

## Article

# Strategies for Adopting Building Information Modeling (BIM) in Sustainable Building Projects—A Case of Malaysia

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**Abstract:** In terms of sustainable growth, Malaysia's construction industry faces significant challenges, such as construction costs and lack of awareness. To meet these challenges, it is essential to integrate building information modeling (BIM) and sustainable development. As a result, this study aimed to establish strategies for adopting BIM in sustainable building projects. A systematic literature review was performed to classify the strategies to accomplish this aim, followed by a questionnaire survey of 129 construction project stakeholders. Mean score and exploratory factor analysis (EFA) were conducted to explore the detailed influence of BIM adoption strategies in sustainable building projects. The results revealed that “workshops, lectures, and conference events are used to enhance public awareness” and “better information on the costs and benefits of sustainable materials” and “strengthened sustainable development” were the most essential strategies to boost sustainable growth in building projects. Furthermore, EFA was conducted to undertake the group analysis, namely, to identify the standardization-related strategy, economic-related strategy, awareness-related strategy, and environment-related strategy. This study paves the way for future scholars, policymakers, and practitioners to investigate the limitations of future studies.

**Keywords:** building information modeling; sustainable building; projects; strategies; construction



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## 1. Introduction

Malaysia's construction boom began in the early 1990s, with the completion of mega-projects, such as the PETRONAS Twin Towers and the Malaysian Skyscraper Development Corporation. The construction industry peaked in 1995 when its GDP surged by an astounding 17.3 percent [1]. This rate of development was comparable to that of developed countries. The GDP of the construction industry increased at a 14 percent annual pace from 1994 to 1997. As a result, when the Asian Financial Crisis hit Malaysia and the Asian region in 1998, the Malaysian construction industry found itself in an even more hazardous situation [2]. However, throughout time, the government has provided the majority of the funding for the Malaysian construction industry in order to assist in the creation of the country's infrastructure [3]. Furthermore, the Malaysian government plans to transform Malaysia into a nation with sustainable growth by 2030. However, in terms of sustainable growth, Malaysia's construction industry has substantial hurdles to overcome, such as building costs and a lack of awareness [4]. Given the current market conditions, enhancing productivity and quality is critical for establishing a long-term viable local construction sector that is capable of capitalizing on worldwide opportunities regarding governing the life cycle of buildings.

Building information modeling (BIM) may act as a central database that aids in the entire process of managing the building life cycle by making digital representations of the physical and functional information of sustainable projects available to all stakeholders.

It has enabled the digital management of the full life cycle of buildings, including the design, construction, operation, management, and maintenance phases of sustainable projects, resulting in a significant improvement in project productivity and cost control, while lowering the risks associated with such projects [5]. BIM models, for example, can be used in advance to determine the necessary construction supplies, equipment, and capital requirements, as well as to conduct schedule planning in sustainable projects [6]. BIM may also be used to track work in real time, estimate costs, identify construction deviations, check construction quality, record product problems, and restore projects on time. Green building designers, builders, and operators can benefit from BIM to improve the design, construction, and management of green buildings [7]. This analytics tool can be used to study the numerous functions of green buildings, such as energy use, carbon emissions, and ventilation assessments, in order to promote building sustainability.

The construction industry benefits society in ways other than profit, health, and well-being. It has significant effects on community services while enhancing individuals' quality of life [8] and safety [9]. The government has a ready supply of public infrastructure in the construction sector that it can offer to the country. As a result of growing concern that human activities are having a major negative impact on the environment, sustainability has become a mainstream paradigm in the construction industry [10]. Today's generally agreed concept of sustainability is that of the World Commission on Environment and Development (WCED), which describes sustainable development as "development that meets the needs of the present without compromising future generations' ability to meet their own needs" [11]. As a result, when carrying out building projects, caution must be taken not to deplete the available capital to the extent that future generations will be unable to meet their own needs.

The sustainable construction process seeks to promote the natural environment while also ensuring protection, increasing human dignity, and fostering economic justice, which is very much in the spirit of the values and purpose of those views [12]. It combines the fundamental themes of sustainable development and aims to instill environmental accountability, social awareness, and economic profitability in key players creating the built environment [13]. Thus, sustainability in construction can be described as a method of striking a balance between economic, environmental, and social factors regarding building design, construction, usage, and maintenance [14]. However, research has shown that the degree of sustainability in the majority of developing countries is low [15].

Abolore [16] linked the low degree of sustainability of building projects to participants' lack of understanding of the idea of sustainability. Jamaludin et al. [17] made a similar discovery when analyzing the awareness, drivers, attitudes, and barriers of sustainable construction. It was found that the level of sustainable construction implementation was poor and this may be attributable to the relative unfamiliarity of people with the idea. However, according to Durdyev et al. [18], the major challenge regarding sustainability implementation is not one of understanding, but one of appropriateness. While sustainability is recognized, it is not followed correctly due to financial constraints, an uneconomical construction project, or the issue of sustainable resource management, which is overlooked given that comprehensive nature of sustainable construction is a difficult task when applied to achieve the desired goals [19].

Yap et al. [20] asserted in an analysis of sustainable construction in developing countries that one major challenge is that it is viewed as a term that would add costs to the project. It has been found that additional costs for construction projects and limited knowledge of the advantages of sustainable construction are the main challenges [21,22]. According to Ahmad et al. [23], the fear of higher investment costs for sustainable buildings relative to conventional buildings, as well as the possibility of unexpected costs, are frequently cited as challenges for sustainable buildings. Ahmad et al. [23] found that monitoring, controlling, practical schedules, problem-solving capacity, project goal comprehension, and resource allocation are critical for ensuring the success of sustainable construction. Based on this theoretical background, this study assessed the adoption of BIM in sustainable

building projects. It is pertinent to mention that the construction sector under discussion remains in its very basic stage regarding the implementation of BIM. One of the challenges lies in considering the proper strategic directions to promote the application of BIM in sustainable developments. This is why the basic concern at the strategic level has been addressed in the current study.

## 2. Literature Review

Stakeholder collaborations will help to improve the overall performance of sustainable building practices by resolving challenges that the owners, public, clients, and consumers face [24]. By providing an online forum for people to work on, BIM can make building life much more effective than conventional methods, enabling them to easily switch from designs to implementation to post-design to maintenance [25,26]. BIM adds a level of usefulness to the design that allows it to be used to solve problems while also contributing to environmental sustainability [27,28]. With this intelligent BIM model, an entire building performance analysis can be performed, performance effects can be observed, an appearance simulation can be run, and a visualization of the building can be presented [28].

Although it can be used in a variety of fields, BIM is ideally suited for sustainable building projects and applications that need data on sustainability and energy efficiency [28]. This is a method of making improvements that are beneficial to long-term environmental sustainability. Previous research has shown that using BIM technology plays an important role in waste reduction, which is an important feature of a sustainable project. Curry et al. [29] suggested the convergence of BIM and LCA was based on a life cycle cost assessment. Bynum et al. [30] studied sustainable design applications to various scenarios and applications, including by architects and developers, prior to understanding the perceptions applied to applying BIM, especially as part of sustainable construction. Kota et al. [31] investigated the use of BIM for quantifying day lighting within sustainable buildings based on analyses and simulations of day-lighting models.

It is vital to conduct further research in order to have a better understanding of strategies to adopt BIM in sustainable building projects in Malaysia. Previous research did not thoroughly discuss these strategies; however, these strategies must be carefully considered in order to establish and adopt successful initiatives for improving BIM technology usage in sustainable building projects. This study identified these strategies and examined their effect on sustainable building projects of Malaysia. From an extensive literature review, the following strategies were highlighted, as shown in Table 1.

**Table 1.** Strategies used to adopt BIM in sustainable building projects.

Strategies	References
Efficient energy forecasts in sustainable buildings	[32]
Prompting construction industry standards	[33]
More research on BIM toward sustainable buildings	[34]
Improvements in BIM application standards in sustainable buildings	[35]
Economic and additional financial BIM adoption rewards	[36]
Enhance social networking (e.g., print media, internet, and radio and television programs)	[37]
Strengthened sustainable development	[38]
Workshops, lectures, and conference events are used to enhance public awareness	[39]
Overall support from the senior management	[40]
Acknowledging and supporting BIM experts	[41]
Better information on the costs and benefits of sustainable materials	[42]
Compel strict environmental controls and assessments	[43]
System of green or environmentally friendly labeling	[44]

### *BIM and Sustainability*

BIM has changed the way sustainable building projects are undertaken [45]. Constructions can be evaluated using BIM to determine their advantages and disadvantages, as well as their opportunities, while accounting for other factors, such as financial, technical, and environmental aspects [46]. It is believed that BIM has the potential to help the construction industry and that widespread adoption could have a significant effect on sustainability [47]. The term “BIM,” which could be used to describe this process, means “elaborate an integrated and holistic building strategy” that includes design, construction, and operational aspects, as well as the use of modeling [48]. A significant concern in building-oriented designs and implementation methods is ensuring that construction does not deplete natural resources [49]. These things were shown to be beneficial in achieving a proper balance of the two goals, namely, reducing the environmental effect and streamlining construction procedures, through creativity and application of these advanced technologies to the construction industry regulation of energy conservation [50].

Sustainable development is beneficial in all aspects of building projects when incorporating BIM [51]. This involves the development and application of long-term strategies, as well as modern, cutting-edge technology. Sustainable building projects, as an advanced building type, are attracting worldwide attention [52]. According to the researchers at Osaka University in Japan, the “sustainable architecture” plan was first implemented in their research facility. The buildings are surrounded by a green yard and a fresh-looking wall, which greatly decreases their energy costs [53]. As a result, builders, architects, and designers are exploring new building design models that fit people and the environment during the planning, construction, usage, and maintenance as much as possible [54]. Such sustainable practices and innovations will generate enormous profits as a result of reduced carbon dioxide (CO<sub>2</sub>) emissions and increased energy efficiency, as well as being more environmentally friendly. It is credited with promoting resource management and protecting workers’ safety during construction, resulting in less waste and fewer people being exposed to risks [55].

BIM technology is gaining popularity due to its model-based characteristics and the technology for coordinating the use of building expertise [56]. BIM has many benefits owing to its integration of expertise from design and project participants, which include improving the design efficiency, reducing construction costs, and promoting the sustainability of projects while ensuring that project workers are interconnected and contributing toward accelerating projects and help to maximize project activities [57]. In terms of practical use, real BIM technology ventures are widely used in Western countries. Despite widespread acceptance, there is strong evidence that BIM adoption and innovation have helped sustainable growth in both the United States and Europe [58]. According to the U.S. National BIM standard, BIM adoption increased from 13 to 48% between 2010 and 2014 [59]. BIM refers to representative approaches to streamlining sustainability processes in which one can define and handle the various components that comprise a system, as well as anticipate and enhance its capacity [60].

BIM aids both project participants and beneficiaries in realizing various benefits in sustainable development [61]. A flow system can easily generate and project information on energy use while still providing accurate work data during the construction project. BIM provides an information and communication technology (ICT) system that encourages collaboration between stakeholders across the life cycle of sustainable projects; this makes it simple to input, extract, share, or transform information in the BIM platform [62]. The most challenging task for sustainable buildings is the inability to collect life cycle data, track projects, and perform real-time data analysis to share with project participants [63]. Despite these limitations, the substantial progress that has been made in the use of BIM technology and sustainable building projects are able to achieve positive results by taking into account these new features [64].

### 3. Research Methodology

In the research methodology, there were three stages. In the first stage, data were collected from the literature by identifying BIM adoption strategies and developing a questionnaire survey to be distributed to stakeholders (contractors, clients, and consultants). In the second stage, the SPSS 22.0 software package was used to evaluate the respondents' feedback and undertake data analysis, such as demographic analysis of the questionnaire respondents, convergent validity, Spearman's rank correlation coefficient, mean score analysis, and exploratory factor analysis (EFA). In the third and final stage, a discussion was carried out on the basis of the analysis results. The research methodology flowchart is shown in Figure 1.

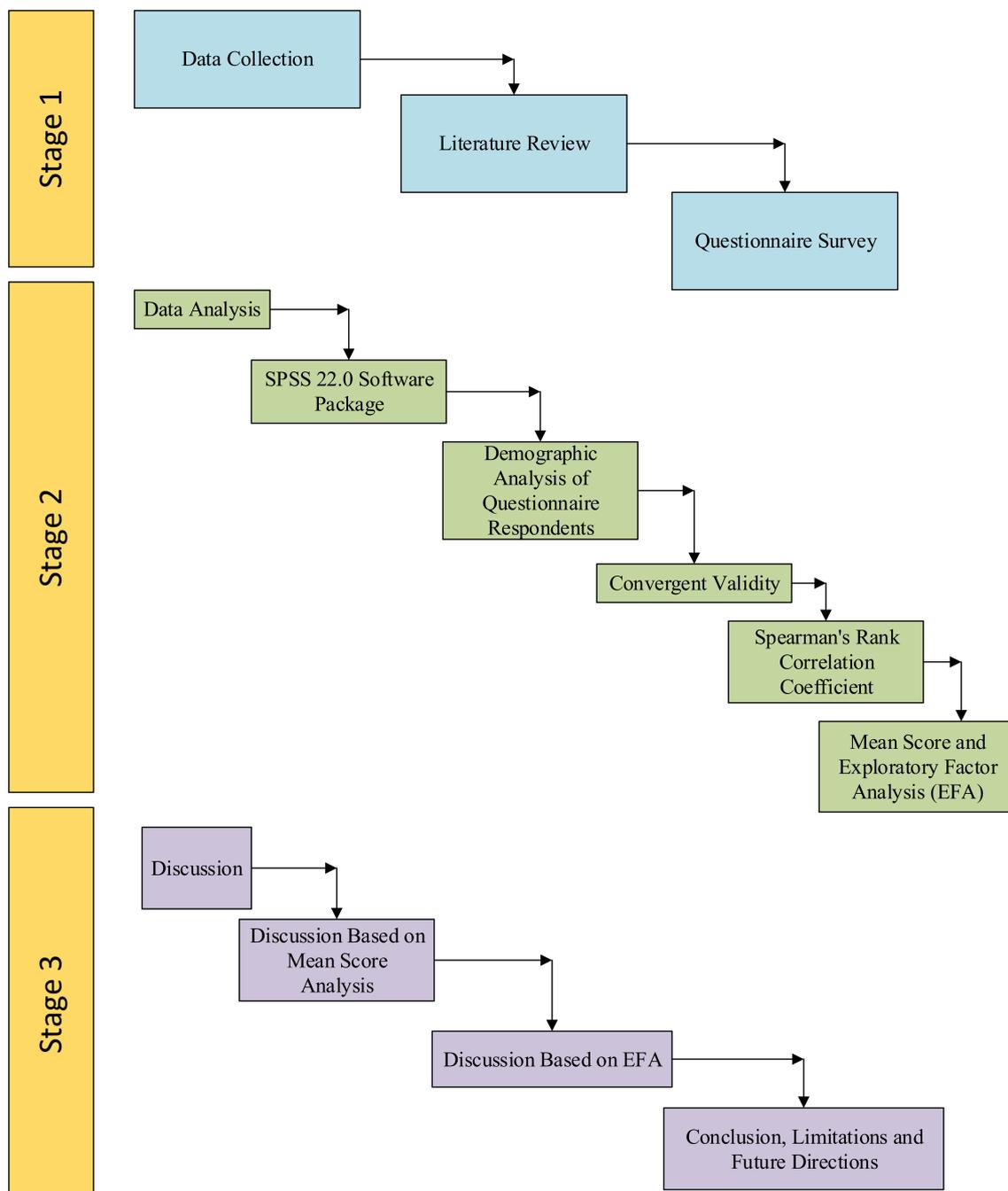


Figure 1. Research flowchart design.

### Questionnaire Design and Survey

A semi-structured interview was conducted prior to the final questionnaire survey. The final questionnaire was developed using a literature review, as well as input from the semi-structured interviews. The aim of these semi-structured interviews was to determine the relevance and completeness of the questionnaire data. Two assistant professors, two professors, and one postgraduate student took part in semi-structured interviews. The final questionnaire was divided into two sections: (a) general information about the respondents and (b) strategies used to adopt BIM into sustainable building projects using a Likert scale (1–strongly disagree, 2–disagree, 3–moderately, 4–agree, 5–strongly agree). In addition, 250 questionnaires were distributed via e-mail with 129 responses, yielding a response rate of 51%. The questionnaire was distributed in the northern region of Malaysia. The respondents were chosen based on their work experiences in the fields of BIM and sustainability, as well as their understanding of BIM and their depth of knowledge.

## 4. Results Analysis

This section explores the results of the demographic analysis of questionnaire respondents, convergent validity, Spearman’s rank correlation coefficient, mean score analysis, and EFA in detail.

### 4.1. Demographic Analysis of Questionnaire Respondents

The questionnaire survey respondents were categorized based on their gender, education qualification, working experience, construction projects’ stakeholders, and position of stakeholders. Table 2 elaborates the distribution of respondents.

**Table 2.** Distribution of respondents.

Item	Description	Number of Participants	Percentage (%)
Gender	Male	101	78
	Female	28	22
Educational qualification	Bachelors	32	35
	Masters	29	25
	PhD	45	22
	Professional engineers	23	18
Working experience	5–7 years	55	45
	8–9 years	36	35
	More than 10 years	38	20
Construction projects’ stakeholders	Contractors	56	43
	Clients	26	37
	Consultants	47	20
Position of stakeholders	Project engineer	45	38
	Quantity surveyor	35	27
	Construction manager	49	35

### 4.2. Convergent Validity

The degree of accuracy within the measurement result was used to assess the reliability. This analysis was able to assess the data’s reliability by using SPSS 22.0. It also produced a Cronbach’s alpha coefficient, which is a popular method of determining data validity. The Cronbach’s alpha coefficient usually has a value between 0.6 and 0.8; if it has a value higher than 0.8, it is the most reliable [65]. The analysis for this study yielded a reliability coefficient value of 0.912, indicating a very high degree of data reliability.

#### 4.3. Spearman's Rank Correlation Coefficient

The Spearman's rank correlation coefficient ( $r_s$ ) is calculated using the following equation [66]:

$$r_s = 1 - \left[ 6 \sum_{n=1}^5 \frac{(d^2)}{n(n^2 - 1)} \right]$$

where  $r_s$  = Spearman's rank correlation coefficient;

$d$  = the difference between ranks assigned to items;

$n$  = the number of respondents.

The Spearman's rank correlation coefficients were calculated for all stakeholders. The consultants and contractors had a coefficient value of 0.890. The correlation between clients and consultants was 0.813, while the correlation between clients and contractors was 0.841. Furthermore, there was a substantial relationship between the three stakeholders  $p = 0.000$  which was less than the allowable sum of significance of 0.01. In other words, a deep relationship between consultants and contractors, or to put it another way, a long, intimate bond between clients and consultants.

#### 4.4. Mean Score Analysis

The aim of mean score analysis is to rank the relative importance of factors in a quantitative analysis. Mean score analysis was also used in various previous studies [67,68]. The rankings of BIM adoption strategies were categorized into four parts with the data analysis results using mean values: (a) overall ranking, (b) ranking according to contractors' perspectives, (c) ranking according to consultants' perspectives, and (d) ranking according to clients' perspectives. Table 3 illustrates the detailed picture of the mean score analysis.

**Table 3.** Mean score analysis of respondents.

Strategies	Overall Respondents		Contractors' Perspectives		Consultants' Perspectives		Clients' Perspectives	
	Mean Value	Rank	Mean Value	Rank	Mean Value	Rank	Mean Value	Rank
Workshops, lectures, and conference events are used to enhance public awareness	4.10	1	4.02	2	4.09	2	4.00	1
Better information on the cost and benefits of sustainable materials	3.99	2	3.90	1	3.89	1	3.85	3
Strengthened sustainable development	3.80	3	3.81	3	3.82	4	3.72	2
System of green or environmentally friendly labelling	3.82	4	3.75	4	3.71	3	3.67	12
Overall support from the senior management	3.64	5	3.66	6	3.33	5	3.50	4
Acknowledging and supporting BIM experts	3.60	6	3.40	5	3.20	6	3.41	5
Economic and additional financial BIM adoption rewards	3.07	7	3.12	7	3.11	7	3.29	6
Compel strict environmental controls and assessments	2.96	8	2.90	13	2.99	10	3.01	7
Prompting construction industry standards	2.87	9	2.85	8	2.82	9	2.80	10
Enhance social networking (e.g., print media, internet, and radio and television programs)	2.76	10	2.71	12	2.69	8	2.75	13
More research on BIM toward sustainable buildings	2.70	11	2.60	10	2.58	13	2.69	9
Efficient energy forecasts in sustainable buildings	2.61	12	2.51	9	2.49	11	2.45	8
Improvements in BIM application standards in sustainable buildings	2.56	13	2.43	11	2.32	12	2.30	11

The analysis results show that the top three strategies to use when adopting BIM in sustainable building projects are as follows: “workshops, lectures, and conference events are used to enhance public awareness,” “better information on the cost and benefits of sustainable materials,” and “strengthened sustainable development.” According to the contractors’ perspectives, “workshops, lectures, and conference events are used to enhance public awareness” was ranked second, “better information on the cost and benefits of sustainable materials” was ranked first, and “strengthened sustainable development” was ranked third. According to the consultants’ perspectives, “workshops, lectures, and conference events are used to enhance public awareness” was also ranked second, “better information on the cost and benefits of sustainable materials” was also ranked first, but “strengthened sustainable development” was ranked fourth.

Furthermore, according to the clients’ perspectives, “workshops, lectures, and conference events are used to enhance public awareness” was ranked first, “better information on the cost and benefits of sustainable materials” was ranked third, and “strengthened sustainable development” was ranked second. Therefore, it is worth mentioning that according to the feedback of contractors, clients, and consultants, it was shown that “workshop, lecture, and conference events are used to enhance public awareness,” “better information on the cost and benefits of sustainable materials,” and “strengthened sustainable development” were the most common strategies. Although the ranking varied, these strategies gained attention from contractors, clients, and consultants.

#### 4.5. Exploratory Factor Analysis (EFA)

Exploratory factor analysis (EFA) is a technique that aids in the identification of the common factor among multiple variables that support or underpin the items in a given collection. The KMO value of this study was 0.519, which was acceptable as it satisfied the threshold of 0.50. Table 4 illustrates the clear picture of EFA analysis and comprises four groups: (i) standardization-related strategy, (ii) economic-related strategy, (iii) awareness-related strategy, and (iv) environment-related strategy.

**Table 4.** Results of the EFA analysis.

Strategies	1	2	3	4	Grouping
Prompting construction industry standards	0.873				Standardization-related strategy
Improvements in BIM application standards in sustainable buildings	0.865	-	-	-	
Compel strict environmental controls and assessments	0.833				
Economic and additional financial BIM adoption rewards	-	0.821	-	-	Economic-related strategy
Better information on the costs and benefits of sustainable materials		0.819			
Enhance social networking (e.g., print media, internet, and radio and television programs)			0.765		Awareness-related strategy
More research on BIM toward sustainable buildings	-	-	0.759	-	
Workshop, lecture, and conference events are used to enhance public awareness			0.751		
Overall support from the senior management			0.740		
Acknowledging and supporting BIM experts			0.732		
System of green or environmentally friendly labeling	-	-		0.690	Environment-related strategy
Efficient energy forecasts in sustainable buildings				0.621	
Strengthened sustainable development				0.615	

## 5. Discussion

This section addresses the top three strategies for adopting BIM in sustainable building projects in depth based on the mean score analysis and group formation by EFA.

### 5.1. Discussion Based on the Mean Score Analysis

#### 5.1.1. Workshop, Lecture, and Conference Events Are Used to Enhance Public Awareness

In Malaysia, there is still a lack of understanding about the benefits of using BIM. When a company uses BIM in its daily operations, the level of BIM acceptance and team awareness increases, and teaching or facilitating seminars become passive if they are not used. Willingness and dedication both contribute to its successful adaptation, and participation in the development of BIM strategies aids in keeping team members and colleagues actively involved in the project. The implementation of workshops, lectures, and conference events to discuss the need for the construction industry to incorporate sustainability in building projects is crucial. Professional bodies have an important obligation to organize workshops, lectures, and conference events related to the use of BIM in sustainable building projects in order to raise awareness of the value of sustainability. The current trend in developing countries toward environmental sustainability has resulted in a huge demand for delivering construction projects, which has exceeded sustainability concerns.

#### 5.1.2. Better Information on the Costs and Benefits of Sustainable Materials

The majority of projects fail because the cost estimate significantly underestimates the actual cost of the project. Unfortunately, the bulk of the projects were not completed on time or on budget. Construction projects have received a substantial portion of national investment funds from developing-country governments. Projects in developing countries have a significant economic impact because of their profound effects on climate and socioeconomic systems. Aside from financial considerations, project priorities and building performance are the most important factors in determining construction sustainability. The construction industry contributes to the majority of economic well-being by assisting in the construction of sustainable projects and adding value to building materials [69]. The use of building materials has a significant environmental effect, owing to the vast quantity of non-renewable resources that have the potential to deprive future generations of their use.

#### 5.1.3. Strengthened Sustainable Development

Sustainable development provides a new way of thinking that aligns the universal human desire to enhance our quality of life with the constraints placed by our global environment. The adoption of BIM in construction is gaining traction as a means of boosting long-term growth. When considering the built environment, which has an effect on the heart of social–ecological processes, information technology, and natural ecosystems, a wider view of sustainable development is necessary. BIM has historically been used in project- and construction-related fields such as production and design, but there has recently been a surge of interest in the idea of sustainable development.

### 5.2. Discussion Based on EFA

#### 5.2.1. Standardization-Related Strategy

The standardization-related strategy consists of “promoting construction industry standards,” “improvements in BIM application standards in sustainable buildings,” and “compel strict environmental controls and assessments.” BIM refers to long-term structures and technologies that enable stakeholders to interact over the life cycle of a project by enabling them to insert, remove, update, or change information in the BIM model. Traditional project application tools produce less accessible data and knowledge for visualizations and simulations than BIM applications. The implementation of BIM software that integrates the model and simulation would expand on previous technological advances to allow for analyzing and processing multiple information streams at the same time, resulting in the elimination of data handling errors. According to Zhang et al. [69], the intelligent

data generated by the BIM model can be used to conduct whole-building energy analysis, simulate the performance, and visualize the appearance. As this system is integrated into the design, designers will make direct comparisons of the design's results over the life cycle to help ensure that its capabilities and design defects are detected and removed early.

#### 5.2.2. Economic-Related Strategy

The economic-related strategy consists of "economic and additional financial BIM adoption rewards" and "better information on the cost and benefits of sustainable materials." Sustainable building projects necessitate a long-term perspective that weighs the initial capital cost against the structure's operating costs. The greatest economic benefits of sustainable construction are seen in terms of lower operating and service costs, as well as operational and maintenance costs, and greater building efficiency, which are mutually beneficial. Since the time required to introduce sustainable practices is clearly insufficient to justify their adoption in a highly competitive market, the long-term costs could be prohibitive. There is a lag in implementing new and more sustainable methods that strive to increase overall performance as long as good practices spread. According to Ayarkwa et al. [70], this lag is mostly due to a lack of client demand, as well as the mistaken belief that sustainable construction methods are more expensive than traditional construction methods. To ensure more competitive options are available, cost consultants should add a 10% margin to capital costs.

#### 5.2.3. Awareness-Related Strategy

The awareness-related strategy consists of "enhance social networking (e.g., print media, internet, and radio and television programs)," "more research on BIM toward sustainable buildings," "workshop, lecture, and conference events are used to enhance public awareness," "overall support from the senior management," and "acknowledging and supporting BIM experts." The Construction Industry Development Board (CIDB) Malaysia, which aims to increase, advance, and promote construction growth while also assisting in making the industry more sustainable, has identified the need for better environmental aspects as one of its main functions. The CIDB Malaysia has organized a number of seminars, dialogues, and forums to resolve and prioritize environmental needs in the construction industry. Other Malaysian institutions that have spearheaded research in this field include the National Institution of Valuation, Malaysia (INSPEN); the Malaysian Science and Technology Information Centre (MASTIC); and local universities [71]. Several government, technical, and non-profit organizations have launched a variety of sustainable application programs for developers to help them gain a better understanding of these concerns and learn how to apply them responsibly. Several seminars, lectures, presentations, workshops, and speeches have been given about the importance of sustainable practices in the construction industry in order to elevate the industry's status as a long-term developer.

#### 5.2.4. Environment-Related Strategy

The environment-related strategy consists of "system of green or environmentally-friendly labelling," "efficient energy forecasts in sustainable buildings" and "strengthened sustainable development." Building professionals all over the world are involved in improving the environment and introducing innovative development technologies that have a lower environmental impact, which has resulted in buildings with recycling and eco-labeling incorporated in their designs. Building efficiency is now a significant concern for building professionals and environmental building performance evaluation has emerged as one of the major concerns in sustainable construction. In 2009, the Board of Architects Malaysia (PAM), in partnership with the Association of Consulting Engineers Malaysia (ACEM), launched the Green Building Index (GBI) Malaysia to guide the Malaysian property industry toward being more environmentally friendly. Through this rating system, developers have an opportunity to create and construct environmentally friendly buildings while reducing energy and water use, reducing air pollution, increasing accessibility

to public transportation, improving accessibility to community green initiatives, getting people involved in recycling, and beautifying their properties

### 5.3. Comparison of Results with the United States and New Zealand

To this end, this study compared the top three identified strategies for Malaysia, the United States, and New Zealand. This type of outcome comparison has piqued the interest of academics in the field of construction management. Table 5 shows that “workshop, lecture, and conference events are used to enhance public awareness” was the most popular strategy for adopting BIM in sustainable building projects in Malaysia, while ranking ninth in the United States and “not identified” in New Zealand. Furthermore, “better information on the cost and benefits of sustainable materials” was placed second in Malaysia, despite being rated sixth in both the United States and New Zealand. Malaysia ranked the strategy “strengthened sustainable development” in third place, which is comparable to the United States, which ranked it fourth, and New Zealand, which ranked it fifth.

**Table 5.** Comparison of results with the United States and New Zealand.

Top 3 Strategies	Malaysia (Current Study)	United States [72]	New Zealand [73]
Workshop, lecture, and conference events are used to enhance public awareness	Rank 1st	Rank 9th	Not identified
Better information on the costs and benefits of sustainable materials	Rank 2nd	Rank 6th	Rank 6th
Strengthened sustainable development	Rank 3rd	Rank 4th	Rank 5th

## 6. Conclusions, Limitation, and Future Directions

This study’s main aim was to analyze how BIM can be used in sustainable buildings in Malaysia. It was found that workshops, lectures, and conference events were used to enhance public awareness. Better information on sustainable materials’ costs and benefits and strengthening sustainable development were the topmost essential strategies for boosting sustainable growth in building projects. Based on the EFA analysis, this study classified four groups of strategies: standardization-related strategy, economic-related strategy, awareness-related strategy, and environment-related strategy. In addition, the findings of this study provide a valuable guide for relevant authorities and governments when developing relevant legal norms to enhance the applications of BIM in sustainable buildings; by developing relevant regulations, project participants can clarify the application requirements of BIM technology. Furthermore, BIM users should consider the importance of using BIM technology in the construction of sustainable buildings.

In terms of building design, for practical applications, it is required that facilities management personnel be incorporated into the building development alongside architecture and engineering. This finding provides a foundation for researchers interested in studying the impact of BIM in developing countries, especially in the fields of construction engineering and management. This understanding will boost the perceived satisfaction and increase the desire to use the framework. This study has some limitations. Since this research was conducted in Malaysia, the results may not be valid in other countries due to cultural differences. However, it is recommended that additional research is performed to compare the results. Furthermore, structural equation modeling (SEM) will be needed in the future to gain a thorough understanding of the strategies for implementing BIM in sustainable building projects.

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