American Journal of Civil Engineering and Constructions (AJCEC)

ISSN: 3070-0884 (ONLINE)

VOLUME 2 ISSUE 2 (2026)

PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

American Journal of
Civil Engineering and Constructions (AJCEC)

Volume 2 Issue 2, Year 2026
ISSN: 3070-0884 (Online)
DOI: https://doi.org/10.54536/ajcec.v2i2.7679
https://journals.e-palli.com/home/index.php/ajcec

Adoption of Building Information Modeling (BIM) to Improve Urban Construction in Bangladesh

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Article Information

Received: March 30, 2026

Accepted: May 03, 2026

Published: Auguet 01, 2026

Keywords

BIM, Building Information Modeling, Digital Transformation, Implementation Strategy. Smart City, Urban Construction

ABSTRACT

Bangladesh's rapid urbanization and Smart City vision demand transformative approaches to construction project delivery. Building Information Modeling (BIM) offers proven benefits in efficiency, cost reduction, and lifecycle management, yet adoption remains limited due to financial, technical, and institutional barriers. This paper explores how phased investment strategies and financial support mechanisms can mitigate risks and accelerate BIM adoption in Bangladesh. To identify key barriers, evaluate global best practices, and develop a strategic roadmap tailored to Bangladesh's construction sector. The study integrates statistical risk measurement with phased investment (real-options approach), reframing BIM adoption as a manageable, evidence-based process rather than a high-risk commitment. A dual approach is employed: (i) a comprehensive literature review of global BIM implementation strategies and Bangladesh-specific studies, and (ii) application of the statistical risk measurement framework to quantify implementation risks in terms of probability and cost. Findings reveal challenges, including high upfront costs, workforce skill shortages, interoperability issues, and cultural resistance. Risks are categorized into management, employment, and technical domains. Global evidence highlights the importance of government leadership, national standards, and structured education. Phased investment enables learning, reduces uncertainty, and limits financial exposure, while quantified risks justify financial support mechanisms such as subsidies and low-interest financing. A strategic roadmap is proposed, emphasizing phased BIM implementation, government mandates, capacity building, adoption of open standards (e.g., IFC, ISO 19650), and international collaboration to support sustainable urban development in Bangladesh.

INTRODUCTION

Building Information Modeling (BIM) represents a paradigm shift in the architecture, engineering, and construction (AEC) industries, moving from traditional 2D drafting to intelligent 3D model-based processes that integrate time (4D), cost (5D), and facility management (6D) data (Inzerillo *et al.*, 2024). BIM implementation. Globally, BIM adoption is accelerating, driven by the demand for enhanced project delivery, reduced costs, improved sustainability, and better lifecycle management of built assets. For developing nations like Bangladesh, which face rapid urbanization, infrastructure deficits, and the pressing need for sustainable development, BIM offers a critical tool to support Smart City visions (Ozcan-Deniz *et al.*, 2025). Bangladesh's urban centers, particularly Dhaka, are experiencing unprecedented growth, leading to complex construction challenges including inefficient project delivery, cost overruns, safety issues, and environmental concerns. The concept of Smart Cities urban areas that leverage technology to improve efficiency, sustainability, and quality of life is gaining traction in national policy dialogues (Hossain *et al.*, 2024). Integrating BIM into this vision can significantly enhance planning, design, construction, and operational phases of urban projects.

However, BIM implementation in Bangladesh remains limited due to technological, financial, cultural, and regulatory barriers (Hagan *et al.*, 2025a). This paper aims to analyze these barriers and propose a strategic framework for BIM adoption, informed by successful global practices. By examining case studies and strategies from countries that are leaders in BIM adoption, this study provides actionable insights for policymakers, industry stakeholders, and academic institutions in Bangladesh.

LITERATURE REVIEW

Global BIM Implementation Trends and Lessons

Global BIM brings different design teams together like architects, engineers, and system planners into one shared

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model. This helps everyone work more smoothly, spot problems early, and stay on the same page. Connecting all parts of a project makes building processes faster, clearer, and more efficient worldwide (Figure 1).

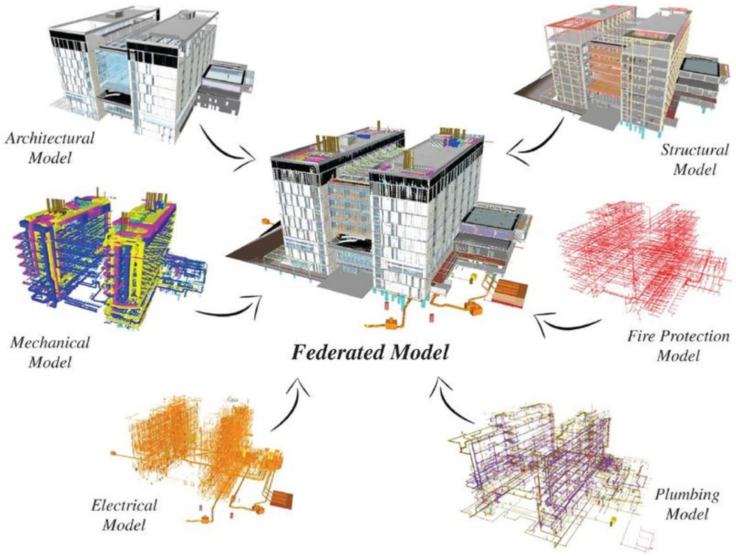

Figure 1: Depiction of a BIM Federated Model (from ankura.com)

Global Momentum and Drivers

BIM implementation has gained significant momentum worldwide over the past decade. McGraw Hill's global surveys indicate a dramatic increase in BIM adoption, particularly in North America, where contractor usage rose from 28% in 2007 to 71% in 2012 (Toyin & Mewomo, 2023). This growth is driven by government mandates, client demand, and the pursuit of competitive advantage. The European Union's Public Procurement Directive (EUPPD), which encourages BIM use in public projects, exemplifies high-level policy driving industry transformation (Atik Shahariyar Hasan *et al.*, 2024)

Leadership and Government Mandates

Government leadership is consistently identified as the most critical factor in successful BIM implementation (Md. Halimuzzaman *et al.*, 2024). In the United States, the General Services Administration (GSA) mandated BIM for spatial validation on federal projects as early as 2007, setting a precedent for public-sector leadership (Abdullah *et al.*, 2024). Building information modeling (BIM),Similarly, the UK government's 2011 mandate requiring BIM on all centrally procured projects by 2016 aimed to achieve 20% savings in procurement costs (Lee *et al.*, 2025). Such mandates create market demand, compelling firms to develop BIM capabilities.

Standardization and Interoperability

The development of national and global standards is essential for BIM efficiency and interoperability. Industry Foundation Classes (IFC), a vendor-neutral data format, enable collaboration across different software platforms (Okonta *et al.*, 2024a). Countries like Singapore and the Scandinavian nations have actively promoted open BIM standards to facilitate data exchange and integration (Durdyev *et al.*, 2021a). The UK's National BIM Library provides free access to standardized BIM objects, supporting widespread adoption (Strelets *et al.*, 2025).

Legal and Contractual Frameworks

BIM introduces complex legal issues related to liability, intellectual property, and data ownership. The American Institute of Architects (AIA) has developed BIM protocol documents to address these challenges, defining model development levels and responsibilities (Mastan *et al.*, 2025). BIM implementation]. Similarly, integrated project delivery (IPD) contracts are increasingly used to align incentives and foster collaboration among project stakeholders (Rezgui *et al.*, 2025).

Education, Training, and Research

BIM education is crucial for developing a skilled workforce. Leading universities worldwide have integrated BIM into their AEC curricula (Papuraj *et al.*, 2025a). Professional training programs and certification schemes, such as those offered by building SMART, further support industry capacity building [Din, M. D. B. M. (2021). Research and pilot projects demonstrate BIM's value, helping to build the business case for investment.

BIM in Developing Countries

In developing countries, BIM adoption faces unique challenges, including limited technological infrastructure, high upfront costs, and a lack of skilled professionals (Atik Shahariyar Hasan *et al.*, 2024). However, countries like China and India are making strides through government-supported initiatives and international collaborations [Government of Bangladesh. For instance, China's BIM Union, established in 2013, aims to develop national standards and promote BIM adoption (Lee *et al.*, 2025).

BIM Governance for Bangladesh from Previous Studies

Although global BIM governance and maturity frameworks have been widely discussed (Kurniawan & Sushandoyo, 2025), Bangladesh-focused studies primarily emphasize barriers and adoption challenges rather than structured national implementation models (Cao *et al.*, 2025). There remains no validated, country-specific BIM governance and maturity roadmap tailored to Bangladesh that integrates policy, legal frameworks, education systems, industry incentives, and alignment with national digital strategies such as Government of Bangladesh (2020). Moreover, existing research is largely perception-based and survey-driven, lacking quantitative, project-level financial performance data. Longitudinal ROI measurement and comparative financial benchmarking between BIM and non-BIM projects in Bangladesh remain absent, highlighting a significant empirical and policy-level research gap (Figure 2).

Figure 2: 3D BIM-based Urban Model of Dhaka City

Challenges and Mitigation Strategies

Despite the compelling benefits, Bangladesh's journey toward comprehensive BIM adoption will inevitably encounter significant implementation challenges that must be anticipated and proactively addressed through targeted mitigation strategies. These challenges span financial, cultural, technical, and security dimensions, each requiring thoughtful responses that acknowledge Bangladesh's specific economic context, institutional frameworks, and technological readiness levels (Takyi-Annan & Zhang, 2023). Perhaps the most immediate challenge involves overcoming the substantial financial constraints that many construction firms particularly small and medium-sized enterprises face when considering BIM investment. The upfront costs of software licenses, hardware upgrades, and specialized training can represent a significant barrier, especially in a market characterized by intense price competition and thin profit margins. To mitigate this challenge, the implementation strategy should emphasize phased investment approaches that allow organizations to begin with lower-cost applications before scaling up to more comprehensive solutions. Additionally, the government should facilitate public-private partnerships that provide shared access to expensive software and computational resources, particularly for smaller firms. International experience suggests that cloud-based BIM solutions offering subscription-based pricing models can significantly reduce entry barriers in price-sensitive markets, making this an important consideration for Bangladesh's implementation approach (Halimuzzaman *et al.*, 2024). Financial mechanisms such as low-interest technology adoption loans or targeted subsidies for first-time adopters could further alleviate the initial investment burden while stimulating market demand for BIM services. Beyond financial considerations, cultural resistance to change represents a profound challenge rooted in established work practices, traditional contractual relationships, and risk-averse organizational cultures prevalent in Bangladesh's construction sector. Many industry professionals may view BIM as a disruptive technology that threatens existing roles, responsibilities, and revenue streams rather than as an opportunity for enhanced collaboration and value creation. To address this challenge, the implementation strategy must emphasize visible leadership advocacy from respected industry figures and government officials who can articulate a compelling vision for digital transformation. Additionally, the systematic documentation and dissemination of success stories from early adopters—particularly those demonstrating tangible business benefits in the Bangladeshi context—can help overcome skepticism through peer influence and social proof. Research on construction innovation adoption highlights the importance of "champion networks" that cut across organizational boundaries to create momentum for change, suggesting that Bangladesh's implementation strategy should intentionally cultivate and support such networks of influential advocates (Kineber *et al.*, 2023). Change management initiatives should acknowledge and address legitimate concerns while clearly communicating the risks of falling behind as regional competitors advance their digital capabilities. Technical challenges related to interoperability issues between different software platforms and data formats represent another significant implementation barrier with particular relevance to Bangladesh's heterogeneous technology landscape. Without consistent standards and protocols, BIM models may not transfer effectively between different stakeholders' systems, undermining the collaboration potential that represents one of BIM's primary value propositions. The mitigation strategy must emphasize the adoption of open BIM standards such as Industry Foundation Classes (IFC) and Building SMART Data Dictionary (BSDD), which facilitate information exchange across different software applications. Additionally, promoting vendor-neutral platforms and avoiding proprietary lock-in to specific software ecosystems will enhance long-term flexibility and reduce migration costs as technology evolves. International standards such as ISO 19650 provide a valuable framework for managing information throughout the asset lifecycle, and Bangladesh's national standards should align closely with these global references while addressing local requirements [Government of Bangladesh. (2020)]. Technical support mechanisms, including reference implementations and testing services for software interoperability, should be established to help organizations navigate these complexities during the initial adoption period. Finally, concerns about data security and intellectual property protection present significant challenges as BIM implementation expands, particularly as cloud-based collaboration becomes more prevalent. Comprehensive BIM models contain sensitive commercial information, proprietary design methodologies, and detailed facility data that could be vulnerable to unauthorized access or misuse if appropriate safeguards are not established. To address these concerns, Bangladesh's implementation strategy must include the development of robust cybersecurity protocols specifically tailored to BIM data management requirements. These protocols should address data encryption standards, access control mechanisms, audit trail requirements, and breach notification procedures. Additionally, legal frameworks must evolve to clarify data ownership rights, usage permissions, and liability allocations in case of security incidents, providing the certainty necessary for organizations to confidently participate in collaborative digital workflows (Uddin *et al.*, 2024). As a developing digital ecosystem, Bangladesh has the opportunity to incorporate security-by-design principles from the outset rather than retrofitting protection measures after vulnerabilities are exploited, potentially creating a more resilient foundation than many established markets that adopted BIM before cybersecurity emerged as a paramount concern. These security considerations should be integrated throughout the implementation framework rather than treated as an isolated technical issue, requiring ongoing attention as technology capabilities and threat landscapes continue to evolve (Table 1).

Table 1: Key Challenges and Corresponding Mitigation Strategies for BIM Implementation

Challenge Category	Specific Challenges	Proposed Mitigation Strategies
Financial Constraints	High upfront costs for software, hardware, and training; Limited capital among SMEs; Price-sensitive market	Implement phased investment approaches; Facilitate public-private partnerships for shared resources; Provide low-interest technology adoption loans; Promote cloud-based subscription models
Resistance to Change	Cultural attachment to traditional practices; Fear of role displacement; Risk-averse organizational culture	Visible leadership advocacy from industry figures; Documentation and dissemination of early adopter success stories; Development of "champion networks" across organizations; Targeted change management initiatives
Interoperability Issues	Software compatibility problems; Data format inconsistencies; Lack of standardized protocols	Adoption of open BIM standards (IFC, BSDD); Promotion of vendor-neutral platforms; Alignment with international standards (ISO 19650); Establishment of technical support and testing services
Data Security Concerns	Protection of sensitive commercial information; Intellectual property rights; Vulnerability in cloud-based systems	Development of cybersecurity protocols for BIM data; Implementation of encryption and access controls; Legal clarification of data ownership and liability; Security-by-design approach in implementation

Phased Investment and Financial Support Mechanisms

The paper's statistical risk measurement framework provides strong theoretical justification for phased BIM investment and financial support mechanisms in Bangladesh. The methodology treats implementation risks as measurable "occurrences" with assigned probabilities and potential costs, enabling data-driven decision-making (Liu *et al.*, 2024). A phased investment strategy directly addresses key risk categories identified in the paper. Management risks including unclear competencies and poor decision-making are mitigated by allowing organizational learning between phases. Employment risks (B1) varying workforce diligence and integrity are reduced through targeted training investments at each stage rather than overwhelming one-time programs (Acebes *et al.*, 2024). The paper's use of probability distributions (Beta PERT, triangular) and expected value calculations enables quantification of total risk exposure. For Bangladesh's resource-constrained construction sector, phased investment functions as a real-options approach: initial pilot phases provide empirical data to refine subsequent investment decisions. If risks prove higher than anticipated, further investment can be paused, capping potential losses (Aladayleh & Aladaileh, 2024). Financial support mechanisms government subsidies, low-interest loans, training grants become justifiable when risks are quantified using this methodology. By demonstrating that phased approaches reduce risk variance and make outcomes more predictable, stakeholders can build credible business cases for external funding. This transforms BIM adoption from a speculative high-risk leap into a managed, evidence-based process tailored to Bangladesh's specific construction context (Aladayleh & Aladaileh, 2024). From a mitigation perspective, phased investment should be complemented by governmental financial incentives, shared digital infrastructure platforms, and subsidized training programs. Such financial support mechanisms would lower entry barriers for SMEs, promote early pilot adoption, and create scalable pathways toward full BIM maturity within Bangladesh's construction sector (Ahmad *et al.*, 2025).

Champion Networks and Change Management

Champion networks and structured change management represent a critical mitigation strategy for overcoming resistance to BIM adoption. The referenced study emphasizes that BIM should not be treated merely as a technological tool, but as an integrated knowledge management platform that captures, organizes, and disseminates project intelligence across stakeholders. This perspective highlights that successful BIM implementation depends on active participation from multidisciplinary teams rather than isolated technical adoption (Bidhendi *et al.*, 2026). The paper demonstrates that BIM-based knowledge management systems incorporate structured information such as project data, team roles, IFC files, and "lessons learned," linking them to defined contributors and areas of expertise. Such structured knowledge environments require organizational champions individuals who promote collaborative data sharing, encourage knowledge contribution, and bridge communication gaps among architects, engineers, and project managers (Elalwani & Çalışkan, 2024). From a change management perspective, embedding knowledge contributors within BIM workflows fosters ownership and accountability. By formalizing information exchange and capturing experiential learning within IFC-based structures, organizations can reduce resistance rooted in uncertainty and fragmented communication. Therefore, cultivating champion networks supported by BIM-based knowledge systems can accelerate cultural transformation, enhance interdisciplinary collaboration, and ensure sustainable BIM maturity in Bangladesh's construction sector (Zhang *et al.*, 2024).

Adoption of Open Standards (IFC and ISO 19650)

The adoption of open standards such as Industry Foundation Classes (IFC) and ISO 19650 represents a critical mitigation strategy for ensuring effective and scalable BIM implementation in Bangladesh. The referenced global strategy paper emphasizes that national and global standards are fundamental to moving the industry toward world best-practice BIM protocols and collaborative design processes Without standardized data structures and exchange protocols, BIM risks reinforcing soloed workflows rather than enabling lifecycle integration (Jia *et al.*, 2024). Effective process and data exchange mechanisms are essential for integrating briefing, design, construction, manufacturing, and maintenance activities across the facility lifecycle. Open standards such as IFC directly address this need by enabling interoperability across different software platforms, while ISO 19650 provides a structured framework for information management throughout the asset lifecycle (Okonta *et al.*, 2024b). Furthermore, the development of a regulatory framework based on object-based information models is identified as necessary for automated compliance checking and performance assessment. Aligning Bangladesh's BIM roadmap with internationally recognized standards would therefore mitigate interoperability risks, prevent vendor lock-in, enhance collaboration, and ensure long-term digital sustainability within the national construction ecosystem (Godager *et al.*, 2024).

Cybersecurity and Legal Framework Development

Cybersecurity and legal framework development functions as a core mitigation strategy to address the growing risks associated with BIM-enabled collaborative environments. The referenced paper demonstrates that BIM-based Common Data Environments (CDEs) operate across multiple organizations within temporary project networks, creating complex governance and accountability challenges. In such fragmented ecosystems, the absence of sector-specific cybersecurity regulations exposes projects to data breaches, intellectual property theft, and contractual disputes. (Turk *et al.*, 2022).As a mitigation measure, the study proposes structured cybersecurity governance aligned with the UK National Cyber Security Centre's Cyber Assessment Framework (CAF), which provides principles for risk management, access control, incident response, and supply-chain security. However, it stresses that generic frameworks must be tailored to construction's project-based and multi-stakeholder nature. Furthermore, existing international cybersecurity standards do not specifically address construction-sector vulnerabilities, reinforcing the need for a dedicated BIM cybersecurity framework. (Turk *et al.*, 2022)

Research Objectives

1. Promote Awareness and Understanding of BIM to increase knowledge about Building Information Modeling (BIM) among engineers, architects, and stakeholders.
2. Enhance Skills and Training Capacity to provide professional training programs and develop skilled BIM users.
3. Encourage Industry-wide Implementation and Collaboration to promote BIM usage across all stages of construction (design, construction, operation).
4. Develop National Policies and Regulatory Framework to establish government guidelines, standards, and legal support for BIM implementation.
5. Improve Project Efficiency and Sustainability to use BIM for reducing cost, time, and errors while enhancing sustainability.

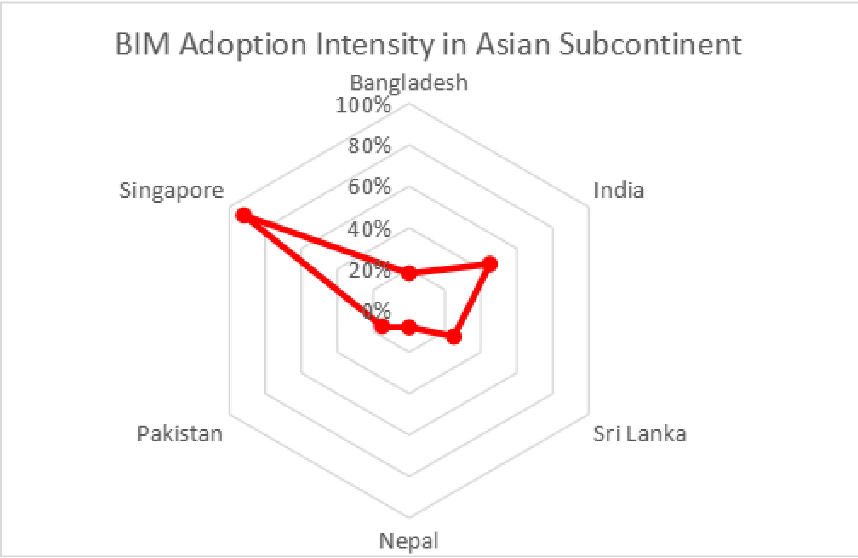

Figure 3: BIM Adoption Ratios Asian Subcontinent

MATERIALS AND METHODS

Bangladesh is one of the most densely populated countries in the world, with an urbanization rate exceeding 5% annually (Manik, 2024). Dhaka, the capital, faces severe infrastructure pressures, including housing shortages, traffic congestion, and environmental degradation (Rahman *et al.*, 2025). The construction sector, a major contributor to GDP, is characterized by informal practices, fragmented project delivery, and reliance on labor-intensive methods. The increasing demand for efficient construction practices, the integration of Building Information Modeling (BIM) remains limited, BIM adoption in Bangladesh is still in its infancy, with less than 10% of projects utilizing BIM, primarily due to lack of awareness, insufficient technical expertise, high implementation costs, and absence of regulatory frameworks. Lack of comprehensive studies focusing on awareness and knowledge of BIM among key stakeholders (Durdyev *et al.*, 2021b).Insufficient investigation into the role of education, training, and capacity-building programs. This study employs a qualitative research methodology based on an extensive review of global BIM literature, case studies, and policy documents. Sources include academic journals, industry reports (e.g., McGraw Hill, NBS), and governmental publications from leading BIM-adopting countries. The analysis focuses on extracting key strategies, best practices, and lessons applicable to the Bangladeshi context. The findings are synthesized to develop a strategic framework for BIM implementation in Bangladesh, addressing technological, regulatory, economic, and social dimensions.

RESULTS AND DISCUSSION

Strategic Framework for BIM Adoption in Bangladesh

Drawing from global best practices, the following strategic framework is proposed for BIM implementation in Bangladesh's Smart City context.

Foundation and Awareness

Awareness and understanding of Building Information Modeling (BIM) can be examined through the interaction between awareness driven initiatives and the resulting level of comprehension and adoption among construction professionals. The extent of BIM awareness initiatives

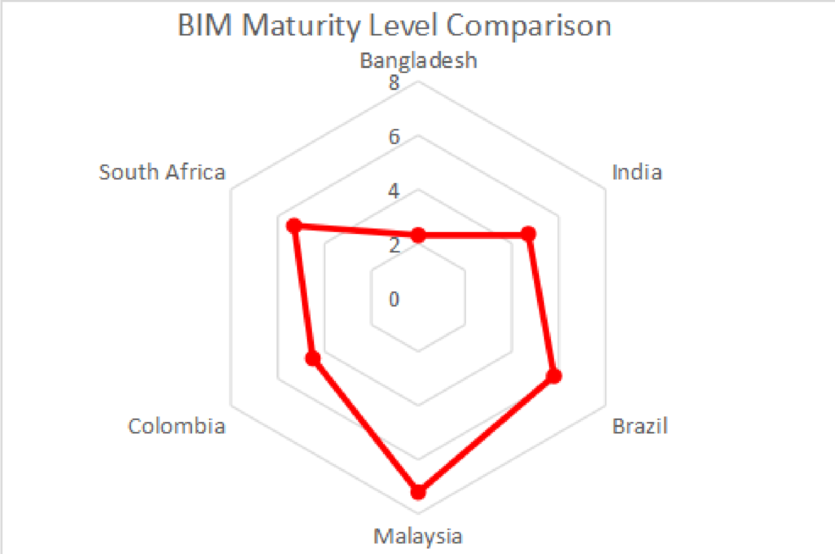

Figure 4: Global BIM Adoption Rates of Developing Countries

such as academic curriculum inclusion, professional workshops, seminars, and industry campaigns serves as the independent variable, as it represents the primary input that can be strategically enhanced. The dependent variable, in turn, is the level of understanding and practical adoption of BIM practices within the industry. Existing literature consistently indicates that awareness alone does not guarantee effective implementation unless it is supported by deeper knowledge and training (El Asri & Benhlima, 2022).For example, a study found that while general awareness of BIM concepts is increasing, the lack of structured educational exposure limits its practical application. Similarly, (Shanto *et al.*, 2025) revealed that although a significant proportion of professionals have familiarity with BIM, only a much smaller percentage contains adequate technical understanding, indicating a gap between awareness and competency (Shanto *et al.*, 2025). Furthermore, observed that in environments where awareness levels are minimal, BIM adoption remains extremely limited, reinforcing the importance of early-stage knowledge dissemination (Ali, 2025). These findings collectively suggest that increasing the intensity and quality of awareness initiatives has a direct and positive influence on improving understanding, which ultimately facilitates broader BIM adoption in Bangladesh and other developing countries.

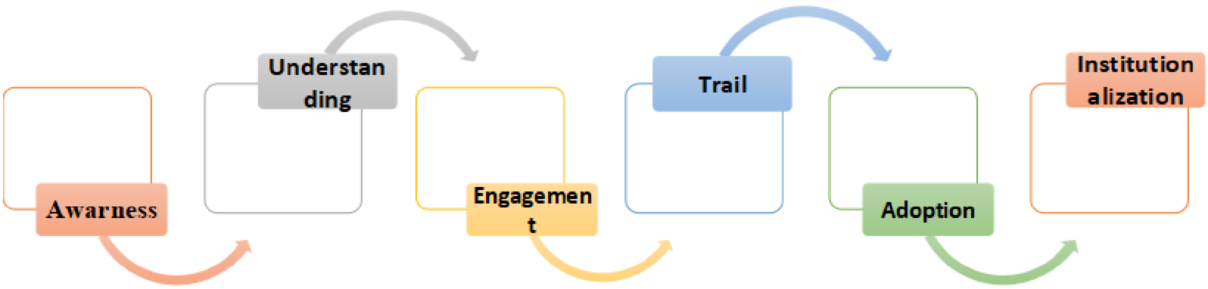

Figure 5: Variables to BIM Adoption Metrics.

Enhance Skills and Training Capacity

Skills and training capacity for BIM adoption can be understood through the relation between training initiatives and professional competency levels. The availability and quality of BIM training programs function as the independent variable, while the level of BIM skills and competencies among professionals serves as the dependent variable. Empirical evidence suggests that inadequate training is a major barrier to BIM implementation. Skill development is essential for effective BIM use (Sacks *et al*). Additionally, lack of training significantly limits BIM uptake in developing countries (Papuraj *et al.*, 2025b). This indicates that increasing training opportunities will directly enhance workforce capability and BIM adoption.

Encourage Industry Wide Implementation and Collaboration

Encouraging industry-wide BIM implementation and collaboration can be described through the interaction

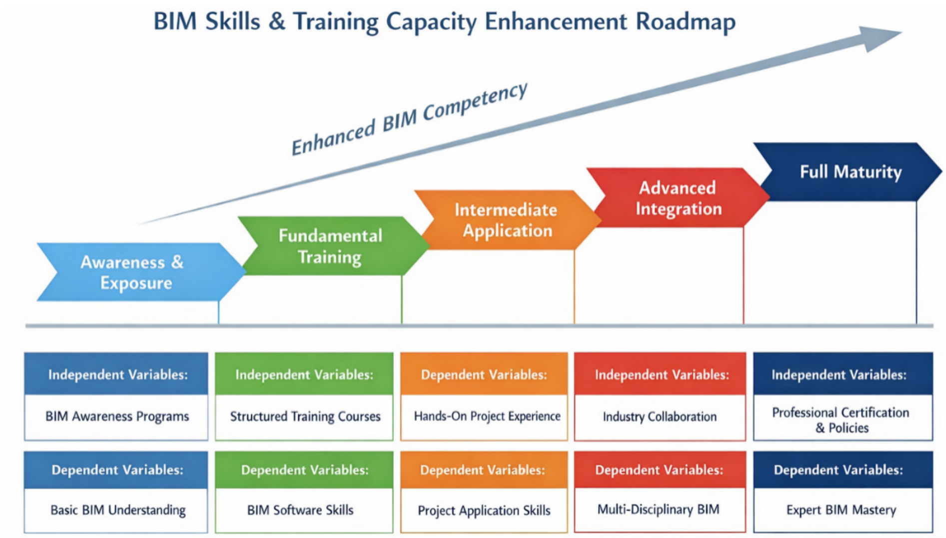

Figure 6: Skills And Training Capacity for BIM Adoption

between collaborative practices and project integration outcomes. The level of collaborative BIM practices among stakeholders (architects, engineers, contractors) acts as the independent variable, while the degree of integrated BIM implementation across project phases serves as the dependent variable. Research shows that BIM's effectiveness depends heavily on collaboration found that BIM improves coordination and reduces project conflicts (Olugboyega *et al.*, 2024). Moreover, emphasized that collaborative workflows are central to BIM success (Sun *et al.*, 2025). Thus, stronger collaboration leads to more effective and comprehensive BIM implementation.

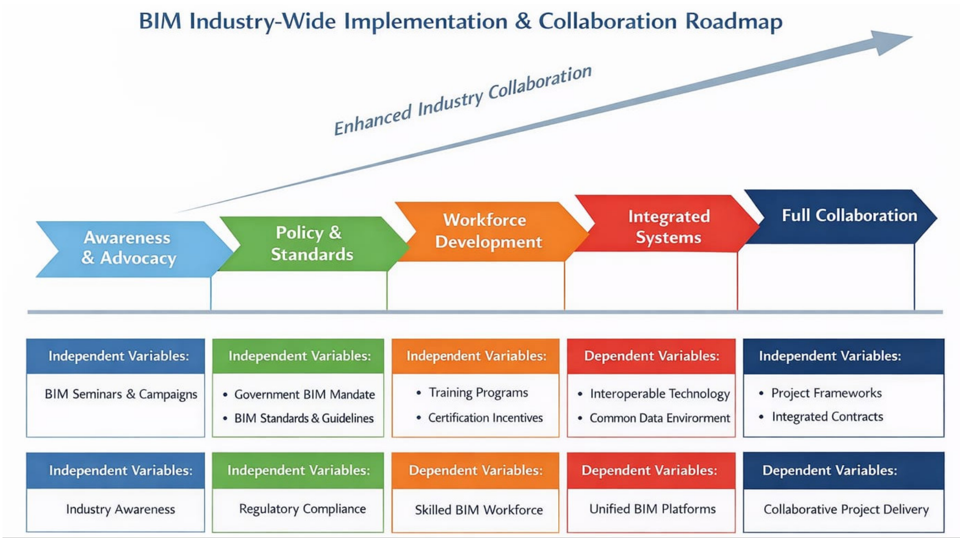

Figure 7: BIM Roadmap Industry-Wide Implementation

Develop National Policies and Regulatory Framework

The development of national policies and regulatory frameworks for BIM adoption can be explained by examining how the governance structures influence implementation practices. The strength and clarity of BIM-related policies and regulations act as the independent variable, while the level of standardized BIM implementation across the construction industry represents the dependent variable. Studies indicate that the absence of clear regulatory guidelines significantly hinders BIM adoption. Policy frameworks are critical for guiding consistent BIM practices. Furthermore, the countries with well-defined national BIM mandates achieve higher implementation rates (Hagan *et al.*, 2025b). Therefore, stronger policy support directly contributes to structured and widespread BIM adoption.

Improve Project Efficiency and Sustainability

Efficiency and sustainability of project through BIM adoption could be amplify by examining how BIM usage influences project performance outcomes. The extent of BIM utilization in project lifecycle management acts as the independent variable, while the level of project efficiency (cost, time, error reduction) and sustainability performance serve as the dependent variable. Studies have demonstrated that BIM significantly enhances project outcomes. Reported that BIM reduces costs and improves efficiency (Fuzi *et al.*, 2024). Similarly, found that BIM supports sustainable design and resource optimization (Al Aamri *et al.*, 2025). Therefore, increased BIM usage leads to more efficient and sustainable construction practices. The graph represents the UK BIM adoption framework and illustrates how increasing levels of BIM implementation contribute to improved project efficiency and performance outcomes. There are significant reductions in project duration, cost overruns, design errors, and rework. This pattern reflects the success of the UK Government BIM mandate, which established structured policies and standards to ensure consistent implementation across the construction industry.

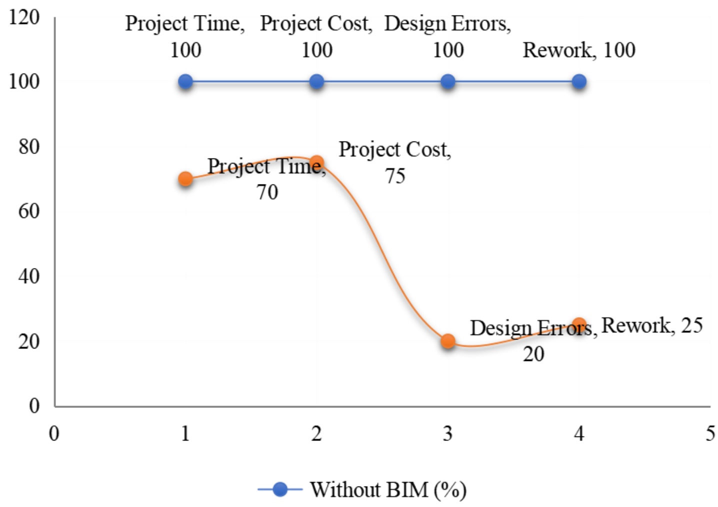

Figure 8: Efficiency of Project with and without BIM Based on Time, Cost, Errors and Rework

Potential Benefits for Bangladesh's Smart Cities

The strategic implementation of BIM across Bangladesh's construction sector promises to deliver transformative benefits that extend far beyond individual project improvements to fundamentally enhance how cities are planned, built, and managed. These advantages align closely with the objectives of Bangladesh's Smart City initiatives, providing the technological foundation for more efficient, sustainable, and resilient urban development that improves citizens' quality of life while optimizing resource utilization. Perhaps the most immediately recognizable benefits relate to enhanced project efficiency throughout the design and construction process. BIM facilitates automated clash detection that identifies conflicts between building systems before construction begins, significantly reducing the costly rework that typically occurs when These problems are discovered on-site. The technology enables optimized construction sequencing through 4D simulations that visualize the construction process over time, allowing project teams to identify potential logistical challenges and safety hazards before mobilization. Furthermore, BIM supports improved design coordination among architectural, structural, and mechanical disciplines, reducing the information gaps and misinterpretations that frequently cause delays in traditional project delivery approaches. Research on BIM implementation in developing countries has documented efficiency improvements of 20-30% in project timelines when these capabilities are effectively utilized, with particularly significant benefits for complex infrastructure projects common in urban development initiatives (Bamgbose *et al.*, 2024). Complementing these efficiency gains are substantial opportunities for lifecycle cost savings through better planning and resource management. BIM's capability for accurate quantity takeoffs and automated cost estimation (5D BIM) enables more reliable budgeting and reduces contingency allowances typically required to accommodate uncertainties in traditional estimating methods (Agwa & Celik, 2025). During construction, the technology supports material optimization and waste reduction through precise fabrication information and just-in-time delivery coordination. Perhaps most significantly, BIM models containing comprehensive asset information can dramatically reduce facility management costs over a building's operational life, with studies indicating that owners recoup 75-80% of their BIM investment through improved maintenance efficiency and reduced operational disruptions (Ndwandwe *et al.*, 2024). For Bangladesh's public sector, which faces continual budget constraints while addressing massive infrastructure needs, these cost management capabilities represent a compelling value proposition that extends throughout the asset lifecycle. From a sustainability perspective, BIM offers powerful tools for improved energy modeling, waste reduction, and compliance with green building standards all critical components of sustainable urban development. The technology enables sophisticated analysis of building performance during the design phase, allowing architects and engineers to optimize orientation, envelope design, and system selection for energy efficiency before commitments are made to specific construction approaches. BIM supports construction waste minimization through precise material quantification and prefabrication opportunities, addressing a significant environmental concern in Bangladesh's construction sector. Furthermore, the technology facilitates performance-based compliance checking against sustainability standards such as those outlined in Bangladesh's own Green Building guidelines, automating what is traditionally a labor-intensive manual verification process (Forcael *et al.*, 2025). These sustainability applications position BIM as an essential tool for achieving the environmental objectives embedded in Bangladesh's Smart City vision while delivering tangible economic benefits through reduced operational costs. BIM implementation also promises significant safety enhancements through simulated safety planning and risk mitigation in complex urban projects. The technology enables hazard identification during the design and planning stages through 4D simulations that reveal potential safety conflicts before workers ever arrive on-site. BIM supports the development of site-specific safety plans that account for the unique challenges of congested urban construction environments, which are particularly relevant to Bangladesh's dense cities. Furthermore, the technology facilitates safety training through immersive virtual experiences that prepare workers for site conditions without exposing them to actual risks. International studies have documented 40-50% reductions in reportable safety incidents on construction projects utilizing BIM for safety planning, with particularly significant improvements in preventing falls from height and struck-by incidents two of the most common causes of serious injuries in construction globally (Karim *et al.*, n.d.; Uddin *et al.*, 2024). For Bangladesh, where construction safety represents an ongoing challenge, these capabilities offer the potential for transformative improvement in worker welfare alongside project efficiency.

Finally, BIM enables data-driven urban governance through integration with Geographic Information Systems (GIS) and other smart city platforms. This integration creates comprehensive digital twins of urban areas that support informed decision-making across multiple domains, from infrastructure planning and traffic management to disaster preparedness and environmental monitoring. BIM models of individual buildings and infrastructure elements can be aggregated to understand neighborhood-scale impacts and optimize resource allocation for services such as water distribution, waste collection, and emergency response. The interoperability between BIM and GIS is particularly valuable for visualizing underground utilities and understanding the complex interactions between built and natural environments in flood-prone areas like Dhaka (Owais *et al.*, 2025). This holistic data-driven approach to urban management represents the realization of the Smart City concept, moving beyond isolated technological applications to create an integrated digital ecosystem that supports sustainable, resilient, and responsive urban development tailored to Bangladesh's specific challenges and opportunities.

CONCLUSION

The comprehensive implementation of Building Information Modeling across Bangladesh's construction industry represents a formidable but essential undertaking that aligns directly with the nation's aspirations for sustainable urban development and technological advancement. The phased framework outlined progressing from foundational awareness through capacity building to mandatory implementation provides a structured pathway that acknowledges both the transformative potential of digital construction technologies and the practical realities of Bangladesh's current industry landscape. This journey requires sustained commitment across multiple domains: from governmental leadership in establishing clear policy direction and regulatory frameworks, to educational institutions in developing future-ready professionals, to industry organizations in adapting business models and workflows to capitalize on new technological capabilities. The cross-cutting enablers of legal reform, research investment, and international collaboration will prove equally crucial in creating an ecosystem where BIM can deliver its full potential value rather than functioning as merely an isolated technical tool. While significant challenges undoubtedly await particularly regarding financial constraints, cultural resistance, and technical interoperability these obstacles are neither unique to Bangladesh nor insurmountable with thoughtful, context-sensitive mitigation strategies. The compelling benefits for Bangladesh's Smart City initiatives from enhanced project efficiency and lifecycle cost savings to improved sustainability outcomes and data-driven governance justify the substantial investment required. As Bangladesh positions itself for continued economic growth and urban development in the coming decades, strategic adoption of digital construction technologies like BIM will prove instrumental in building the resilient, efficient, and sustainable cities that its citizens deserve, while enhancing the global competitiveness of its construction industry in an increasingly digital world. BIM represents a critical enabler for Smart City development in Bangladesh, offering pathways to more efficient, sustainable, and resilient urban infrastructure. While challenges exist, the global experience provides a clear blueprint for success centered on government leadership, standardization, education, and strategic partnerships. By adopting a phased, collaborative approach, Bangladesh can leapfrog traditional construction practices and position itself as a leader in digital construction within South Asia. The time for action is now delaying BIM adoption risks widening the gap with global peers and missing opportunities for transformative urban development.

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