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Article

Barriers and Challenges in BIM-Enabled Facility Management: A Delphi Study in Thailand

Tanapat Namjan [1], Sunun Monkaew [1,*], Kwanchanok Oonta-on [1], Atikom Rueangsakpakdee [2], Chookiat Choosakul [3] and Gritsada Sua-iam [1]

[1] Faculty of Engineering, Rajamangala University of Technology Phra Nakhon (RMUTP), Bangkok, 10800, Thailand.
[2] Policy and Planning, Rajamangala University of Technology Phra Nakhon (RMUTP), Bangkok, 10300, Thailand.
[3] College of Industrial Technology and Management, Rajamanagala University of Technology Srivijaya, Nakhon Si Thammarat, 80210, Thailand.
* Correspondence author: sunun.m@rmutp.ac.th

Abstract: Building Information Modeling for Facility Management (BIM-FM) has gained increasing attention as an approach to improving building operation and lifecycle management. However, BIM-FM adoption in Thailand remains limited due to organizational, technological, and managerial challenges. This study aims to identify and prioritize the barriers affecting BIM-FM adoption within the Thai context using the Delphi method. A two-round Delphi study was conducted with 29 experts from academia and industry with experience in BIM-FM. The questionnaire was developed based on a literature review and expert interviews. The findings indicate that insufficient management support, budget limitations, inadequate training, shortages of BIM-FM experts, and the lack of standardized data management practices are the most significant barriers. The results also suggest that these barriers are interrelated and can be categorized into three levels: root causes, operational barriers, and outcome barriers. In addition, the study proposes a BIM-FM implementation framework to support sustainable facility management practices. This research contributes to the BIM-FM body of knowledge by providing empirical evidence from a developing-country context and highlighting the influence of organizational and policy-related factors on BIM-FM adoption in Thailand.

Keywords: Building information modelling; Facility management; Barriers and challenges; Construction industry.

1. Introduction

The construction industry has developed alongside human civilization, yet it continues to be plagued by declining efficiency due to reliance on traditional solving strategies, outdated technologies, and the lack of creative solutions that adapt to sustainability targets (Nagy et al., 2021). In the rapidly evolving digital era, every industry needs to get in line with emerging challenges in order to survive. The construction industry, in particular, must embrace new technologies and innovations to enhance its competitive edge and step into the "Digital Construction" age. Emerging construction technologies such as 3D printing, virtual reality, robots, and BIM have been increasingly used in the industry. The global need for BIM has been increasing as the global agencies and government also actively promote its adoption (Nor et al., 2016). BIM is now the universally accepted industry standard in every one of the architecture, engineering, and construction (AEC) disciplines as a transformational tool to process, manage, store, and share building, construction, and maintenance information throughout the entire life cycle of a building project (Chan et al., 2019; Aakash et al., 2024).BIM enables the storage of digital information related to building configurations and other critical project details, thereby supporting more efficient and accurate life cycle assessment (LCA) processes (Al-Habaibeh et al., 2024). During the design phase, BIM facilitates project integration and success (Shirowzhan et al., 2020). Its benefits are improved efficiency, minimized errors, and increased transparency along with better interaction among project participants through the creation of high-quality digital models with decision-making support (Saka & Chan, 2021; Croce et al., 2021; Schönfelder et al., 2023; Volk et. al., 2014). Besides this, BIM enhances building construction project productivity (Li et al., 2019), improves organizational performance (Lee et al., 2015), and diminishes construction disputes (Wang et al., 2023).

Apart from project execution, BIM enables improved communication, project planning, monitoring, and control to ensure successful project delivery (Aka et al., 2021; Ismail et al., 2022). It also saves time and costs (Mohammed, 2024), enables improved communication among stakeholders, and maximizes the use of project data (Bradley et al., 2016). BIM also enables coordination among designers and engineers (Shim et al., 2011), minimizes construction conflicts (Liu et al., 2015), and aids sustainable construction through maximum energy usage and reduced material wastage (Haruna et al., 2021). The integration of artificial intelligence (AI) with BIM has been shown to significantly reduce discrepancies between predicted and actual energy consumption values (Mahasneh & Almigbel, 2024). BIM-generated data, collected throughout a project's lifecycle, is instrumental in maintaining optimal operational status, predicting maintenance needs, and enhancing infrastructure safety (Costin et al., 2018). Moreover, BIM serves as an effective tool for assessing carbon emissions in new construction projects (Hao et al., 2020).

Despite these advantages, the uptake of BIM in the construction industry is restricted by several factors including a deficiency in acceptance and awareness among personnel, poor training, issues concerning standardization, and data integration issues across various systems (Chen et al., 2018). Additionally, the cost of adopting BIM and managing big data is of greatest concern to most stakeholders (Olanrewaju et al., 2021). Although barriers to BIM adoption have been widely studied within the general construction industry context, the application of BIM for FM continues to face distinct challenges, particularly in relation to lifecycle data management, interoperability between BIM and FM systems, asset information requirements, and long-term data integration for operational support. Consequently, the barriers affecting BIM-FM adoption differ from those associated with BIM implementation during the design and construction phases. In Thailand, implementation of BIM in building management is still low owing to various barriers that must be researched further. This study aims to explore and analyze barriers preventing the implementation of BIM in Thai construction industry building maintenance. It also aims to propose solutions to minimize the barriers and enhance the effectiveness of BIM in FM. By addressing these problems, the study contributes to the enhanced application of BIM, eventually resulting in an improved working environment and promoting the development of the construction industry in Thailand.

2. Literature review

2.1. Barriers and challenges in the adoption of BIM in the construction industry

The demand for BIM is gradually increasing as various international organizations and governments promote its use throughout the building lifecycle (Nor et al., 2016). However, large-scale adoption still faces major challenges, particularly in developing countries (Olanrewaju et al., 2021) and SMEs (Bamgbose et al., 2024). Past research identifies several factors behind these challenges. Bamgbose et al. (2024) found that SMEs in Nigeria faced system incompatibility, BIM-related risks, lack of resources, low client support, and skill gaps. Gerrish et al. (2017) noted that one major issue is the lack of standardized methods for interpreting and exchanging BIM data. Building managers often lack proper skills, and current data processes are inadequate, making the development of new standards difficult.

Similarly, Hamma-Adama & Kouider (2019) identified 13 barriers in Nigeria, including lack of in-house capability, poor technical skills, unclear standards, no client/government support, limited funding, team resistance, high capital costs, infrastructure gaps, unclear ROI, and ownership issues. Saka & Chan (2020) highlighted excessive costs, training expenses, contract uncertainties, and poor awareness in SMEs. Saka et al. (2020) further emphasized issues with organizational readiness, software compatibility, policy gaps, client requirements, executive sponsorship, and corporate culture. Wang et al. (2015) listed insufficient BIM skills, poor awareness, costly training, and expensive software/hardware as barriers. Mohammed (2024) added challenges in training, resistance to change, lack of business value clarity, high cost, unclear standards, and weak government support.

Ata et al. (2025) stated that executive support, organizational culture, available specialists, ease of use, competition, and policy drive BIM adoption in Palestine. Sexton et al. (2006) pointed to sensitivity to BIM benefits, executive backing, financial resources, and organizational culture. Alreshidi et al. (2017) reported social, financial, and technical issues in the UK. Lin & Hsu (2021), Xu *et al.* (2014), and Mutis & Mehraj (2022) emphasized collaboration issues stemming from inconsistent BIM meanings. Ismail et al. (2022) found Malaysian SMEs hampered by financial costs, training, licensing, and software investment aligned with Lee et al. (2012). Saka et al. (2019) confirmed training expenses, resistance, lack of specialists, and poor education on BIM's benefits as major concerns.

Schönfelder et al. (2023), Tan et al. (2019), and Jamal et al. (2019) emphasized professional shortages as a key issue, particularly in forming in-house BIM teams. Zahrizan et al. (2014) added poor stakeholder collaboration, low client demand, and low investment. Ben et al. (2022) noted technology-related issues in Canadian SMEs, such as incomplete software libraries and need for continuous training. Javaherikhah et al. (2025) noted that BIM-blockchain integration offers precision and real-time monitoring but faces complexity, cost, and security risks. Khoshfetrat et al. (2022) reported ignorance, training needs, resistance, and lack of BIM engineers. Sander et al. (2021) added staff motivation, organizational limits, and time constraints, particularly under weak executive leadership. Lastly, Faizal & Mohammad (2019) observed low BIM adoption in Indonesia due to lack of professionals and weak technical resources.

2.2. Barriers and challenges in implementing BIM for facility management

BIM has drawn more attention from the architecture, engineering, construction, and operations (AECO) sector in the last decade. The revolutionary technology is of major value to enhancing operating processes, design, and construction procedures (Marocco & Garofolo, 2021). Facility managers can use the adoption of BIM in building maintenance management to automate preventive maintenance decision-making, budgeting, asset and space management (Becerik et al., 2012). Moreover, it allows system analysis and test procedures to be built (Becerik et al., 2012), emergency response plans to be created (Zou & Wang, 2009), and decommissioning and re-use strategies to be implemented (Volk et al., 2014). The increasing complexity of building systems and occupant behavior has created a growing need for data-driven solutions to enhance energy efficiency while maintaining optimal indoor environmental quality (Onweh et al., 2025). In this context, BIM can serve as a critical platform for collecting, analyzing, and integrating real-time building data, thereby supporting intelligent building management and more effective sustainability-oriented decision-making.

BIM-based building management extends beyond construction and design and can take a longer time. Enhancing efficiency in the FM stage can make processes less redundant, more effective, and reduce training, maintenance, and operational expenses (Pishdad-Bozorgi et al., 2018). BIM has been applied primarily in design and construction, whereas its application in FM is still underutilized. A lack of established methodologies has led to issues in utilizing BIM in operations in a structured manner (Patacas et al., 2020). A Taiwanese case study found issues like the lack of updating BIM-FM models, no creation of BIM-FM for new buildings, and limited time for model development (Lin et al., 2022). Durdyev et al. (2022) discussed BIM adoption challenges in New Zealand during the FM phase, highlighting software/hardware costs and training fees. Similarly, McArthur (2015) found four challenges in developing BIM for sustainable operations: identifying needed data, resource demands for model updating, coordination of data exchange with real-time monitoring, and incomplete documentation.

Matarneh et al. (2019) noted interoperability and information exchange between BIM and FM systems are critical. Duong & Lin (2022) added that FM is the most expensive and longest lifecycle stage. However, low-quality blueprints and poor data in most buildings hinder efficient FM processes. Lovell et al. (2024) reported BIM-FM is not fully developed due to unknown user requirements. Moreover, FM involves complex data management not easily handled by BIM tools (Lu et al., 2019; Kameli et al., 2021; Ciccone et al., 2022). Interoperability issues among tools and differing requirements between BIM and FM teams further restrict integration (Kula & Ergen, 2021; Matarneh et al., 2019). BIM-FM data consistency needs proper data handover without excess, keeping necessary data ready for FM use (Dias & Ergan, 2020). Excessive data management costs (Floros & Ellul, 2021), duplicate data (Fang et al., 2022), and poor-quality models can carry errors into FM (Leygonie, 2022). Absence of FM information in BIM remains a major limitation (Dixit et al., 2019; Benn & Stoy, 2022; Stride et al., 2020), compounded by FM experts' lack of BIM awareness (Tsay et al., 2022). Sadeghi et al. (2023); Alnaggar & Pitt (2019) found proprietary naming in design-phase BIM models impedes data exchange in FM. Naghshbandi (2016) questioned COBie's efficiency in FM data exchange, aligning with Gao & Pishdad-Bozorgi (2019). Javaherikhah & Sarvari (2025) showed BIM's strengths in airport

FM but noted barriers such as resistance to change, high costs, technical skill requirements, and reluctance to adopt new workflows.

Hussien et al. (2025) explored BIM adoption challenges among SMEs in Iran, identifying key barriers: employer demand, BIM awareness and implementation, ROI assurance, and regulation mechanisms. Ehab et al. (2024) listed barriers such as high cost, staff shortage, data complexity, integration issues, and cyber security. Wijeratne et al. (2024) emphasized protecting BIM-generated data in digital ecosystems. Yang & Mao (2021) added low corporate initiative, poor knowledge, long payback times, and complexity in O&M applications. Liu (2023) pointed to resistance, differing BIM readiness, no standard data format, and piecemeal strategies. Academic studies continue to highlight persistent technological, economic, organizational, and regulatory barriers.

3. Research methodology

3.1. Questionnaire design and details

This study begins with a comprehensive literature review of previous research and expert interviews to identify the key challenges associated with the adoption of BIM in the construction industry in Thailand. Findings obtained from the literature review and interviews were systematically integrated, analyzed, and categorized, leading to the development of the final set of barrier factors employed in the subsequent survey phase. Based on the findings, five major categories of barriers to BIM adoption in building facility management (Figure 1) were identified:

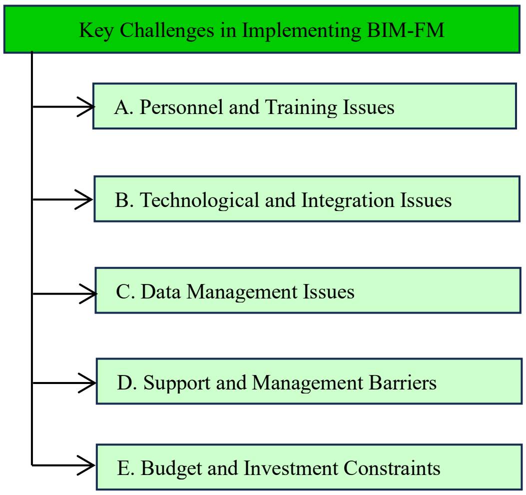

Figure 1. Key challenges in implementing BIM for facility management in Thailand

3.2. Experts' choice

The above-mentioned barriers were placed in a formal questionnaire and distributed to 29 industry experts with practical experience in using BIM-FM. The group of experts included project managers, engineers, architects, and facility managers. A purposive sampling approach was employed for expert selection based on the following criteria: (1) a minimum of five years of industry experience, (2) involvement in projects utilizing BIM, (3) knowledge and experience in FM and (4) experience in digital data integration and the application of BIM to support building operation and maintenance throughout the building lifecycle. The questionnaire employed a five-point Likert scale (Likert, 1932) to analyze the level of severity of each barrier.

3.3. Data analysis

The Delphi Technique was applied in data analysis since it is widely accepted as a systematic method of collecting the opinion of experts and achieving a consensus (convergence of opinion) on complex issues. The Delphi technique is well suited for investigating complex issues with limited empirical evidence, as it systematically gathers expert opinions through an iterative process. This approach helps reduce variability in responses, improve consensus among experts, and allow participants to refine their views based on feedback. In addition, respondent anonymity minimizes bias caused by social pressure or dominant individuals, thereby enhancing the objectivity and reliability of the findings (Okoli & Pawlowski, 2004; Dalkey & Helmer, 1963). Therefore, the results are appropriate for supporting policy development and decision-making related to BIM implementation in FM. The technique is best suited for research with diverse opinions and expert judgment. Past studies reveal that Delphi studies should involve at least 10-15 experts (Hsu & Sandford, 2007), though fewer numbers of experts, i.e., 5-10, can also offer valid consensus findings in certain situations (Skulmoski et al., 2007; Dalkey & Helmer, 1963). Delphi technique is comprised of iterative rounds of data collection to close expert views and enhance result credibility. At least two rounds of data collection were conducted to assist credibility (Fernandez-Avila et al., 2020). The combined use of mean, median, and interquartile range (IQR) can effectively enhance the reliability of consensus evaluation and data stability in Delphi studies (Holey et al., 2007). To ensure consistency of responses, the following statistical measures were computed:

- Mean (Arithmetic Average): Reflects overall significance of each issue.
- Median: Establishes central tendency of the responses.
- Mode: Reveals the score most selected.
- Interquartile range (IQR): Measures the spread of responses to test variability.

3.4. Consensus criteria

The consensus criteria applied in this study were adapted from the Delphi technique guidelines proposed by Mengual-Andrés et al. (2016) and Von Der Gracht (2012). Cases that did not meet these criteria were excluded from the final analysis. Final consensus was determined based on the following criteria:

- The mean score must be 3.0 or higher, indicating a moderate to high level of importance for the issue.
- The difference between the median and mode should not exceed 1, indicating consistency in expert opinions.
- The interquartile range (IQR) should not exceed 1.5, indicating an acceptable level of consensus among the experts.

3.5. Iterative data collection process

The Delphi study in this research was conducted in two rounds. In the first round, experts evaluated the importance of barriers to BIM-FM implementation using a five-point Likert scale questionnaire. The collected data were then analyzed using descriptive statistics, including Mean, Median, Mode, and IQR. The summarized results were anonymously provided as feedback for the subsequent round. In the second round, the experts reviewed the group responses and were given the opportunity to revise their initial answers in order to improve consensus and enhance the reliability of the findings. The process continued until a stable level of consensus was achieved (Grime & Wright, 2016). All items satisfied the predefined consensus criteria, and no significant changes in the evaluation scores were observed during the second round. Conceptually, the research procedure is illustrated in Figure 2.

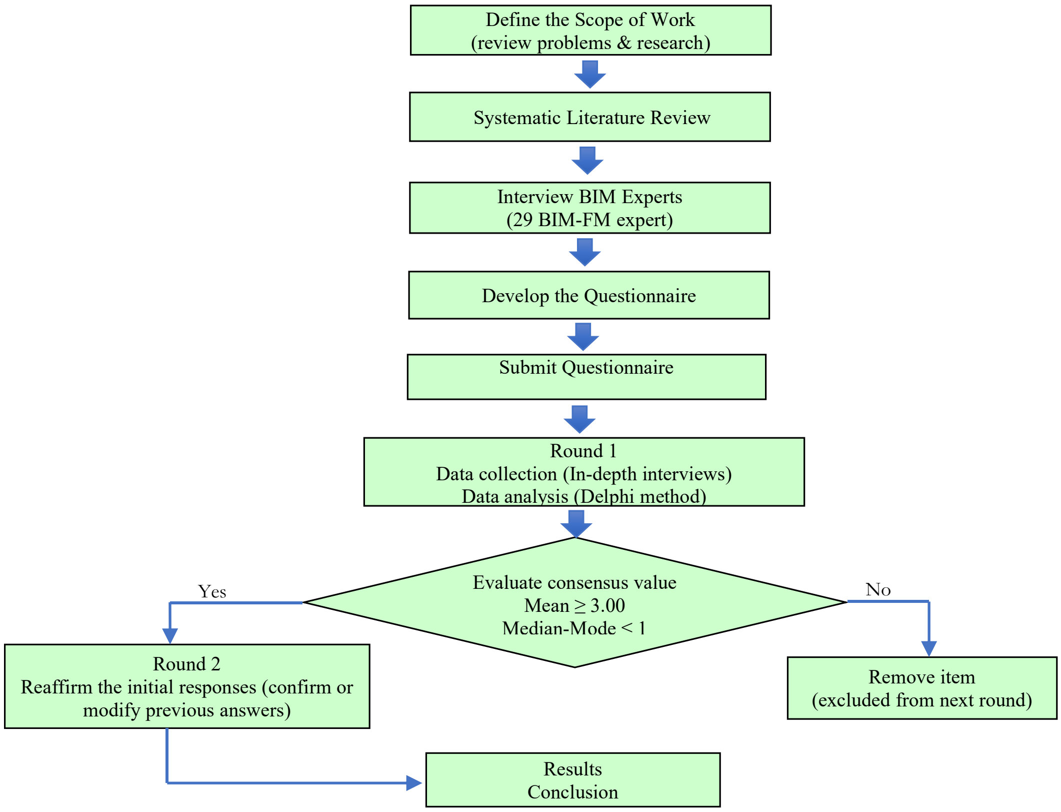

Figure 2. Summary research procedure

4. Results

To evaluate the key challenges associated with the implementation of BIM in building management in Thailand, a survey was conducted among 29 experts with practical experience in BIM applications. The expert panel included project managers, engineers, architects, and facility managers. The results from the first round of the survey are presented in Table 1.

Table 1. Results of the first-round survey

Problem Statement	Mean*	Median-Mode	IQR**	Result
A. Personnel and training issues				
A1. Lack of personnel readiness	3.65	0	1	Passed
A2. Insufficient training programs	4.39	0	1	Passed
A3. Resistance to change among personnel	3.63	0	1	Passed
A4. Lack of knowledge and understanding of BIM	3.80	0	1	Passed
A5. Shortage of BIM-FM specialists	4.35	0	1	Passed
A6. Lack of motivation to adopt BIM	1.99	1	1	Not Passed
A7. Heavy workload preventing BIM learning	2.35	0	1	Not Passed
B. Technology and integration issues				
B1. Software or hardware-related issues	2.31	0	1	Not Passed
B2. Incompatibility of software or hardware	2.17	1	2	Not Passed
B3. Interoperability issues among BIM software	3.48	0	1	Passed
B4. BIM models being too large for practical use	2.78	0	0	Not Passed
B5. Integration issues between BIM and FM systems	3.51	0	1	Passed
B6. BIM's inability to fully integrate with other technologies	2.13	0	1	Not Passed
B7. High data requirements of BIM	2.05	0	1	Not Passed
B8. Difficulties in integrating BIM with maintenance workflows	1.87	1	1	Not Passed
C. Data management issues				
C1. Complexity in managing BIM data	2.07	0	2	Not Passed
C2. Inconsistencies in BIM-generated data	1.45	0	1	Not Passed
C3. Lack of standardized BIM data management	4.24	0	1	Passed
C4. Challenges in updating BIM data	3.66	0	2	Not Passed
C5. BIM data not aligning with real operational needs	2.13	0	1	Not Passed
C6. Issues with data quality in BIM models	2.14	1	2	Not Passed

C7. Inappropriate Level of Detail (LOD) specification	1.84	0	1	Not Passed
C8. Unclear ownership of BIM data	3.88	0	0	Passed
C9. BIM containing excessive information for FM use	2.04	0	0	Not Passed
C10. Lack of clear Key Performance Indicators (KPIs) for BIM-FM	2.30	0	1	Not Passed
D. Support and management barriers				
D1. Inadequate management support for BIM implementation	4.65	0	1	Passed
D2. Lack of government policies promoting BIM adoption	4.24	0	1	Passed
D3. Inefficiencies in team collaboration	4.03	0	1	Passed
D4. Lack of best practice guidelines for BIM-FM implementation	1.66	1	1	Not Passed
D5. Poor change management strategies	2.22	0	1	Not Passed
D6. Lack of clearly defined strategic goals for BIM adoption	1.69	0	2	Not Passed
D7. Absence of clearly defined return on investment (ROI) metrics	1.84	0	0	Not Passed
E. Budget and investment constraints				
E1. Budgetary constraints	4.46	0	1	Passed
E2. High costs of BIM maintenance and updates	2.14	1	1	Not Passed
E3. Long transition period required for BIM adoption	1.69	0	1	Not Passed
E4. Questionable cost-effectiveness of BIM for FM-only application	3.65	0	1	Passed
E5. Lack of legal requirements for BIM-FM adoption	3.87	0	1	Passed
E6. Data security concerns in BIM implementation	3.76	0	1	Passed

*A higher mean score indicates a greater perceived importance of the issue.
**A lower IQR value signifies higher consistency in expert responses.

This research serves as a thermometer to assess the current understanding of BIM adoption challenges for FM in Thailand. Key personnel-related obstacles include insufficient training (A2: 4.39), shortage of BIM-FM experts (A5: 4.35), and lack of personnel readiness (A1: 3.65), aligning with prior studies (Mohammed, 2024; Khosfetrat et al., 2022; Durdyev et al., 2022). Change resistance (A3: 3.63) and lack of BIM familiarity (A4: 3.80) also pose concerns, though workload (A7: 2.35) and low motivation (A6: 1.99) were less significant. Technologically, interoperability (B3: 3.48) and integration with FM systems (B5: 3.51) are key challenges, rather than hardware limitations (B1: 2.31) or model complexity (B4: 2.78). On data management, lack of standards (C3: 4.24), unclear ownership (C8: 3.88), and update issues (C4: 3.66) are serious, while complexity (C1: 2.07), inconsistency (C2: 1.45), and LOD (C7: 1.84) are not. Critical managerial barriers include lack of management support (D1: 4.65), weak policies (D2: 4.24), and poor team coordination (D3: 4.03), whereas ROI (D7: 1.84) and strategic planning (D6: 1.69) were less pressing. Financially, budget limits (E1: 4.46), high initial cost (E4: 3.65), and legal uncertainty (E5: 3.87) are notable, while general costs (E2: 2.14) and long transitions (E3: 1.69) appear less influential. The study identified and analyzed a number of challenges associated with the implementation of BIM for FM in Thailand. Through consensus of experts, Table 1 summarizes the outcome of the initial round of survey results, where 22 issues did not achieve the consensus cut-off, while 16 issues were agreed and validated. The 16 issues were re-examined using the second-round survey, where all 29 experts validated their initial answers. The final consensus-based issues are presented in Table 2, showing significant issues that are obstacles to successful implementation of BIM in FM.

Table 2. Results of the second-round survey

Problem Statement	Mean Score	Ranking
A. Personnel and Training Issues		
A1. Lack of personnel readiness	3.65	12
A2. Insufficient training programs	4.39	3
A3. Resistance to change among personnel	3.63	13
A4. Lack of knowledge and understanding of BIM	3.80	10
A5. Shortage of BIM-FM experts	4.35	4
Average Score	3.90	
2. Technology and Integration Issues		
B3. Limited interoperability between BIM software	3.48	15
B5. Challenges in integrating BIM with FM systems	3.51	14
Average Score	3.50	
3. Data Management Issues		
C3. Lack of standardized BIM data management practices	4.24	5

C8. Unclear ownership of BIM data	3.88	8
Average Score	4.06	
4. Support and management barriers		
D1. Insufficient support from executive management	4.65	1
D2. Lack of government policies to support BIM adoption	4.24	6
D3. Inefficiencies in team coordination	4.03	7
Average Score	4.31	
5. Budget and Investment constrains		
E1. Budget constraints	4.46	2
E4. Uncertainty about the return on investment in BIM for FM applications	3.65	12
E5. Lack of legal regulations regarding BIM-FM implementation	3.87	9
E6. Data security concerns in BIM	3.76	11
Average Score	3.94	

The results of the survey show that the barriers and challenges in BIM adoption can be summarized into five principal areas rankings by average score as shown in Figure 3. Findings that can be observed from the results are:

Figure 3. Rankings of the five primary areas in a radar chart

Support and management barriers (Avg. score 4.31) were identified as key challenges, with insufficient executive support (Mean = 4.65, Rank = 1) emerging as the most critical, indicating a need for stronger leadership commitment. In addition, the lack of government support (Mean = 4.24, Rank = 6) and poor interdepartmental integration (Mean = 4.03, Rank = 7) underscore the importance of policy and organizational alignment for effective BIM adoption. Data management issues (Avg. score 4.06) also posed significant concerns, particularly the absence of standardized data guidelines (Mean = 4.24, Rank = 5) and unclear ownership rights (Mean = 3.88, Rank = 8), both of which risk compromising data integrity and accessibility. Budget and investment constraints (Avg. score 3.94) further limited implementation, with restricted budgets (Mean = 4.46, Rank = 2), uncertainty about return on investment (Mean = 3.65, Rank = 12), lack of legal mandates (Mean = 3.87, Rank = 9), and data security concerns (Mean = 3.76, Rank = 11) all discouraging organizational uptake. Personnel and training issues (Avg. score 3.90) were especially prominent, including lack of training (Mean = 4.39, Rank = 3), shortage of BIM-FM professionals (Mean = 4.35, Rank = 4), resistance to change (Mean = 3.63, Rank = 13), and limited awareness (Mean = 3.80, Rank = 10), echoing findings in previous studies (Mohammed, 2024; Khoshfetrat et al., 2022; Durdyev et al., 2022; Javaherikhah & Sarvari, 2025; Liu, 2023). Lastly, technological and integration issues (Avg. score 3.50) were noted, with software incompatibility (Mean = 3.48, Rank = 15) and insufficient connectivity between BIM and FM systems (Mean = 3.51, Rank = 14), highlighting the need for standardized data exchange protocols and enhanced platform interoperability.

5. Discussion

This study investigates the issues and challenges of BIM implementation in FM in Thailand. As outlined in Table 2, sixteen critical sub-issues were found to affect BIM-FM adoption in Thailand. These include:

Rank 1: Lack of management support, this issue emerged as the most significant challenge. Respondents emphasized that managerial commitment is critical to successful BIM implementation.

Without it, initiatives often lack the necessary direction, resources, and prioritization. This finding aligns with previous studies, such as Saka et al. (2020), which highlighted the lack of senior management support as the central obstacle to sustainable BIM adoption in Nigerian SMEs. Similarly, studies by Ata et al. (2025), Sexton et al. (2006), and Sander et al. (2021) underscore the importance of management support in establishing BIM capabilities.

Rank 2: Budgetary constrain, high upfront costs associated with BIM software, hardware, and training present a substantial barrier. While BIM offers long-term operational savings, the initial investment is often prohibitive. Mohammed (2024) identified financial limitations and the absence of supportive initiatives as critical inhibitors in infrastructure projects. Saka & Chan (2020) observed that SMEs in developing countries face significant challenges due to high BIM-related costs. Other studies (e.g., Wang et al., 2015; Sexton et al., 2006; Alreshidi et al., 2017; Lin & Hsu, 2021; Xu et al., 2014; Ismail et al., 2022; Lee et al., 2012) consistently highlight budgetary constraints as a recurring challenge across multiple regions. Recent findings (e.g., Javaherikhah et al., 2025; Durdyev et al., 2022; Ehab et al., 2024) reaffirm that high software and hardware costs hinder BIM-FM adoption globally.

Rank 3: Inadequate training, insufficient training programs impede the development of skilled BIM practitioners. The high cost of training limits access, especially for small- and medium-sized firms. Studies by Saka & Chan (2020), Wang et al. (2015), and Khoshfetrat et al. (2022) reported that expensive and inadequate training contributes to low BIM adoption. Durdyev et al. (2022) and Mohammed (2024) also identified training costs as a major barrier to BIM utilization.

Rank 4: Lack of BIM-FM experts, the absence of skilled professionals with expertise in BIM for FM poses a serious challenge. Effective implementation requires advanced competencies in digital tools, data management, and maintenance planning. Research by Schönfelder et al. (2023), Hamma-Adama & Kouider (2019), Wang et al. (2015), Ata et al. (2025), and others found that the lack of in-house experts severely limits BIM adoption. Additional studies (e.g., Tan et al., 2019; Jamal et al., 2019; Zahrizan et al., 2014; Ben et al., 2022; Faizal & Mohammad, 2019; Sander et al., 2021; Yang & Mao, 2021) confirm this deficiency as a widespread issue in various construction sectors.

Rank 5: Lack of standardized BIM data management, BIM requires standardized data protocols to ensure interoperability among systems and stakeholders. The absence of such standards leads to inefficiencies, errors, and reduced model usability. Mousa (2015) highlighted that inconsistent interpretations of BIM data impede team collaboration. Similarly, Mutis & Mehraj (2022), Fang et al. (2022), Leygonie et al. (2022), Dixit et al. (2019), Benn & Stoy (2022), and Stride et al. (2020) identified poor data governance and low-quality models as primary contributors to BIM-FM integration issues.

Rank 6: Insufficient government policy support, a lack of clear regulatory frameworks, mandates, and incentives for BIM use discourages investment. Hamma-Adama & Kouider (2019) and Saka et al. (2020) noted that the absence of government policies is a major impediment to BIM adoption in developing countries. Ata *et al*. (2025) also emphasized the pivotal role of government support in fostering BIM adoption in Palestine.

Rank 7: Ineffective team coordination, collaboration among stakeholders is often undermined by incompatible BIM tools and misaligned objectives between construction and FM teams. Kula & Ergen (2021), Sing & Kumar (2024) and Matarneh et al. (2019) pointed out tool interoperability issues, while Dias & Ergan (2020) stressed the importance of restructuring data for FM usability during handover. Floros & Ellul (2021), Fang et al. (2022), and Leygonie et al. (2022) added that redundant or poor-quality BIM models complicate FM integration.

Rank 8: BIM data ownership issues, defining ownership and access rights for BIM data is complex due to the involvement of multiple parties. Tan et al. (2023) this ambiguity can lead to long-term data access and governance problems. Hamma-Adama & Kouider (2019) emphasized that unresolved intellectual property rights present significant legal and practical challenges to BIM implementation.

Rank 9: Lack of legal standards for the application of BIM in FM, the absence of clearly defined legal standards and protocols for BIM use in FM in Thailand creates confusion regarding responsibilities, data exchange, and operational practices. Lovell et al. (2024), Lu et al. (2019), Kameli et al. (2021), and Ciccone et al. (2022) stressed that BIM-FM requires robust legal and technical frameworks to handle its complexity. Hamma-Adama & Kouider (2019) and Mohammed (2024) also noted that unclear regulations hinder BIM adoption.

Rank 10: Limited understanding and knowledge of BIM, While BIM has been widely accepted in the majority of countries, Thailand's building construction industry lags behind concerning limited understanding and knowledge of BIM, with resistance and refusal to implement it. There should be an upgrade of the level of understanding for this technology in all organizational layers. Bamgbose et al. (2024) opined that the main inhibitor to BIM adoption in the Nigerian construction sector is lack of awareness and competence gaps among stakeholders. Similarly, Saka & Chan (2020) observed that developing SMEs face BIM implementation challenges brought about by a lack of skills. Wang et al. (2015) also found that inadequate knowledge and knowledge gap regarding BIM technology is a significant inhibitive factor.

Rank 11: Data security constraints, Data security is a major concern in BIM implementation since BIM contains valuable digital data that must be protected from unauthorized use or access. Development and use of high-security technology are required for effective BIM application. Javaherikhah et al. (2025) referred to the fact that while BIM is associated with many advantages in FM, such as high levels of data accuracy, good management of data, and monitoring data in real time, the security problems must be addressed before BIM adoption can occur. Ehab et al. (2024) also identified data security problems that hinder the adoption of BIM, and Wijeratne et al. (2024) emphasized securing BIM data in organizations.

Rank 12: Workforce readiness challenges, the FM industry lacks personnel with skills in data interpretation, analysis, and technology integration, creating barriers to BIM adoption. Firms must invest in targeted training and encourage BIM-focused curricula in academia. Key challenges include low motivation, limited time, and insufficient BIM experts (Sander et al., 2021), along with poor awareness of BIM's benefits and organizational culture misalignment (Sexton et al., 2006). Organizational and technical hurdles in the UK echo these issues (Alreshidi et al., 2017; Lin & Hsu, 2021; Xu et al., 2014). Besides same score at *Rank 12, Investment in BIM may be unprofitable if used solely for FM*, Investing in BIM might be unprofitable if used exclusively for FM. However, its area of application is extended to design and construction to enhance long-term return on investment. Advanced that uncertainties in business value remain the overarching impediment to investment in BIM (Mohammed, 2024). Indicated that ROI from BIM adoption remains questionable (Hamma-Adama & Kouider, 2019). Argued that beliefs in benefits to BIM and ROI guarantee will decrease adoption barriers (Hussien et al., 2025). Also focused on the point that initiative shortages in the adoption of BIM, high payback times, and return uncertainty are impacts influencing BIM uptake (Yang & Mao, 2021). Further mentioned that a central challenge lies in the poor appreciation and perception of BIM's true worth (Faizal & Mohammad, 2019). In order to get maximum out of BIM investment, companies need to roll out BIM across every aspect of the construction and design phase instead of using it exclusively in FM.

Rank 13: Staff resistance to change, familiarity with traditional workflows and fear of complexity inhibit BIM uptake. Transitioning to BIM demands time and support via training and awareness programs, since resistance undermines efficiency gains, cost savings, and service quality improvements (Javaherikhah & Sarvari, 2025; Liu, 2023).

Rank 14: BIM-FM integration with other systems, despite BIM's integration potential, linking BIM with preventive maintenance and asset management systems is problematic. Varied data formats and proprietary naming conventions hinder cross-organizational data exchange in the BIM–FM phase (Sadeghi et al., 2022; Alnaggar & Pitt, 2019).

Rank 15: BIM software compatibility issues, collaboration suffers when different BIM tools use disparate standards or file types (e.g., Industry Foundation Classes (IFC)). Some software cannot reliably read or convert IFC files, causing interoperability failures. The lack of standardized data-sharing procedures and insufficient infrastructure further impede BIM implementation (Gerrish et al., 2017; Hamma-Adama & Kouider, 2019). Effective BIM–FM integration requires robust data exchange and system interoperability (Matarneh et al., 2019; Ehab et al., 2024). Since FM is the longest, most expensive lifecycle phase (Duong & Lin, 2022), poor-quality as-built plans and incomplete historical data exacerbate information-sharing difficulties, leading to inefficient facility management. Questions remain about COBie's support for FM data exchange (Naghshbandi, 2016) and the need for a universal data format to streamline BIM handovers (Liu, 2023).

6. Research Implications

The findings suggest that management support and budget limitations are closely related organizational factors influencing BIM-FM adoption in Thailand. In many organizations, decisions regarding digital transformation remain dependent on executive perspectives and financial considerations. Limited understanding of BIM-FM benefits and uncertainty regarding ROI may reduce organizational support, affecting budget allocation, personnel development, and technology investment. The identified barriers can be grouped into three interconnected levels. The first level consists of root causes, including insufficient managerial support, limited governmental support, and unclear strategic direction for BIM adoption. The second level involves operational barriers, such as inadequate training, shortages of BIM-FM expertise, interoperability issues, and lack of data management standards. The final level includes outcome barriers, such as inefficient information exchange, fragmented facility management processes, and limited utilization of BIM throughout the building lifecycle. These findings indicate that operational challenges in BIM-FM implementation may be associated with broader organizational and policy-related limitations. The study also found that some factors receiving relatively low importance scores, such as uncertainty regarding BIM return on investment, may reflect limited organizational awareness and experience in evaluating the long-term benefits of BIM-FM. Therefore, under budget constraints, organizations may benefit from prioritizing workforce training, BIM data standardization, and small-scale pilot projects to support BIM-FM implementation. This study contributes to the BIM-FM literature by providing empirical evidence from the Thai context and by categorizing barriers into root causes, operational barriers, and outcome barriers. The findings also highlight the interconnected nature of organizational, managerial, and operational factors influencing BIM-FM adoption in developing-country contexts.

7. BIM-FM Implementation Framework

The conceptual framework developed in this study explains the relationships among enabling factors, BIM-FM implementation processes, and operational outcomes in sustainable facility management. The framework consists of four main components: (1) input factors, (2) BIM-FM implementation processes, (3) operational outcomes, and (4) sustainable facility management. Input factors include organizational readiness, BIM knowledge and skills, management support, technological infrastructure, data standards, and financial and policy support. The implementation process involves BIM model development, integration with facility management systems, and the use of technologies such as IoT and Digital Twin for real-time monitoring and maintenance management. The operational outcomes include improved information accessibility, maintenance efficiency, operational performance, and energy management. These outcomes ultimately support sustainable facility management through more effective decision-making and smart building operations. Figure 4 presents the proposed BIM-FM implementation framework.

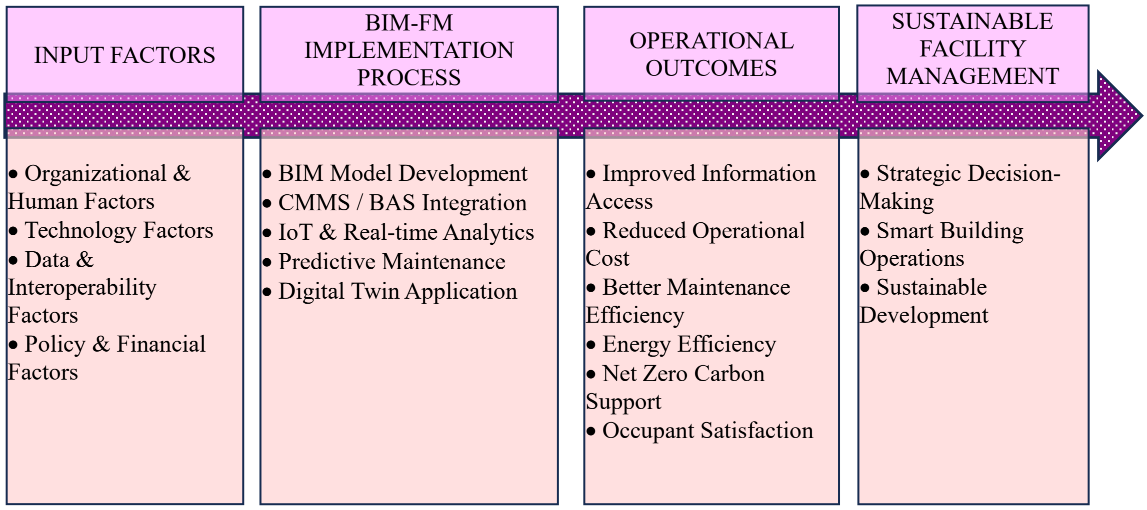

***Figure**.4* Conceptual Framework for BIM-FM

8. Conclusion

The adoption of BIM in FM in Thailand is still ridden with several key challenges, which make its integration with the industry smooth. The top five key hindrances are (1) lack of management support, (2) stringent budget constraints, (3) inadequacy of training, (4) unavailability of qualified experts, and (5) unavailability of standardized data management procedures. Additionally, the lack of efficient government policies, including regulations and incentive programs, has caused a lack of motivation among companies to adopt BIM in FM operations. The workforce in the construction and FM sectors remains poorly skilled with specialist expertise required to execute BIM successfully. The culture of opposition to change persists, as professionals remain accustomed to conventional methods and do not welcome digital workflows. Data management issues also represent a major hindrance, as procedures to own BIM data are not well defined. Ambiguity poses a problem in sharing information and access rights among the project stakeholders. Besides, interoperability between FM and BIM systems exists because data standards are not consistent and software incompatibility leads to an inefficient information exchange. Another significant barrier is the adoption cost of BIM, including software procurement, hardware maintenance expense, and training expense, all of which are organizational financial burdens. Overall, the findings indicate that successful BIM implementation for FM Thailand depends not only on technological capability, but also on organizational leadership, strategic planning, and institutional readiness. Management commitment plays a significant role in influencing investment decisions, personnel development, and data management practices. Therefore, FM organizations should prioritize workforce training, data standardization, and BIM pilot projects to establish a sustainable foundation for long-term BIM-FM integration.

Recommendations

This study has several limitations. First, the findings are based on the perspectives of experts from the Thai construction and facility management industries, which may limit the generalizability of the results to other countries or industries. Second, although the Delphi method is effective for systematically obtaining expert consensus, the findings still rely on the professional experience and judgment of the participants. Future research may incorporate quantitative validation methods or cross-country comparative studies to enhance the generalizability of the findings. For organizations with budget limitations, priority should be given to workforce development and data standardization, as these are fundamental to effective BIM-FM integration. In addition, implementing small-scale pilot projects may help organizations evaluate the practical benefits of BIM-FM before full-scale adoption.

To address these issues, active government intervention is essential. Policies offering tax relief, rewards, or low-interest loans can encourage BIM adoption in FM. Regulations should clearly define BIM data ownership and promote BIM-based coordination in FM. Workforce readiness can be improved by integrating BIM-focused curricula to produce skilled professionals and reduce resistance to change. Standardized data management and promotion of open formats like IFC are also vital for interoperability. To ease financial barriers, R&D should focus on developing low-cost or open-source BIM tools, especially for SMEs. Integrating BIM with maintenance and asset management systems can further enhance long-term efficiency. These measures can significantly boost BIM adoption in Thailand's FM sector, supporting sustainable and cost-effective building operations.

Author Contributions

Conceptualization: S.M., G.S.; Methodology: T.N., S.M., G.S.; Data analysis: T.N., S.M., C.C.; Original draft preparation: S.M., G.S., C.C.; Review and editing: S.M., G.S., K.O.; Review and validation: T.N., S.M., K.O., A.R., C.C., G. S. All authors have read and agreed to the published version of the manuscript. Authorship must be limited to those who have contributed substantially to the work reported.

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Ethical approval

This study was conducted in accordance with ethical research standards. Informed consent was obtained from all participants prior to data collection, and all responses were anonymized and kept confidential. The study did not involve human experimentation or direct intervention; therefore, ethical approval from a human research ethics committee was not required.

Conflict of Interest Statement

The authors declare no conflicts of interest

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