Adoption of Building Information Modeling (BIM) in Facilities Management (FM) Practices in Malaysia

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ABSTRACT

Building Information Modeling (BIM) is a collaborative process that transforms the capturing, sharing, and development of construction project information, essential for the planning, design, and construction of buildings. However, the application of BIM in Facilities Management (FM) is still emerging, particularly in Malaysia, where its integration within FM practices has not been extensively studied. This study uses an online questionnaire distributed to FM companies across Malaysia to assess the awareness, barriers, and potential of BIM within the FM sector. Data collected have been analysed by using SPSS, with descriptive analysis, frequency analysis, and the Relative Importance Index (RII). The findings will highlight key challenges in BIM adoption and outline strategies to enhance its integration into FM practices, providing valuable insights to help FM practitioners optimize the benefits of BIM in the Malaysian FM industry.

Keywords - Facilities Management (FM), Building Information Modeling (BIM), Factors Hindering, BIM Potential

INTRODUCTION

Building Information Modeling (BIM) has emerged as a transformative approach to managing information across a building's lifecycle. According to the NBIM (2007), BIM is defined as “an improved planning, design, construction, operation, and maintenance process using a standardized, machine-readable information model for each facility, whether new or old, containing all relevant information created or gathered about that facility in a format usable by all stakeholders throughout its lifecycle.” This comprehensive definition highlights BIM’s potential to streamline and enhance collaboration across various project phases.

BIM’s use in capturing, sharing, and managing project data is enhancing efficiency, productivity, and quality control throughout the building lifecycle (Azhar, 2011; Pardis et al., 2018). For architects, engineers, and contractors (AEC professionals), BIM has become integral across various stages, providing substantial benefits (Saratu et al., 2019; Ruwini et al., 2017). However, despite its proven benefits, the use of BIM in Facilities Management (FM) remains relatively underexplored and is still in the early stages of development.

Though widely adopted in design and construction phases, the application of BIM in Facilities Management (FM) is still emerging and yet to reach its full potential (Edirisinghe, London, Kalutara, & Aranda-Mena, 2017). While the United Kingdom has mandated BIM for public projects, including certain aspects of Facilities Management (FM), Singapore has adopted a phased approach, encouraging but not universally requiring BIM for FM. In comparison, Malaysia is at an earlier stage of adoption, with BIM integration in

FM still developing. However, with the rapid evolution of technology, the need to integrate BIM into FM services is increasingly urgent to facilitate more efficient and effective FM processes.

A significant shift is occurring in Facilities Management (FM) toward predictive maintenance, driven by BIM-enabled FM models that support proactive decision-making and integrate dynamically with other systems (Edirisinghe et al., 2017). This approach has the potential to unlock the full capabilities of FM, making it more responsive to complex operational demands. Meanwhile, global trends in the architecture, engineering, and construction (AEC) sectors indicate an increasing need for sophisticated projects that deliver high-quality outcomes within shorter timelines, further accelerating BIM adoption (Autodesk Group, 2017). Although BIM's application has advanced considerably in design and construction, its integration into FM remains in the early stages, representing an emerging field with transformative potential for both AEC and operational practices (Teicholz, 2013; Eastman et al., 2011; Azhar, 2011).

Although BIM has made substantial advancements in design and construction, its integration into FM remains an emerging field with unique challenges that this study seeks to address. This study aims to fill this research gap by examining the specific barriers and potential of adopting BIM in FM, particularly within the Malaysian context. The objectives of this study are thus to identify barriers and potential of BIM-FM integration, guiding the development of a framework that could enhance BIM's role in FM decision-making.

This study explores the current literature to identify factors that impede BIM-FM integration and examines the potential of BIM in supporting FM tasks. A questionnaire survey was developed to validate these findings, targeting FM professionals to gain insights into the challenges and benefits of BIM-FM integration. The outcomes of this study are intended to support FM professionals in developing a standardized framework for BIM-FM integration, optimizing BIM's role in FM decision-making.

LITERATURE REVIEW

Factors Hindering the Implementation of BIM in FM

Despite the growing recognition of Building Information Modeling (BIM) in the design and construction phases, its application in Facilities Management (FM) remains underexplored. According to a Smart Market Report by Dodge Data and Analytics, while 86% of building owners use BIM during the construction phase, only 17% extend its use to FM (Jones, 2015). Several factors contribute to the slow adoption of BIM in FM, as outlined below.

BIM Management Factors: A key challenge to BIM adoption in FM lies in the management of the BIM process. Building professionals often find themselves performing redundant tasks due to a lack of clarity around roles and responsibilities. The absence of a well-defined structure for BIM workflows and reluctance to share information across stakeholders further hinder progress. Additionally, the lack of standardized protocols for controlling or validating BIM data creates inconsistencies that impact the overall effectiveness of BIM in FM (McAuley, 2016).

Moreover, the comprehensive capture of building information is critical throughout the building's lifecycle, from material specifications and operational instructions to warranties and maintenance schedules (Liu and Issa, 2013; Becerik-Gerber et al., 2011). Inaccurate or incomplete data capture can lead to discrepancies within the BIM model, which in turn affects the quality of decisions made in FM processes.

Another limitation is the technological barrier of integrating BIM with mobile devices. Many mobile systems used in FM operations are incapable of uploading essential data to BIM systems in real time. This results in delays in accessing vital information during maintenance or operational procedures, which can lead to miscommunication and errors in work orders, maintenance tasks, and asset management decisions (Kang and Hong, 2015).

Finally, a lack of comprehensive documentation and awareness about BIM's potential benefits for FM means that clients often do not actively request BIM for FM purposes. Without proper demand from clients, BIM models are often neglected and poorly maintained throughout the building's lifecycle (McAuley, 2016; Elmualim and Gilder, 2014). This lack of awareness further slows the adoption of BIM in FM.

Technology Factors: The integration of digital technologies with traditional paper-based media during the design and construction phases often leads to compatibility issues that hinder the effective use of BIM in Facilities Management (FM). The challenge arises when trying to update or transfer paper-based information into BIM systems, resulting in incompatible file formats and data inconsistency (Geodert, 2008).

Another challenge is the selection of a standardized software platform for BIM, which can be complicated by regional preferences, software availability, and compatibility issues (Liu and Zettersten, 2016). Different stakeholders in the construction and FM processes may favor distinct software tools, which makes achieving smooth interoperability difficult.

Interoperability challenges are further exacerbated by incompatibilities between BIM and other FM technologies, such as building automation systems. These issues often create barriers to seamless integration, limiting the full potential of BIM in supporting FM tasks (Teicholz, 2013).

Additionally, the large size of BIM files presents a practical challenge, especially when they need to be transferred to on-site FM personnel. These files are typically designed to be accessed on desktop computers, which makes them cumbersome and less suitable for real-time applications in FM activities, particularly in fieldwork scenarios. On-site FM teams often require quick, mobile access to BIM data for maintenance tasks, but the large data sizes and desktop-focused design can significantly slow down processes. To address these challenges, there is a growing need for optimized BIM platforms or mobile solutions that can handle large files more efficiently and are designed for on-the-go access.

Software compatibility continues to be a significant barrier to BIM adoption in the construction industry. Differences between software versions or platforms can limit access to BIM models and disrupt collaboration, undermining the efficiency and effectiveness of FM operations (Liu and Zettersten, 2016).

Finally, there is a reluctance among building professionals to invest time and resources into adopting new applications for data management, further hindering the transition from paper-based systems to digital BIM systems. Consequently, a combination of both digital and paper-based media continues to be used, creating difficulties in accessing, tracking, and verifying information (Anderson et al., 2012; Kivits and Furneaux, 2013).

Cost-based Factors: The adoption of BIM often involves significant upfront costs, particularly in terms of administration, software acquisition, and training programs (Beach et al., 2017). To ensure a smooth transition, it is crucial to allocate adequate resources to equip construction professionals with the necessary skills to effectively integrate BIM into their workflow. This investment, however, can pose a financial burden for many organizations, especially smaller ones with limited budgets.

Another challenge lies in the considerable time and effort required by construction professionals to verify, identify, and separate essential data from less relevant information (Kang and Hong, 2015; East and Brodt, 2007). This manual process not only consumes valuable time but also introduces the risk of errors and inconsistencies in data management. These inefficiencies can lead to complications during Facility Management (FM) operations, highlighting the importance of streamlining data management processes.

Although the immediate financial benefits of BIM for FM may not be readily apparent, organizations that highlight its value in improving task efficiency, enhancing data accessibility, and reducing storage costs can foster greater acceptance (Kivits and Furneaux, 2013). Over time, these advantages become more evident, which can help persuade project owners to invest in BIM for the Operations and Maintenance (O&M) phase of their projects.

Legal and Contractual Issues: BIM models are typically initiated by designers and modified by multiple stakeholders throughout the building lifecycle (Beach et al., 2017). This collaborative process introduces complexities in ensuring that only relevant information is accessible to specific project participants. The lack of clear criteria for categorizing and controlling access to this information makes this task both challenging and time-consuming (Kivits and Furneaux, 2013).

While paper-based documents continue to play a significant role in construction projects, including equipment lists, product data sheets, warranties, and maintenance instructions (Kelly et al., 2013), the integration of BIM into these workflows can present several challenges. Legal and contractual agreements generated using BIM often face difficulties related to accessibility, comprehension, and the accurate transfer of information between parties (Kelly et al., 2013).

Additionally, the security of the BIM model is a critical concern, as it contains sensitive data that could be vulnerable to cyber-attacks. Malicious hackers have the potential to tamper with, leak, or alter this information, presenting a significant threat to the integrity and confidentiality of the data (Kivits and Furneaux, 2013).

The BIM model was initially established by the designer and subsequently modified by multiple stakeholders involved in the building lifecycle (Beach et al., 2017). This complexity arises from the necessity of ensuring that only pertinent and crucial information is accessible to specific project participants. However, the absence of clear criteria for categorizing information makes this process challenging and time-consuming (Kivits and Furneaux, 2013).

Paper-based documents play a vital role in construction projects, encompassing equipment lists, product data sheets, operations and maintenance instructions, warranties, spare parts sheets, and specification lists (Kelly et al., 2013). Although certain contractual agreements may be generated using BIM, this practice can introduce challenges concerning accessibility, comprehension, and the accurate transfer of information (Kelly et al., 2013).

The integrity and security of the Building Information Model (BIM) are at risk as malicious hackers possess the capability to tamper with, leak, or alter this sensitive information, presenting a substantial threat (Kivits and Furneaux, 2013).

Potential of BIM in Supporting FM Tasks

The application and implementation of BIM in FM shall be encouraged as it benefits and contributes a lot to the FM field. An ideal BIM model facilitates the transfer of facility data throughout the whole phases of the building lifecycle and offers trustworthy facility data and information for the facility manager to have integrated views to easily retrieve and analyze the data (Lee et al., 2012; Azhar et al., 2017).

Locating Building Components: The BIM model serves as a platform for collaboration among parties involved to efficiently determine and identify the optimal location of building components within the BIM model, thereby saving time. The integration of BIM with digital twin technology has proven effective in enhancing the accuracy and efficiency of locating building components, which ultimately facilitates better decision-making and more effective facility management.

Facilitating Real-Time Data Access: Throughout the building lifecycle, anyone involved in the delivery process can access the BIM server at any time and from anywhere (Moshood, 2017). The BIM serves as an online platform that enables FM professionals to access the latest information and knowledge conveniently and swiftly when needed.

Visualization and Marketing: By utilizing a three-dimensional graphical interface and incorporating elements such as material texture, lighting sources, landscaping, and spatial arrangement, BIM improves spatial visualization for facility managers during the design and construction phases of renovations and remodels (Burcin et al., 2012).

Checking Maintainability: BIM technology enables the effective assessment of maintainability by facilitating maintainability studies that concentrate on achieving desired performance at different stages of the facility's life cycle. This allows FM practitioners to identify instances where the facilities' performance falls short of expectations, indicating the need for maintenance to be carried out (Azhar et al., 2017).

Creating and Updating Digital Assets: With the aid of BIM technology, FM professionals can promptly upload digital assets once the building commissioning is completed. It requires collaboration with equipment manufacturers and vendors to provide barcodes, and corresponding databases, for storage within the BIM model.

Space Management: BIM technology empowers FM professionals to anticipate the visual and functional aspects of both interior and exterior spaces in a building even before the construction phase commences. By harnessing BIM technology, FM professionals can make well-informed decisions regarding space management, proactively plan for future requirements, and ensure optimal utilization of spaces (Zou & Wang, 2019).

Planning and Feasibility Studies for Non-Capital Construction: The BIM model can store valuable historical data, encompassing design and construction costs, labor costs, material costs, and others. This historical data can serve as a reference for FM professionals when estimating costs and timelines for planned renovation, remodeling, or demolition projects (Li et al., 2021).

Emergency Management: By utilizing the spatial data stored in BIM, responders can reveal hidden correlations between evacuation routes and environmental hazards, thereby assisting in emergency decision-making (Zou & Wang, 2009).

Controlling and Monitoring Energy: The BIM environment improves communication efficiency by offering enhanced access to pertinent information at the management level (Ibrahim & Kate, 2012). The utilization of sensors & BIM-based visualization environments can achieve effective management of energy.

METHODOLOGY

To explore the factors influencing the implementation of BIM in Facility Management (FM) and its potential to support FM tasks, two data collection approach was adopted. The first one involved conducting a literature review, where recent studies on BIM in FM, particularly in the Malaysian context, were identified. Relevant articles, journals, and theses were retrieved with key search terms such as "BIM", "FM", "BIM in Malaysia", and related terms regarding challenges, benefits, and potential. The literature informed the development of a questionnaire survey designed to gather insights from FM professionals in Malaysia regarding BIM adoption and its capabilities. The survey included four sections: (1) demographic profile, (2) awareness of BIM, (3) factors hindering BIM adoption, and (4) potential of BIM in supporting FM tasks. To ensure the reliability and validity of the questionnaire, a pilot test was conducted with 30 numbers of participants. Following this, the main survey proceeded only after the reliability of the instrument was confirmed, ensuring that the data collected would be both consistent and dependable. Feedback from the pilot was incorporated to refine questions for clarity, relevance, and flow, ensuring that the final version effectively captured the necessary information.

A random sampling method was used to select participants from FM companies in Malaysia. Random sampling was employed to ensure a diverse representation of FM professionals across various management levels and years of experience. This approach allows for a more generalized insight into the perceptions of

BIM-FM integration across the sector. However, one limitation of random sampling is that it may not capture niche perspectives from specific subgroups of FM practitioners, potentially limiting the depth of insight into specialized applications.

Given that the exact number of FM professionals is unknown, the population was estimated to include 280 professionals across 70 companies, with an average of four FM professionals per company. Based on this estimate, the sample size was calculated using the Taro Yamane formula, resulting in a required sample size of 74 professionals. This sample size was deemed sufficient to provide a reliable representation of the FM industry's views on BIM adoption and its potential in supporting FM tasks.

The analysis of the data collected involves a combination of descriptive analysis and Relative Importance Index (RII). These methods were selected to derive meaningful insights and address the research objectives.

Descriptive Analysis: Descriptive statistics were used to summarize the data, including measures such as mean, median, and standard deviation. This technique offered an initial understanding of the data, helping to identify key trends, patterns, and relationships within the dataset related to the research objectives.

Relative Importance Index (RII): RII, or the Weighted Average Method, was employed to rank the factors hindering the implementation of BIM in FM and the potential of BIM in FM practices. This method provides a quantitative measure of the relative importance of various factors, helping prioritize them for decision-making. The RII formula is used to calculate the relative importance of each factor:

$RII = \Sigma W / (A*N)$

Where:

W = Weight given to each factor by the respondents

A = Highest weight (the highest possible score)

N = Total number of respondents

Relative Importance Index (RII) was selected as the primary method for ranking factors hindering BIM integration and the potential applications of BIM in FM. RII was chosen over other ranking methods due to its effectiveness in quantifying the importance of each factor relative to the others, which is particularly useful in studies where prioritization is needed across a wide range of variables. The RII method also allows for a straightforward interpretation of results, making it suitable for practitioners who may later use this study as a practical reference

RESULTS

Demographic Profile

The majority of the respondents (61%) are categorized under tactical management, with 39% in strategic management. Operational management was excluded from consideration, as it primarily handles day-to-day facility operations, which may not involve advanced technology implementation like Building Information Modeling (BIM). Including operational FM professionals could potentially skew the results, as they are less likely to interact with complex technological solutions.

The highest proportion (31%) of respondents have between 6 to 10 years of experience in FM, followed closely by 28% with 11 to 15 years of experience. 22% of respondents have 0 to 5 years, while 14% have between 16 to 20 years. The smallest group (5%) consists of respondents with over 20 years of experience.

The following tables present the mean, RII and rank for the factors that hindering the implementation of BIM in FM (Table 1) and potential of BIM in supporting FM tasks (Table 2).

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TABLE 1: Factors that Hindering the Implementation of BIM in FM

Factors	Mean	RII	Rank
Unperceived Costs Benefits of Using BIM	4.58	0.916	1
Long Adaptation Times When Using New Technology	4.41	0.882	2
Software Issues	4.22	0.842	3
Costs Associated with Training BIM Personnel	4.12	0.824	4
Costs Associated with Information Management	4.12	0.824	5
Unclear BIM Workflow	4.11	0.822	6
Lack of Client Demand to Use BIM in FM	4.09	0.818	7
Interoperability Between BIM and FM Technologies	3.92	0.784	8
Improper Information Capture	3.85	0.770	9
Failure to Update BIM Information	3.80	0.760	10
Contractual and Compliance Issues	3.77	0.754	11
Ownership and Responsibility for BIM Data	3.77	0.754	12
Cyber Security and Privacy	3.74	0.748	13
Incompatible File Exchange Formats	3.74	0.748	14
Availability of Multiple Software Platforms	3.68	0.736	15
Large File Size	3.16	0.632	16

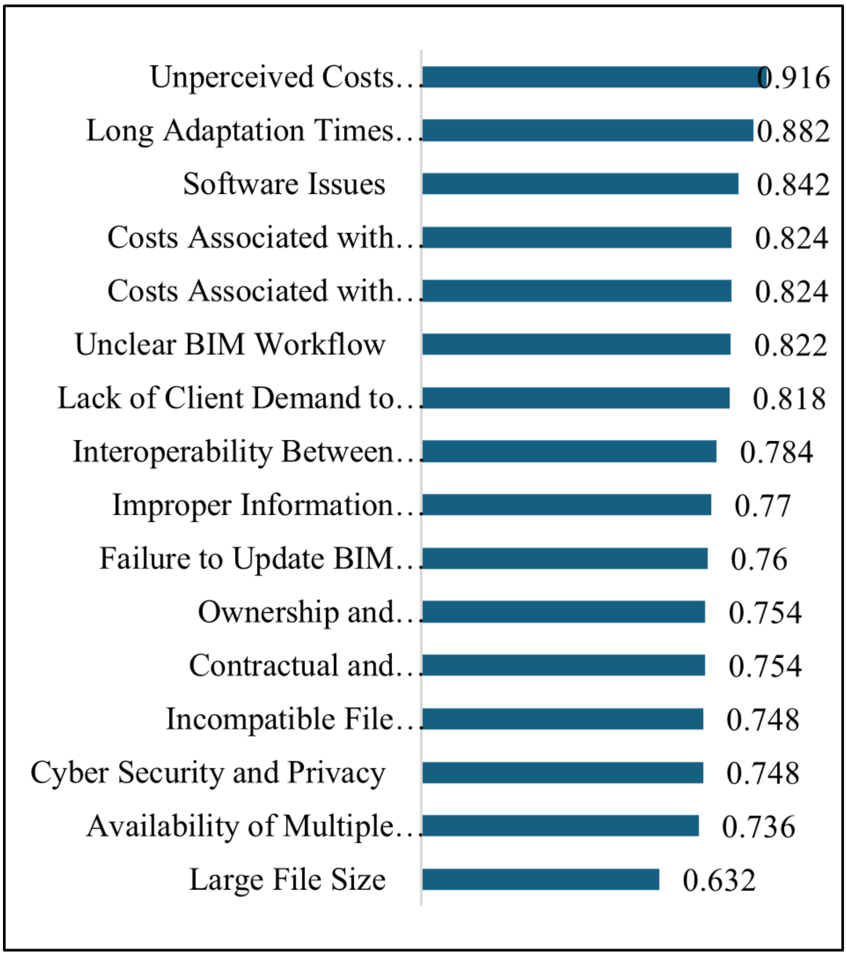

Figure 1 RII loading of factors hindering the implementation of BIM in FM

Table 1 and Figure 1 shows various obstacles ranked by their Relative Importance Index (RII) and mean score. The highest-ranked factor is Unperceived Costs Benefits of Using BIM (Mean = 4.58, RII = 0.916), indicating that the unclear cost benefits are a significant barrier. This indicates that there is a lack of clarity about the financial advantages of BIM adoption, which can discourage investment. Despite the potential efficiencies that BIM promises, if these benefits are not well-documented or communicated, stakeholders may hesitate to allocate resources to its implementation. This aligns with research suggesting that clearly defined financial impacts and ROI calculations are crucial for the successful adoption of new technologies in FM.

Long Adaptation Times When Using New Technology follows, showing a high mean of 4.41 and an RII of 0.882, reflecting concerns over time invested in adapting to BIM. This further compounds the hesitation, as the time required for FM teams to become proficient with BIM technology represents a significant initial barrier. The industry faces pressure to minimize operational disruptions, and prolonged training periods can be seen as a hindrance, especially for firms with limited resources to invest in lengthy transition processes. This finding is supported by studies noting that gradual technology adoption in FM is common due to time and skill-building constraints.

The presence of Software Issues (Mean = 4.22, RII = 0.842) highlights technical limitations, suggesting that software-related complications can interfere with smooth BIM integration. In addition, the Costs Associated with Training BIM Personnel (Mean = 4.12, RII = 0.824) and Costs Associated with Information Management (Mean = 4.12, RII = 0.824) are notable, underscoring that BIM adoption requires substantial investment in both personnel development and ongoing data management. These findings indicate that FM managers may perceive BIM as a resource-intensive solution, where costs related to both personnel and data management pose challenges.

Another significant factor is the Unclear BIM Workflow (Mean = 4.11, RII = 0.822). This result suggests that without clearly established procedures and guidelines, integrating BIM into FM workflows is challenging, leading to inefficiencies and resistance to adoption. The absence of a standardized workflow or integration framework can increase the complexity of BIM implementation, especially for FM teams not familiar with the software's functionality and requirements.

Cyber Security and Privacy and Incompatible File Exchange Formats are also notable but rank lower (Mean = 3.74, RII = 0.748). While security and compatibility are concerns, they appear to be viewed as secondary compared to cost and adaptation time. This might indicate that while there is awareness about the need for secure and compatible BIM solutions, these issues are not as immediately pressing as the direct costs and time investments.

Lastly, Large File Size (Mean = 3.16, RII = 0.632) is identified as the least impactful factor. This may reflect an understanding that technological advancements have reduced file size concerns over time, or that BIM's data-intensive nature is generally accepted as manageable.

TABLE 2 Potential of BIM in supporting FM tasks

BIM potentian in FM	**Mean**	**RII**	**Rank**
Space Management	4.49	0.898	1
Locating Building Component	4.43	0.886	2
Facilitating Real-Time Data Access	4.20	0.840	3
Visualization and Marketing	4.16	0.832	4
Emergency Management	3.95	0.790	5
Creating Digital Assets	3.94	0.788	6
Controlling and Monitoring Energy	3.84	0.768	7
Checking Maintainability	3.84	0.768	8
Planning and Feasibility Study for Non-Capital Construction	3.74	0.736	9

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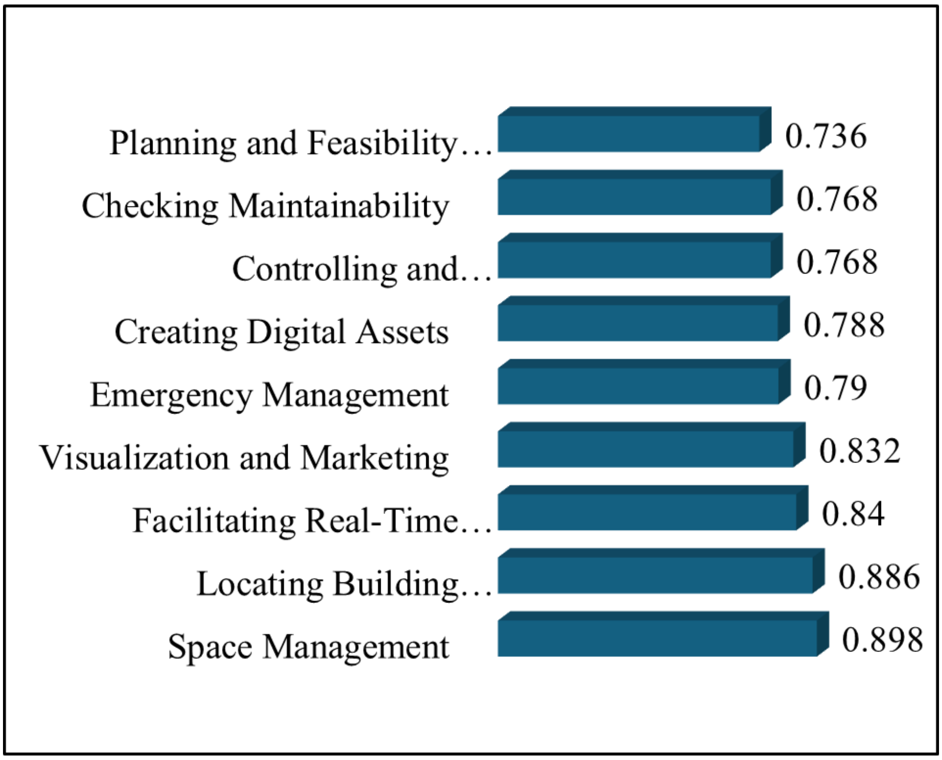

Figure 2 RII loading of potential of BIM in supporting FM tasks

The analysis of BIM potential in FM (Table 2 and Figure 2) reveals various promising applications, ranked by importance based on respondent feedback. The highest-rated potential, Space Management (Mean = 4.49, RII = 0.898), underscores BIM's utility in optimizing space utilization and planning within facilities. Efficient space management is crucial in FM as it directly impacts operational costs, user satisfaction, and resource allocation. The strong rating suggests that BIM's ability to provide accurate spatial data and facilitate flexible space planning is highly valued by FM professionals.

Following closely is Locating Building Components (Mean = 4.43, RII = 0.886). BIM's capability to help identify and locate specific building components offers immense practical benefits, especially in large and complex facilities. This feature not only improves maintenance efficiency by reducing search times but also assists in emergency situations where rapid access to information is critical.

Facilitating Real-Time Data Access (Mean = 4.20, RII = 0.840) ranks third, highlighting the importance of BIM as a centralized information platform that can provide up-to-date data. Real-time access enables FM teams to make informed decisions quickly, an aspect that is particularly beneficial for time-sensitive operations and preventive maintenance planning.

Visualization and Marketing (Mean = 4.16, RII = 0.832) reflects the potential of BIM to enhance communication with stakeholders. BIM's visualization capabilities allow FM teams to present virtual models of facilities, which can aid in marketing and project communication, particularly when illustrating renovation plans or new facility designs to non-technical stakeholders.

Emergency Management (Mean = 3.95, RII = 0.790) and Creating Digital Assets (Mean = 3.94, RII = 0.788) are also significant potentials. The use of BIM in emergency management highlights its role in providing critical information for safety planning, such as evacuation routes and access points. The creation of digital assets, meanwhile, allows FM professionals to build a comprehensive digital record of facility elements, which can support long-term asset management and lifecycle analysis.

Controlling and Monitoring Energy (Mean = 3.84, RII = 0.768) and Checking Maintainability (Mean = 3.84, RII = 0.768) emphasize BIM's role in sustainability and maintenance. Through energy monitoring, BIM can help FM professionals identify inefficiencies and reduce energy consumption. Additionally, checking maintainability allows for better planning of repair schedules, extending asset lifespans, and reducing maintenance costs.

Planning and Feasibility Study for Non-Capital Construction (Mean = 3.74, RII = 0.736) ranks as the lowest-rated potential but remains a valuable application. This finding suggests that while BIM is recognized for its role in supporting the planning of minor renovations and expansions, it may be viewed as secondary compared to the immediate operational benefits offered by other BIM applications in FM.

DISCUSSION

Both the present study and Benn et al. (2022) highlight the importance of Space Management within BIM-FM integration, with both achieving high mean values (4.32 and 4.49, respectively) and ranking among the top priorities. Although both studies recognize Visualization as significant, it ranks differently—10th in this study and 4th in Benn et al. Despite this ranking variation, the mean values for visualization exceed the average in both studies, confirming its essential role in enhancing FM capabilities. Energy Management also differs slightly between studies: the present study ranks it higher (5th out of 9) than Benn et al., which places it at 12th out of 35, suggesting regional variations in prioritizing energy-focused FM functions. A notable distinction emerges with Real-Time Data Access, where Benn et al. emphasize "Real-Time Acquisition and Display of Sensor Data" (mean 3.41), while the present study highlights "Facilitating Real-Time Data Access" with a higher mean of 4.20. This difference underscores a growing recognition of real-time data access as essential for enhancing FM operational efficiency.

In Okoro et al. (2019), a similar significance is observed between Facilitating Real-Time Access and Creating Digital Assets (Okoro's study: 4.18 for both; current study: 4.20 and 3.94, respectively). However, Okoro's study regards these factors as equally influential, while the present study finds real-time access slightly more impactful for BIM-FM effectiveness. Another difference lies in Checking Maintainability, where Okoro's study reports a mean of 4.12 compared to 3.84 in this study, indicating some variance that may stem from distinct methodological approaches, sample demographics, or unique contexts influencing each study.

The study by Durdyev et al. (2022), using a distinct method (P-FAHP), prioritizes cost-based factors as the main BIM-FM integration challenges, particularly Costs Associated with Information Management and Training BIM Personnel. In contrast, the present study places Unperceived Cost Benefits of Using BIM as the primary hindrance, suggesting a notable gap in Malaysia where FM practitioners may not fully understand BIM's advantages, as opposed to the relatively greater awareness observed among New Zealand practitioners. Additionally, BIM Workflow Clarity ranks lower in Durdyev et al. (16th out of 20) but is more prominent in the current study (6th out of 16), indicating that a lack of workflow clarity is a key barrier for BIM in Malaysia but less so in New Zealand. Both studies, however, align on the relevance of interoperability issues, such as Interoperability Between BIM and FM Technologies and Incompatible File Exchange Formats, revealing persistent challenges with technology compatibility in both regions.

Cyber Security and Privacy ranks as the least influential factor in Durdyev et al., likely due to the adoption of blockchain technology in New Zealand to secure BIM data. Conversely, Malaysia's ranking of this factor (13th out of 16) suggests a need for more advanced data protection practices to better support BIM-FM integration and align with global standards.

CONCLUSION

This study underscores the significant potential of BIM in enhancing facility management (FM) practices while identifying the primary barriers hindering its implementation in Malaysia. Key findings reveal that while BIM can greatly facilitate Space Management, Real-Time Data Access, and Visualization, substantial obstacles remain. The highest-ranked barriers—such as unperceived cost benefits, long adaptation times, and software-related challenges—highlight a need for greater awareness and understanding of BIM's value among FM practitioners.

The comparative analysis with previous studies also points to regional differences; Malaysian FM practitioners face unique challenges around cost awareness and workflow clarity, which are less prevalent in other regions. Addressing these issues could accelerate BIM adoption, making it a valuable asset in the FM sector. Enhancing BIM-FM interoperability, investing in cybersecurity, and fostering industry awareness are crucial next steps. By strategically addressing these barriers and leveraging BIM's capabilities, FM in Malaysia can progress toward more efficient, data-driven, and sustainable management practices, aligning with global trends in digital transformation.

Comparative analysis of BIM maturity levels across FM organizations in different states or countries should be undertaken. This analysis would assess the current status of BIM implementation, including technology adoption, standardization, collaboration practices, and BIM competency within FM teams. It would identify variations in BIM maturity and factors contributing to successful implementation, guiding benchmarking, capacity-building initiatives, and policy development to accelerate BIM adoption in FM.

While this study sheds light on the potential of BIM adoption within facilities management in Malaysia, several limitations must be acknowledged. Firstly, the study's sample size, though representative, may limit the generalizability of results to the broader Malaysian FM industry. Additionally, the geographic focus on Malaysia could mean that findings are influenced by specific regional practices, policies, and challenges, which may differ in other countries. Future studies could explore the impact of BIM adoption on key FM performance metrics, such as operational efficiency, cost savings, and sustainability outcomes. Investigating factors like government policies, industry collaboration, and educational initiatives could further illuminate barriers and enablers of BIM adoption specific to the Malaysian FM landscape.

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