Pre-Tender Cost Estimation of Construction Projects: A Case Study in Iran**. *Buildings* 2024; **14**(5): 1260.

[39] Rinchen S, Banihashemi S, Alkilani S. **Driving Digital Transformation in Construction: Strategic Insights into Building Information Modelling Adoption in Developing Countries**. *Project Leadership and Society* 2024; **5**: 100118.

[40] Saleh MMA, Jawabreh OA, Al-Amro SAH, Saleh HMI. **Requirements for Enhancing the Standard of Accounting Education and its Alignment with Labor Market Requirements a Case Study Hospitality and Industrial Sector in Jordan**. *Journal of Sustainable Finance and Investment* 2023; **13**(1): 176–193.

[41] Samimpay R, Saghatforoush E. **Benefits of Implementing Building Information Modeling (BIM) in Infrastructure Projects**. *Journal of Engineering, Project, and Production Management* 2020; **10**(2): 123–140.

[42] Sanni-Anibire MO, Mohamad Zin R, Olatunji SO. **Causes of Delay in the Global Construction Industry: A Meta-Analytical Review**. *International Journal of Construction*

Management 2022; **22**(8): 1395–1407.

[43] Shah AA, Gong Z, Sun R, Naqvi SAA, Naqvi M, Arif M. **Looking Through the Lens of Schools: Children's Perception, Knowledge, and Preparedness for Flood Disaster Risk Management in Pakistan**. *International Journal of Disaster Risk Reduction* 2020; **50**: 101907.

[44] Shojaei RS, Oti-Sarpong K, Burgess G. **Leading UK Construction Companies' Strategies to Tackle BIM Training and Skills Challenges**. *International Journal of Construction Education and Research* 2023; **19**(4): 383–404.

[45] Sood R, Laishram B. **Challenges in Implementing 7D-BIM for Infrastructure Asset Management: A Systematic Review**. *Construction Economics and Building* 2024; **24**(1): 112–132.

[46] Sun C, Xu H, Jiang S. **Understanding the Risk Factors of BIM Technology Implementation in the Construction Industry: An Interpretive Structural Modeling (ISM) Approach**. *Engineering, Construction and Architectural Management* 2020; **27**(10): 3289–3308.

[47] Suleiman A, Asaad S. **BIM Implementation in the Middle East Construction: Evaluating the Prospects and Challenges**. *MATEC Web of Conferences* 2024; **579**: 03004.

[48] Unver S, Ergenc I. **Safety Risk Identification and Prioritize of Forest Logging Activities Using Analytic Hierarchy Process (AHP)**. *Alexandria Engineering Journal* 2021; **60**(1): 159–172.

[49] Van Tam N, Quoc Toan N, Phong VV, Durdyev S. **Impact of BIM-Related Factors Affecting Construction Project Performance**. *International Journal of Building Pathology and Adaptation* 2023; **41**(2): 454–475.

[50] Wang T, Olivier DF, Chen P. **Creating Individual and Organizational Readiness for Change: Conceptualization of System Readiness for Change in School Education**. *International Journal of Leadership in Education* 2023; **26**(6): 1037–1061.

[51] Xia H, Liu Z, Efremochkina M, Liu X, Lin C. **Smart City Digital Twin Technologies for Sustainable Smart City Design: A Review and Bibliometric Analysis of Geographic Information System and Building Information Modeling Integration**. *Sustainable Cities and Society* 2022; **87**: 104162.

[52] Yang L, Lin YC, Cai H, Habib A. **From Scans to Parametric BIM: An Enhanced Framework Using Synthetic Data Augmentation and Parametric Modeling for Highway Bridges**. *Journal of Computing in Civil Engineering* 2024; **38**(3): 04024008.

[53] Yashchenko O, Makatora D, Kubanov R, Zinych P, Prusov D. **Theoretical and Methodological Bases for Implementing BIM Technologies in Construction Companies: Essence, Characteristics, Economic Efficiency**. *Journal of Civil Engineering and Management* 2024; **30**(3): 245–261.

[54] Zakariyyah KI, John IB, Ijaola IA. **Cultural Orientations and Strategic Capability for the Adoption of Building Information Modeling in Construction Firms**. *Engineering Reports* 2021; **3**(10): e12389.

[55] Zhang B, Rui Z. **Application Analysis of Computer Graphics and Image Aided Design in Art Design Teaching**. *Computer-Aided Design and Applications* 2021; **19**(S1): 1–12.

[56] Zhu G, Chou MC, Tsai CW. **Lessons Learned from the COVID-19 Pandemic Exposing the Shortcomings of Current Supply Chain Operations: A Long-Term Prescriptive Offering**. *Sustainability* 2020; **12**(14): 5858.