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Measuring the Benefits and Barriers of the Implementation of BIM in Sustainable Practice in the Construction Industry of Saudi Arabia

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Abstract: The construction industry of Saudi Arabia has witnessed notable innovation in sustainable practices in the form of building information modeling (BIM). Previously, a few studies dealt with either the benefits and barriers of BIM or sustainability. However, there is a limitation in these studies in terms of finding out the benefits and barriers of BIM in sustainable construction projects, especially in the context of Saudi Arabia. Therefore, the present study aimed to examine the determinants that impact the adoption of BIM in the construction industry of Saudi Arabia. A thorough examination of the existing literature was conducted in order to identify the various factors that contribute to the benefits and barriers of BIM. The research employed a questionnaire survey of 152 building engineering professionals from Saudi Arabia. The questionnaire's results emphasize the key factors that are essential for the implementation of sustainable BIM. Initially, barriers and benefits were prioritized according to the relative importance index (RII). In addition, the study utilized statistical methods to identify the top five barriers that were deemed most significant. The Cronbach alpha test confirmed the presence of a statistically significant level of consistency in the responses provided by stakeholders. Moreover, the Spearman correlation test demonstrated that there was no statistically significant variance among the groups in their responses. The results indicated that among the 28 benefit factors, "improving design efficiency (RII = 0.788)", "encouraging the use of energy-efficient clean technology (RII = 0.786)", and "promoting green building design, construction, and management" were the top three benefits from BIM implementation in sustainable construction projects. On the other hand, "recurring demand for increased resources, together with high costs (RII = 0.720)", "absence of a well-defined method for exchanging operational management data (RII = 0.713)", and "lack of skilled personnel (RII = 0.708)" were the top five barriers to the incorporation of BIMs in the sustainable construction industry of Saudi Arabia. This study can provide valuable guidance for policymakers in developing countries who seek to successfully complete sustainable construction projects by encouraging factors that drive BIM implementation and enhancing project performance through the utilization of the benefits of BIM.

Keywords: BIM; construction industry; sustainable practice; project; benefits; barriers; Saudi Arabia

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1. Introduction

It is projected that the architectural, engineering, and construction (AEC) industry will make a significant contribution of approximately 15% to the worldwide gross domestic product (GDP) by the year 2030, as indicated by [1]. The construction industry's products serve as fundamental supports for society and other economic sectors by establishing essential infrastructure and the physical surroundings [2]. Consequently, the consequences for the economy are expected to be more substantial than the direct contribution to the gross domestic product (GDP). The AEC industry has been found to be responsible for approximately 40% of the total energy consumption, 32% of the carbon dioxide emissions, and 25% of the waste generation in Europe, as reported by [3,4]. The current century has experienced a significant change in the construction industry, with a considerable amount of research being aimed at enhancing productivity and excellence through the implementation of inventive methods, methodologies, approaches, and tools for improving project delivery [5]. The construction industry has recently witnessed a promising development known as building information modeling (BIM), which aims to achieve the industry's long-standing objective of quality through efficient project design and management [6]. Despite its longstanding presence, BIM has garnered significant interest in recent years, as evidenced by the growing trend of its implementation in construction projects [7,8]. The adoption of BIM as a means of reducing construction costs and expediting the delivery of construction projects, as exemplified by the "UK Government Construction 2025" initiative, represents a noteworthy instance of policy measures aimed at achieving these objectives [9]. Moreover, it has been observed that certain nations, including Finland, Denmark, and the United States of America, mandate the provision of BIM or Industry Foundation Class (IFC) documents by AEC enterprises during the execution of governmental infrastructure undertakings [10]. However, Al-Yami and Sanni-Anibire [11] revealed that there is a dearth of policy measures in Saudi Arabia aimed at implementing BIM in the construction sector. Additionally, there is an absence of extensive research dealing with sustainable construction projects in the field of BIM in Saudi Arabia.

The proposal of sustainable construction (SC) was put forth to mitigate the construction industry's negative impact on the environment. This approach aims to enhance the economic, social, and environmental awareness of construction procedures, activities, and practices [12]. The introduction of SC was deemed necessary in light of the imperative to ensure the ability of future generations to meet their needs by embracing the principles of sustainability in fulfilling current needs, as highlighted by Brundtland [13]. The utilization of SC materials has become a necessity in the execution of construction projects to accomplish this objective [14–16]. According to Aghimien et al. [17], in order to attain a sustainable built environment, the construction industry must shift from a linear process of construction to a cyclic one in which the life-to-life process is taken into consideration. The impact of constructed structures on the environment has been a topic of extensive discussion in recent decades, as evidenced by numerous scholarly works [18,19]. Both the academic and construction sectors have acknowledged the connection between environmental issues and the construction business [20,21]. Given the escalating sustainability challenges, including the increase in carbon dioxide emissions and the reliance on non-renewable energy sources, several construction initiatives have embraced eco-friendly and sustainable construction approaches [22–25]. These methods have been increasingly acknowledged as an effective means of stimulating the growth of the construction sector [26]. BIM has been widely recognized as a promising avenue for delivering significant advantages to the AEC sector due to its reliance on sophisticated technology and efficient construction methodologies [27]. Collaboration plays an important role in the utilization of BIM as a valuable strategy for the development of sustainable systems, thereby expanding the scope of sustainable construction applications, as noted by Ahmad and Thaheem [28]. Furthermore, BIM has the potential to deliver significant resources during the sustainable construction process for all parties involved in a project [29]. Moreover, BIM has the capability to generate and modify energy consumption data and provide an efficient workflow of information during the project operation stage [30]. BIM has the potential to establish a framework for sharing information that fosters collaboration among stakeholders throughout the sustainable construction life cycle. This facilitates the exchange, processing, and transformation of data within the BIM system, thus creating an environment conducive to such activities [31].

The Kingdom of Saudi Arabia (KSA) possesses one of the most expansive construction industries globally, with a multitude of developmental initiatives underway. The KSA is committed to attaining its developmental objectives, as outlined in "Vision 2030", which was supported by a budget of USD 260.8 billion in 2018, marking the highest budget allocation in the history of the Kingdom. Therefore, it is an opportune moment for the Kingdom of Saudi Arabia to align with the global movement towards sustainable development, as observed in nations such as the US, the UK, and Australia, by implementing BIM. A comprehensive review of the literature reveals that Saudi Arabia has not yet fully utilized the potential advantages of BIM, despite the limited number of studies that have been conducted on the subject [11,32–34]. However, the outlook of the benefits and barriers of implementing BIM in sustainable construction projects is yet to be known. The Saudi Arabian sustainable construction industry presents a broad area for scholarly investigation concerning the uptake and execution of BIM in a specific construction sector. This study aims to establish a foundation for future research on BIM in the KSA by identifying potential research areas and gaps, as well as benefits and barriers associated with BIM implementation for sustainable projects. Therefore, a questionnaire survey was conducted, and the benefits, barriers, and implementation opportunities for BIM in sustainable construction projects were identified.

2. Literature Review

2.1. BIM and Its Applications

BIM (short for building information modeling) is a computer-based technology that is utilized in the construction industry to manage data. Its primary focus is on BIM production, analysis, and communication [35]. According to Azhar [36], BIM involves a precise computer-generated model of a building that allows interested parties to visualize the intended construction. BIM is more than a mere digital representation; it signifies a paradigm shift in the execution and management of construction projects within the industry. According to Datta et al. [37], BIM is an all-encompassing tool that integrates, expands, and collaboratively disseminates all process and product information among pertinent stakeholders.

Currently, in order to ensure the successful delivery of construction projects of superior quality, stakeholders are endeavoring to optimize the operational efficacy of ongoing building activities. As per recent trends, numerous contemporary construction projects are adopting the BIM methodology [38]. The discourse surrounding the implementation of BIM centers primarily on facilitating collaboration among diverse organizational entities and utilizing technological tools. Certain scholars have suggested that BIM technologies offer a foundation for instigating a transformation in data management within the construction industry [39]. Conversely, some argued that the proficient utilization of BIM necessitates a technological modernization to conform to the intricate operational procedures of construction endeavors [30,40,41]. Mehran [42] conducted a study on 28 construction projects and utilized case studies to demonstrate that the majority of construction projects that utilized BIM technologies did not take into account the entire life cycle of the project. Instead, they only concentrated on a single application area, particularly during the design phase. Röck et al. [43] demonstrated that it is feasible to implement intricate BIM solutions in restricted domains. The establishment of successful collaboration has been attributed to the fundamental role played by visualization and clash research, as noted in [30].

Academic researchers have explored relevant studies from the standpoint of technological applications. The majority of these investigations endeavored to scrutinize and improve the assimilation of BIM technology implementation throughout project networks [44]. Doan et al. [45] conducted several studies that aimed to investigate the perspectives of relevant stakeholders in New Zealand regarding the implementation of green building practices and their potential synergies with BIM technology. The study put forth a number of recommendations for enhancing the progress of sustainable construction through the incorporation of BIM. Most studies related to BIM applications were focused on the planning and construction phase. The study conducted by Wang et al. [46] centered on the integration of BIM and a geographic information system (GIS) in the context of sustainable construction. The authors also delved into the practical applications of BIM in various construction projects. The findings indicated that technical optimization is necessary for the successful integration of BIM applications in the AEC industry, as evidenced by previous research.

2.2. BIM in SC Projects

The management of full life-cycle data and the use of data analysis for distribution among project stakeholders are two issues that hinder sustainable building on a global scale at the moment [47]. BIM has the capacity to efficiently store and manage data related to energy use in building projects while also supplying thorough workflow data during construction activities [48]. Users may easily upload, extract, validate, or amend data by using a BIM platform. By using visual features, BIM technology has the ability to overcome these constraints and reach energy-saving goals [49]. Consequently, it is essential for users to guarantee that BIM technology is implemented effectively in sustainable structures, thus promoting sustainable development worldwide.

Several writers investigated building projects that used BIM software and sustainability evaluation techniques. These analyses suggested that such integration has the potential to yield significant benefits for sustainable construction [50–52]. Over the last twenty years, an excess of scholarly research has been conducted on the amalgamation of BIM and eco-friendly construction practices. Several academics have conducted evaluations. Olawumi et al. [53] conducted a study on the significant obstacles encountered by construction stakeholders when endeavoring to incorporate BIM and sustainable practices into their construction procedures. According to research, there exist three primary obstacles that impede the adoption of BIM and sustainable practices. These include the unwillingness of the industry to deviate from conventional work methods, a prolonged period of adjustment to novel technologies, and a shortage of comprehension regarding the requisite processes and workflows. In a recent publication, Gao et al. [50] conducted a review of the integration of BIM technology and building energy modeling for the purpose of optimizing energy efficiency in building design. Using BIM technology and day-lighting simulation, Kota et al. [54] performed research on sustainable building. A simulation analysis and performance evaluation were part of the study. BIM has been used in sustainable construction, especially in connection to the building life cycle, according to the review of Wong and Zhou [55]. The use of BIM in sustainable construction across the various stages of a building project's life cycle was thoroughly analyzed by Lu et al. [56]. Curry et al. [57] concentrated on evaluating the economy in light of the life-cycle process. The research also included life-cycle assessments and BIM. This strategy has the ability to streamline the data translation procedure for a specific project and offer insightful data for both of the tools involved. With an emphasis on sustainable design, Antwi-Afari et al. [58] performed research on the application of BIM technology in sustainable building. The study found that the use of BIM technology may reduce construction costs and improve labor productivity. This result highlights the BIM technology's ability to encourage environmentally friendly building methods.

2.3. Benefits and Barriers of BIM in Sustainable Projects

This research provides a thorough analysis of BIM, the construction industry in the KSA, and the investigation and use of BIM in the KSA. This study examines the perceived benefits and challenges of a local AEC firm adopting BIM, thus adding to the body of knowledge on the topic. Frontline industry experts (such as government officials, contractors, and project managers) must first identify these problems in order to effectively address possible facilitators and inhibitors and discover solutions for the implementation of sustainable construction techniques [59]. Different elements, both good and negative, should impact the identification of contributing variables, since doing so promotes the adoption of beneficial ideas while limiting or removing bad ones. As a result, Table 1 provides the benefits and barriers of sustainability-conscious construction projects. It looks at the reasons for adopting sustainable building methods, their chances of success, and the barriers standing in the way of utilizing BIM. Furthermore, nations such as the United Kingdom, the United States, and Australia have extensively implemented BIM in several research domains, including project management, facility management, and safety management [55,60]. In the context of Australia and New Zealand, the utilization of BIM is currently limited to level 2, primarily emphasizing collaborative efforts in the realm of 2D and 3D modeling [61]. According to researchers, one of the reasons for the limited adoption of BIM in Australia is the lack of trust in the reliability of BIM and the absence of customer demand, among other impediments [62]. Several studies conducted by academics from various countries, including Germany, the United Kingdom, Canada, the United States, Denmark, France, China, Brazil, South Korea, and countries in the Middle East [11,58,63–65], have identified multiple obstacles to the application of BIM. The challenges associated with the adoption of BIM encompass several factors. These include a dearth of expertise in utilizing BIM, high investment costs, limited understanding of BIM, absence of well-defined standards, fluctuations in the market and cultural dynamics, difficulties in achieving interoperability, absence of comprehensive recommendations for BIM implementation, and a tendency to resist change [66]. Nevertheless, it is important to investigate the integration of building information modeling (BIM) in sustainable construction endeavors in order to foster an environmentally conscious atmosphere and expedite the achievement of sustainable objectives. This body of research provides an invaluable basis for the current study, which attempts to quantify the benefits and barriers of BIM-based sustainability-building knowledge among industry practitioners in the KSA. It is essential to draw from an international context to identify and embrace the facilitators and overcome the hurdles to the implementation of sustainable building given the absence of major research, especially on construction in KSA.

Table 1. Benefits and barriers to BIM for sustainable construction projects.

ID	Benefits	References
B1	Monitoring performance	[67]
B2	Controlling energy usage	[68,69]
B3	Promoting the decrease in carbon emissions	[65–69]
B4	Enhancing ventilation effectiveness	[69]
B5	Evaluation of water harvesting	[70,71]
B6	Support for effective resource management	[72]
B7	Providing thermal building life-cycle analysis	[64,72]
B8	Providing lighting building life-cycle analysis	[72]
B9	Evaluating optimal opportunities	[73]
B10	Encouraging the use of clean energy-efficient technology	[74]
B11	Enhancing material wastage reduction	[70,75,76]
B12	Promoting green building design, construction, and management	[65]
B13	Necessary technology for achieving CO_2 goals	[77]
B14	Improving design efficiency	[78–80]
B15	Reducing the overall project costs	[78,79]
B16	Enhancing construction performance	[36,81]
B17	Promoting productivity	[36,65,79]
B18	Improving the management procedure throughout the entire life span of buildings (design, construction, operation, maintenance, and management)	[36,82,83]
B19	Reducing project delivery time	[79]
B20	Examining renewable energy sources that reduce the cost of energy	[70]

Table 1. *Cont.*

ID	Benefits	References
B21	Determining the optimal options for decreasing energy and resource utilization	[36,82]
B22	Predicting energy savings	[84]
B23	Promoting financial and investment opportunities	[85]
B24	Enhancing project safety and health performance	[71,82,86,87]
B25	Increasing building life	[88,89]
B26	Smoothening the transition from design to implementation, post-design, and, finally, maintenance	[88,89]
B27	Enhancing individuals' quality of life	[86,87]
B28	Enhancing the construction industry's brand image and competitive advantage	[90]
	Barriers	References
R1	Lack of a collaborative working environment	[68,91]
R2	High cost of application	[92]
R3	Lack of skilled personnel	[92]
R4	High cost of training staff	[93]
R5	Market readiness for innovations	[93,94]
R6	The industry's reluctance to move away from traditional methods of working	[93,95,96]
R7	Lack of experts	[97–100]
R8	Recurring demand for increased resources, together with high costs	[101]
R9	Inadequate in-depth expertise and know-how for operating sustainability-related analysis software programs	[102]
R10	Absence of well-defined guidelines for utilizing BIM in sustainable construction projects	[103]
R11	Absence of a well-defined method for exchanging operational management data	[103]
R12	Organizational challenges, policies, and project strategies	[77]
R13	Inaccurate energy analysis predictions	[77]
R14	Insufficient data to accurately capture sustainability-related information.	[77]
R15	Lack of a comprehensive framework and implementation plan	[104,105]
R16	Industry's resistance to change from traditional working practices	[106]
R17	Increased liability	[107]
R18	Lack of senior management support and attention toward sustainable practices	[107]
R19	Organizational and regional differences in market responsiveness	[63,95,96]
R20	Lack of a legal framework and contract uncertainties	[90]

From the above literature, it was observed that there were a few studies that dealt with either the benefits and barriers of BIM or sustainability with respect to the Saudi Arabian construction sector. However, there is a limitation in these studies in terms of finding out the benefits and barriers of BIM in sustainable construction projects in Saudi Arabia. This study mainly focused on this gap and identified benefits and barriers based on sustainable Saudi Arabian construction projects to add an extra viewpoint. To further clarify the significance of this study, it can be highlighted that Saudi Arabia, like many other countries, is making significant investments in sustainable construction practices to achieve environmental and social goals. Understanding the role of BIM in advancing sustainability in this context is crucial for informed decision making and policy development. This study thus adds value by shedding light on the unique challenges and opportunities in the Saudi

Arabian construction industry, which can differ from those in other regions due to factors such as climate, regulations, and cultural considerations.

3. Methodology

3.1. Questionnaire Design

Figure 1 is an illustration of the seven distinct sections that made up the overall research project. These steps were carried out so that essential concerns relating to benefits, barriers, and other factors in the implementation of BIM for sustainable construction projects in Saudi Arabia may be evaluated. Contemporary research relating to sustainable construction and BIM itself was used in the formulation of the questionnaire. To determine the depth and breadth of the current levels of benefits and barriers to the implementation of BIM in sustainable projects, a literature review was undertaken as the primary technique for the study. The information collected pertains to the building industries of the KSA, as well as those of other nations. In addition, Scopus, Web of Science, and Google Scholar were selected as the primary databases for the factor extraction process. Keywords such as "BIM", "Sustainable construction industry", "Barriers", "Benefits", "BIM in the Saudi Arabian construction industry", and "Global perspective of BIM and sustainability in construction" were utilized in the databases to facilitate the organization of the research articles. Following an analysis of the research, a questionnaire with 28 benefits and 20 barriers to primary considerations was constructed; this took the literature and other sources into account, as shown in Table 1. The years 2011 through 2022 were used as a framework for the research papers chosen for the questionnaire design. Indicators were selected based on their frequency of appearance, relevance to the research topic, and substantiation in credible sources. It was ensured that the indicators chosen were well supported and representative of the broader discourse in the field. Prior to finalizing the indicators, we sought validation through expert consultation and peer review. Experts in the field of sustainable construction and BIM were consulted to provide feedback on the identified indicators, ensuring that they resonated with practical experiences and academic perspectives. There were three sections to this questionnaire. The first section of the questionnaire included basic demographic questions about the respondents, such as their age, gender, occupation, and years of experience in the field. In addition, the questionnaire asked respondents to rate 28 benefits and 20 barriers. Based on prior research [21], the authors elected to use a Likert scale in the development of their questionnaire. For surveys, questionnaires based on Likert scales are a suitable option because they are easy to fill out and generate reliable data based on respondents' actual experiences [2]. Respondents to this research were asked to rank the severity of their responses to a given question ("strongly disagree, disagree, neutral, agree, and strongly agree"). The survey also included a BIM implementation area for sustainable projects, which contributed to the sustainable project management aspect. The survey's third portion included a suggestion box for respondents to express their opinions on the most pressing problems facing Bangladesh's building sector.

3.2. Data Collection

Nonprobability sampling methods, such as convenience and snowball sampling, were employed in the distribution of the questionnaire [21]. Among all types of nonprobability sampling methods, convenience sampling is by far the most prevalent. The respondents in this study were stakeholders in the Saudi Arabian construction sector, and the questionnaires were distributed to them. The information was gathered from the respondents in two ways: (1) through in-person interviews and (2) through email. The authors reached out to the people in their workplaces, places of residence, and other places. This is called "convenience" sampling because it is likely to add some bias when recruiting only a certain slice of the population, unless the intended user group is actually confined to those persons [108]. The authors employed snowball sampling as well. This is a form of convenience sampling in which what is known as the "pyramid effect" occurs when participants invite their friends to take part in a study as well [108]. This approach allowed us to tap into the richness of the knowledge within this specialized community, where personal connections and referrals are often more effective in identifying suitable participants than random or stratified sampling methods. Recent building sites in Saudi Arabia provided the majority of the respondents. It took us four weeks to gather all of the data. All respondents had some experience in the construction business, and more than half had been working in the field for more than five years. A total of 160 people filled out the surveys, and their responses were based on their ratings on a conventional 5-point Likert scale that illuminated their thoughts on the level of importance. Appendix A contains samples of the questions asked. Only 152 datasets were usable for analysis after incomplete or inaccurate ones were removed. This equated to an overall response rate of almost 81.3%.

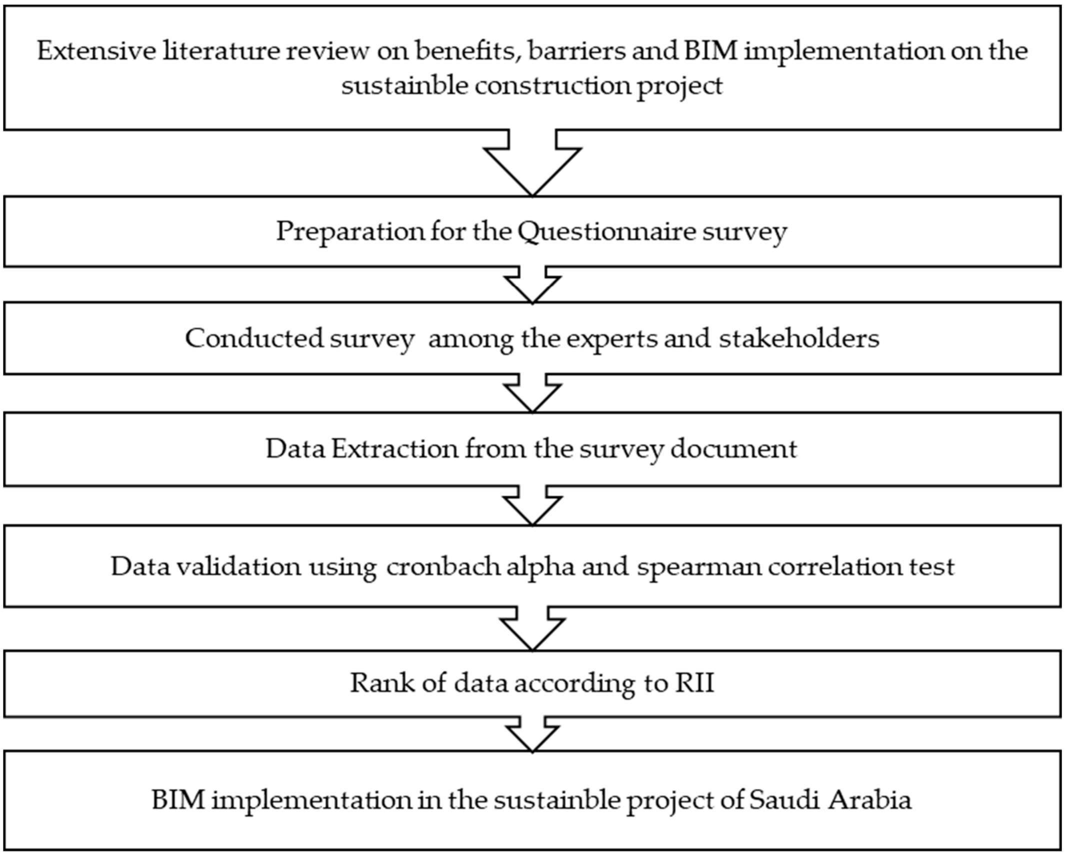


Figure 1. Flowchart of the research process.

3.3. Data Analysis

The statistical program SPSS 25 was used to evaluate the data that had been gathered. The use of these tools made data processing, manipulation, and statistical analysis efficient. The goals of the analysis were to think about how everyone involved in a building project felt about using BIM throughout environmentally responsible phases of development, to identify significant benefits and barriers of implementing BIM in sustainable construction management, and to provide recommendations for improving the barriers to BIM in the construction industry. In this study, ordinal nonparametric data are not normally distributed; therefore, all of the real data from the most influential respondents were gathered and analyzed by using a descriptive statistical measure called the RII [2]. Al-Yami and Sanni-Anibire [11] both noted that the RII, a popular and extensively used analytical method, is appropriate for this type of study. To ensure that each respondent's data were properly accounted for, we utilized the RII method for statistical analysis [109] to document and analyze the data collectively. The higher the RII, the more significant the underlying benefits or barriers of BIM in sustainable construction projects. The RII may be analyzed with the help of Equation (1):

$$\mathrm{RII} = \frac{\Sigma \mathrm{W}}{(\mathrm{A} \times \mathrm{N})} \tag{1}$$

Here, W represents the weight stated for each part by the respondent, A represents the maximum weight, and N represents the total number of respondents. Furthermore, an analysis of the standard deviation and coefficient of variation of the data was conducted to assess the nature of the response.

3.3.1. Reliability Assessment: Cronbach's Alpha

Cronbach's alpha was used to measure the internal consistency of the reliability of the structured data in this study. Cronbach's alpha test was employed to assess the reliability of the data by utilizing the SPSS software. The reliability analysis was conducted on the complete dataset with Cronbach's alpha test to ensure the temporal consistency of the model's construct. For instance, consistency in the attributes being evaluated and the scale used was ensured. Given that the data acquired through the utilization of a Likert scale pattern questionnaire are of an ordinal and nonparametric nature, Cronbach's alpha test was deemed highly suitable for assessing the dependability of the data. According to Datta et al. [21], a value of Cronbach's alpha that is closer to 1.00 is considered more satisfactory. Nevertheless, it is generally applicable to use the subsequent ranges as a heuristic in the majority of situations; a value of 1 or greater than or equal to 0.9 is classified as excellent, while a value between 0.9 and 0.8 is classified as good. An alpha value between 0.8 and 0.7 is considered acceptable, while a value between 0.7 and 0.6 is classified as doubtful. A value between 0.6 and 0.5 is considered poor, and a value less than 0.5 is classified as deplorable.

3.3.2. Agreement Analysis: Spearman Correlation Analysis

The purpose of the analysis was to obtain Spearman's rank correlation for the benefits and barriers through an agreement assessment. Datta et al. [2] also reported a comparable form of agreement analysis. Spearman's rank correlation coefficient is utilized to assess the level of concordance between two entities. Moreover, it can be utilized to evaluate the correlation between two variables based on their ranks. In order to mitigate the potential impact of outliers on the dataset, this correlation technique employed the median rather than the mean. The correlation methodology was used to ascertain whether a relationship existed among the perceptions of the critical factors among the respondents in question. The aforementioned methodology exhibited a correlation spectrum that spanned from a positive one to a negative one, as stated by [110]. A correlation coefficient close to 1 indicates a statistically significant positive correlation between two variables and a high degree of similarity in the interpretation of any factors that contribute to delays. By contrast, a correlation coefficient nearing -1 indicates a noteworthy adverse association between the entities. The mathematical symbol denoting the constant, commonly referred to as Rho, is represented by the lowercase letters "r_s". The Spearman Rho coefficient can be computed by utilizing the following formula:

$$\text{Spearman's Rho } (\mathrm{r_s}) = 1 - \frac{\sum 6\mathrm{d}^2}{\mathrm{N}(\mathrm{N}^2 - 1)} \tag{2}$$

In the aforementioned equation, 'd' represents the disparity in rankings as determined by the indices provided by one party versus another for a singular factor, while 'N' denotes the quantity of factors. The outcomes indicating a high level of concurrence between two respondent groups when evaluating the relative importance index (RII) of every crucial factor. While there may have been slight discrepancies in viewpoints between clients and consultants, their degree of concurrence was the highest, in contrast to clients and laborers, who exhibited the lowest level of concordance.

4. Results of the Questionnaires

4.1. Demographic Details

The questionnaire survey was distributed among 152 construction professionals who were involved in sustainable practice related to construction projects, as presented in Table 2. In the respondent group, project engineers, project managers, site engineers, design engineers, and academics were involved in proportions of 28%, 15%, 23%, 25%, and 9%, respectively. Moreover, 90% of the respondent group was male because of the high tendency to engage males in on-site construction in Saudi Arabia. The age of more than 82% of the respondents was more than 25 years. However, 46% of respondents had less than 5 years' working experience in the field of the construction industry.

Table 2. Characteristics of the respondents of the survey.

Respondents' Characteristics	Frequency (N = 152)	Percentage
Types of respondents		
Project Engineer	43	28%
Project Manager	22	15%
Site Engineer	35	23%
Design Engineer	38	25%
Academic	14	9%
Sex		
Male	137	90%
Female	15	10%
Age		
21–25	27	18%
25–30	62	41%
30–35	25	16%
35–40	26	17%
40 up	12	8%
Working Experience		
≤5 years	70	46%
6–10 years	36	24%
11–20 years	34	22%
≥21 years	12	8%

4.2. Reliability Analysis: Cronbach's Alpha

In accordance with Cronbach's alpha test for the benefits, the obtained value of 0.879, as illustrated in Table 3, was deemed satisfactory and fell within the "excellent" range in terms of the internal consistency of the data. Furthermore, it is worth noting that the value of Cronbach's alpha surpassed the established threshold of 0.70, which was necessary to confirm the internal consistency of the questionnaire. Moreover, as the value was between 0.9 and 0.8, the internal consistency of the data was classified as good. In Table 3, the alpha for the items' covariance was determined to be 0.979, and the standardized value was found to be 0.916, both of which can be found in the first column. When collecting data by questionnaire, a standardized value is often calculated to account for any differences in the answer scale. However, a questionnaire with a fixed five-point scale was employed to compile the data for this investigation. Therefore, the benefits in this research had an alpha value of 0.979.

Table 3. Cronbach's alpha values for the benefits.

"Cronbach's Alpha for Benefits"	"Cronbach's Alpha Based on Standardized Items"	*N* of Items
0.979	0.916	28

On the other hand, Cronbach's alpha test on the barriers achieved 0.966, as shown in Table 4. The value fell within the "excellent" range in terms of the internal consistency of the data. Furthermore, it is worth noting that the value of Cronbach's alpha surpassed the established threshold of 0.70, which was necessary to confirm the questionnaire's internal consistency.

Table 4. The values of Cronbach's alpha for the barriers.

"Cronbach's Alpha for Barriers"	"Cronbach's Alpha Based on Standardized Items"	*N* of Items
0.966	0.896	20

4.3. Agreement Analysis: Spearman Correlation Analysis

Table 5 displays the findings of the agreement analysis, showing that there was substantial agreement between the two respondent groups in estimating the RII of the benefits. Project managers and design engineers had the highest agreement, even if there were slight differences of opinion, whereas design engineers and site engineers had the lowest level of agreement. One possible interpretation of the data the following: project managers and design engineers > site engineers and project managers > design engineers and site engineers.

Table 5. Spearman correlations among the respondent groups for the benefits.

Comparison of Benefits' Rankings	r_s	Significance Level
Project Managers vs. Design Engineers	0.691	0.01
Site Engineers vs. Project Managers	0.568	0.01
Design Engineers vs. Site Engineers	0.329	0.01

Table 6 exhibits the findings of the agreement analysis, showing that there was substantial agreement between the two respondent groups in estimating the RII of the barrier to sustainable construction. The site engineers and project managers had the highest agreement, even if there were slight differences in opinion, whereas the design engineers and site engineers had the lowest level of agreement. One possible interpretation of the data the following: site engineers and project managers > project managers and design engineers > design engineers and site engineers.

Table 6. Spearman correlations among the respondent groups for the barriers.

Comparison of Barriers' Rankings	r_s	Significance Level
Project Managers vs. Design Engineers	0.489	0.01
Site Engineers vs. Project Managers	0.645	0.01
Design Engineers vs. Site Engineers	0.302	0.01

4.4. Ranking of Benefits

Table 7 displays the overall results of the statistical analysis of all 28 beneficial criteria considered in this investigation. The identities of the individual components are listed in the first column. Using Equation (1), the RII was used to rank the elements' overall importance.

In addition, the mean, standard deviation, and relative ordering of the components are also listed in Table 7. The mean values ranged from 3.677 to 3.940, whereas the standard deviations ranged from 1.613 to 2.614.

Table 7. Ranking of the benefits and a statistical assessment based on the respondents.

ID	Benefits	Mean	Standard Deviation	Relative Importance Index (RII)	Rank
B1	Monitoring performance	3.80	2.07	0.761	14
B2	Controlling energy usage	3.84	2.22	0.767	11
B3	Promoting the decrease in carbon emissions	3.82	1.98	0.764	13
B4	Enhancing ventilation effectiveness	3.91	2.18	0.782	5
B5	Evaluation of water harvesting	3.72	2.21	0.743	27
B6	Support for effective resource management	3.80	2.34	0.761	14
B7	Providing thermal building life-cycle analysis	3.74	1.90	0.747	25
B8	Providing lighting building life-cycle analysis	3.75	1.91	0.750	23
B9	Evaluating optimal opportunities	3.74	2.10	0.749	24
B10	Encouraging the use of clean energy-efficient technologies	3.93	2.12	0.786	2
B11	Enhancing material wastage reduction	3.85	1.93	0.770	8
B12	Promoting green building design, construction, and management	3.93	2.22	0.786	2
B13	Necessary technology for achieving CO_2 goals	3.76	2.02	0.751	21
B14	Improving design efficiency	3.94	2.13	0.788	1
B15	Reducing the overall project costs	3.80	1.75	0.759	17
B16	Enhancing construction performance	3.91	2.17	0.783	4
B17	Promoting productivity	3.89	2.10	0.779	6
B18	Improving the management procedure throughout the entire life span of buildings (design, construction, operation, maintenance, and management)	3.84	2.23	0.768	9
B19	Reducing project delivery time	3.68	1.76	0.736	28
B20	Examining renewable energy sources that reduce the cost of energy	3.83	2.16	0.767	11
B21	Determining the optimal options for decreasing energy and resource utilization	3.84	1.91	0.768	9
B22	Predicting energy savings	3.88	1.96	0.776	7
B23	Promoting financial and investment opportunities	3.72	1.61	0.745	26
B24	Enhancing project safety and health performance	3.80	1.75	0.759	17
B25	Increasing building life	3.80	1.93	0.759	17
B26	Smoothening the transition from design to implementation, post-design, and, finally, maintenance	3.79	1.95	0.758	20
B27	Enhancing individuals' quality of life	3.80	2.05	0.761	14
B28	Enhancing the construction industry's brand image and competitive advantage	3.76	1.94	0.751	21

As presented in Table 7, "improving design efficiency", "encouraging the use of clean energy-efficient technology", "promoting green building design, construction, and management", "enhancing construction performance", and "enhancing ventilation effectiveness" were the top five benefits of incorporating BIM into the sustainable construction industry in Saudi Arabia. The relative importance index (RII) for each of these factors was greater than 0.7, indicating that they were all significant. Subsequently, the factors of implementing BIM in sustainable construction projects in Saudi Arabia that had a mediocre benefit were derived. Among them, "promoting productivity", "predicting energy savings", "enhancing material wastage reduction", "improving the management procedure throughout the entire life span of buildings (design, construction, operation, maintenance, and management)", and "determining the optimal options for decreasing energy and resource utilization" were noteworthy. They had RII values between 0.779 and 0.768, which presented significant benefits of using BIM to make a sustainable project.

Moreover, it can be observed in Figure 2 that the RII values were greater than 0.70, which showed that the RII values were located in the medium–high range (0.8 > RII $\geq$ 0.6). It was also found that "reducing project delivery time", "evaluation of water harvesting", and "promoting financial and investment opportunities" were the beneficial aspects of implementing BIM in sustainable construction projects. The similarity of these RII rankings was also observed in the mean value data, where the deviations among the factors' weights were not very high. Therefore, each factor bore significant benefits as an outcome of implementing BIM in sustainable construction projects.

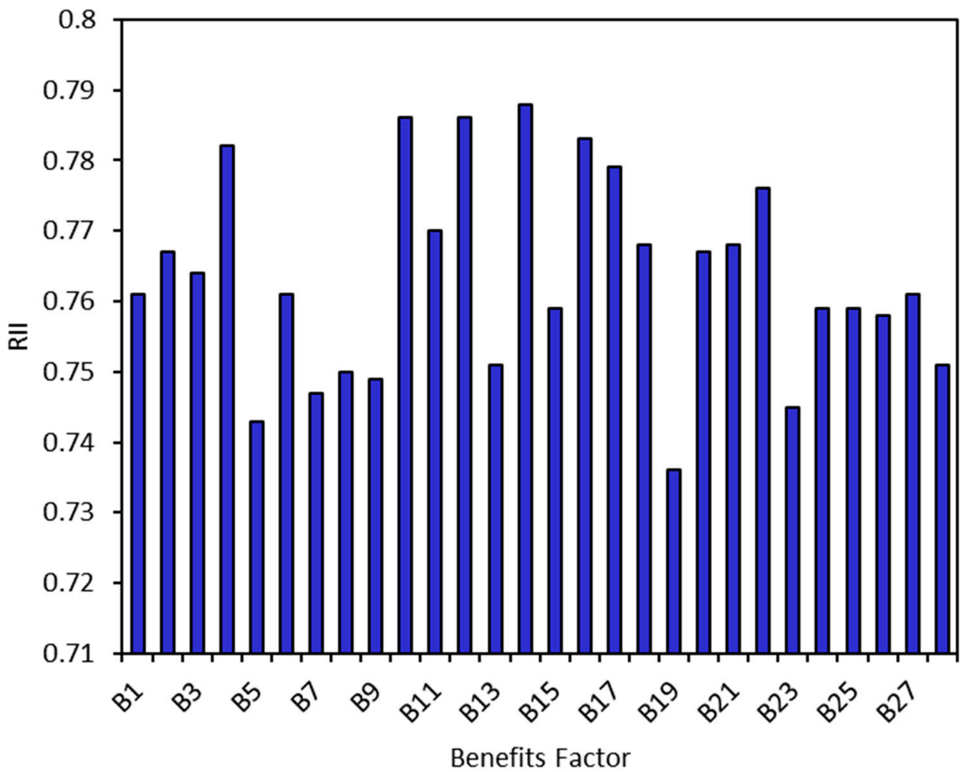


Figure 2. Graphical representation of the RII values of the benefits.

4.5. Ranking of the Barrier Factors

Table 8 displays the overall results of the statistical analysis of all 20 barrier factors considered in this investigation. The identities of the individual components are listed in the first column, and the factors are represented in the second column of Table 8. Using Equation (1), the RII was used to rank the barriers with respect to their overall importance. In addition, the mean, standard deviation, and relative ordering of the components are also listed in Table 8. The mean values ranged from 3.598 to 3.368, whereas the standard deviations ranged from 1.19 to 2.00.

Table 8. Ranking of the barriers and a statistical assessment based on the respondents.

ID	Barrier Factors	Mean	Standard Deviation	Relative Importance Index (RII)	Rank
R1	Lack of a collaborative working environment	3.41	1.34	0.682	17
R2	High cost of application	3.44	1.43	0.688	15
R3	Lack of skilled personnel	3.54	1.59	0.708	3
R4	High cost of training staff	3.39	1.82	0.678	19
R5	Market readiness for innovations	3.51	2.01	0.701	7
R6	The industry's reluctance to move away from traditional methods of working	3.45	1.59	0.691	13
R7	Lack of experts	3.47	1.19	0.695	10
R8	Recurring demand for increased resources, together with high costs	3.60	1.75	0.720	1
R9	Inadequate in-depth expertise and know-how to operate sustainability-related analysis software	3.51	1.37	0.703	6
R10	Absence of well-defined guidelines for utilizing BIM in sustainable construction projects	3.52	1.84	0.704	5
R11	Absence of a well-defined method for exchanging operational management data	3.57	1.54	0.713	2
R12	Organizational challenges, policies, and project strategies	3.53	1.78	0.705	4
R13	Inaccurate energy analysis predictions	3.50	1.66	0.700	9
R14	Insufficient data to accurately capture sustainability-related information	3.46	1.56	0.692	12
R15	Lack of a comprehensive framework and implementation plan	3.45	1.46	0.689	14
R16	Industry's resistance to change from traditional working practices	3.39	1.67	0.679	18
R17	Increased liability	3.37	1.71	0.674	20
R18	Lack of senior management support and attention to sustainability practices	3.43	1.52	0.686	16
R19	Organizational and regional differences in market responsiveness	3.47	1.48	0.695	10
R20	Lack of a legal framework and contract uncertainties	3.51	1.86	0.701	7

In addition, Table 8 shows that "recurring demand for increased resources, together with high costs (RII = 0.720)", "absence of a well-defined method for exchanging operational management data (RII = 0.713)", "lack of skilled personnel (RII = 0.708)", "organizational challenges, policy, and project strategy (RII = 705)", and "absence of well-defined guidelines for utilizing BIM in sustainable construction projects (RII = 0.704)" were the top five barriers to the incorporation of BIM into the sustainable construction industry in Saudi Arabia. The relative importance index (RII) for each of these factors was greater than 0.7, indicating that they were all significant. Subsequently, the factors of the implementation of BIM in sustainable construction projects in Saudi Arabia that had a mediocre benefit were derived. Among them, "inadequate in-depth expertise and know-how to operate sustainability-related analysis software programs", "market readiness for innovation", "lack of a legal framework and contract uncertainties", "inaccurate energy analysis predictions", and "varied market readiness across organizations and geographic locations" were noteworthy. They had RII values between 0.703 and 0.695, which showed that there were significant benefits behind the use of BIM to make a sustainable project.

Furthermore, it can be observed in Figure 3 that the RII values ranged between 0.67 and 0.72, which showed that the RII values were located in the medium–high range (0.8 > RII $\geq$ 0.6). It was also found that "increased liability", "high cost of training staff", "industry's resistance to change from traditional working practices", and "lack of senior management support and attention toward sustainable practices" exhibited the lowest barriers to implementing BIM in sustainable construction projects according to the RII. The similarities in these RII rankings were also observed in the mean value data, where the deviations among the factors' weights were not very high. Therefore, each factor represented a significant barrier to implementing BIM in sustainable construction projects.

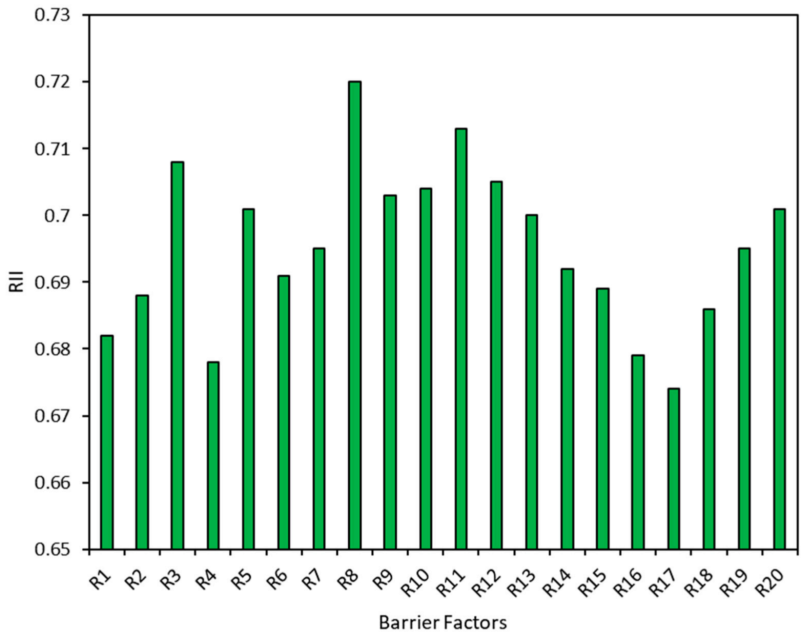
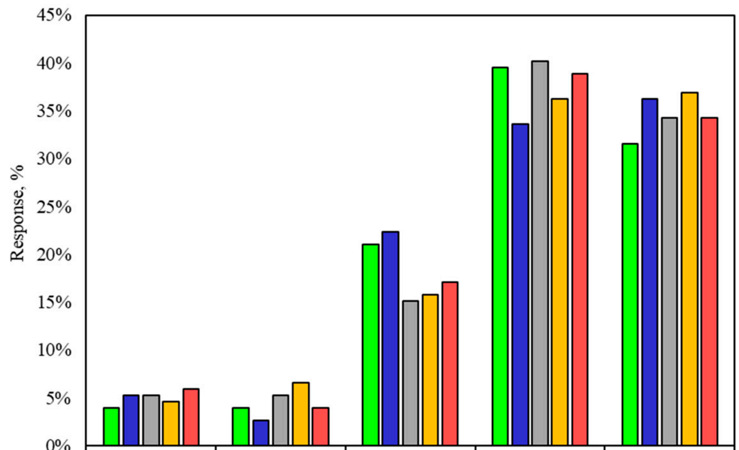


Figure 3. Graphical representation of the RII values of the barriers.

5. Discussion of the Key Benefits and Barriers

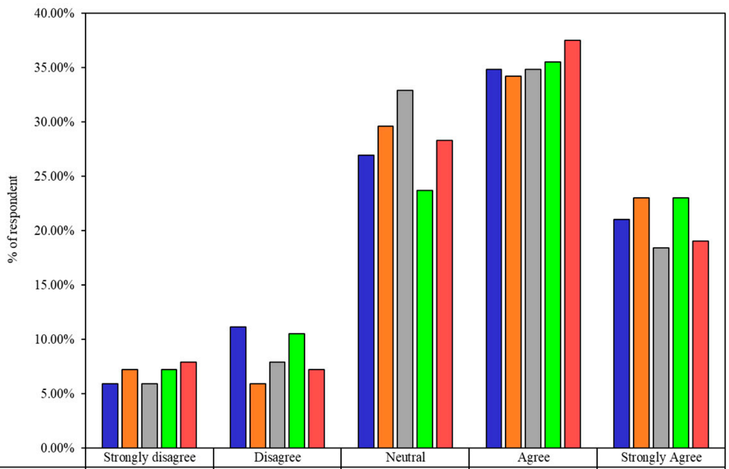
The key benefits of implementing BIM in sustainable construction were "improving design efficiency", "encouraging the use of clean energy-efficient technology", "promoting green building design, construction, and management", "enhancing construction performance", and "enhancing ventilation effectiveness". In Figure 4, it can be observed that about 37% and 36% of respondents strongly agreed and agreed on the benefit of improving design efficiency. BIM is regarded as one of the most significant innovations of recent years because of its ability to increase design process efficiency by decreasing the time spent on non-production-oriented operations and automating design systems [111]. The Smart Market report [112] is just one example of many that suggest that BIM's widespread adoption results in numerous sustainable benefits, such as higher productivity, higher quality, more opportunities for new businesses, and better project outcomes. Efficiency in design lies at the heart of successful sustainable building projects. BIM technology facilitates real-time collaboration and integration of design components, streamlining of decision-making processes, and reductions in potential conflicts. By employing parametric modeling and automated simulations, design iterations can be quickly evaluated for their sustainability implications [64]. Furthermore, BIM's ability to visualize a building's life cycle aids in identifying design alternatives that minimize resource consumption and environmental impact from a global perspective. Thus, enhancing design efficiency through BIM directly aligns with the sustainable project goals of optimized resource utilization and reduced waste [21]. The factor of "encouraging the use of clean energy-efficient technology" received the most opinions that agreed, strongly agreed, and were neutral. Nowadays, clean or renewable energy should be taken into account, as this will have a significant effect on the built environment's sustainability because of changes in legislation and technology [113]. BIM is a novel idea for incorporating clean or renewable energy. It will open up many doors for research and commerce. From a theoretical standpoint, it can reduce carbon emissions and improve energy efficiency throughout a whole neighborhood, town, or city. Not only would energy consumption be reduced, but the surplus might be stored or even used to power nearby facilities. This will have a major positive effect on nature. Furthermore, the integration of energy-saving and clean technologies is pivotal in achieving sustainable building objectives. BIM serves as a platform for evaluating, analyzing, and simulating the performance of various energy-efficient systems and technologies [64]. Through data-rich models, stakeholders can assess the energy consumption of a building across its life cycle to identify opportunities for improvement. BIM's capacity to simulate and visualize energy flows and interactions allows for informed decisions on the integration of technology [54]. Encouraging the use of such technologies becomes more effective when combined with BIM, as it enables a holistic understanding of their impact and aids in selecting the most suitable options [65]. The responses to the factor of "promoting green building design, construction, and management" were close to those of the previously discussed factor. The process of integrating BIM into a green building may be viewed as one that calls for extensive communication and collaboration among many parties, as well as the use of complex modeling and system analyses to achieve a sustainable outcome. To maximize productivity with this mix, strong managerial skills are required [114]. BIM's role extends beyond design to encompass construction and facility management phases. By adhering to green building principles throughout the project lifecycle, BIM can be utilized to track and manage sustainable material choices, construction practices, and operational efficiency [72]. During construction, BIM assists in coordinating schedules, reducing waste, and ensuring adherence to sustainable construction standards. Post-construction, BIM's data-rich models support efficient facility management by offering real-time insights into energy usage, maintenance needs, and potential retrofitting opportunities. This comprehensive approach aligns with the core tenets of green building practices and strengthens the overall sustainability of a project.

On the other hand, the top three key barriers were "recurring demand for increased resources, together with high costs", "absence of a well-defined method for exchanging operational management data", and "lack of skilled personnel". In Figure 5, it can be observed that about 23.03%, 34.21%, and 29.61% of the respondents strongly agreed, agreed, and were neutral in their position on the "recurring demand for increased resources, together with high costs" barrier. Numerous studies have shown that price is the primary barrier [61], which is similar to the situation in Hong Kong and China, where high costs are seen as a barrier to implementing BIM [66,115]. It was considered the most significant obstacle in the entire Middle East [42]. In addition, one way to get over the "high cost" barrier is to set aside money for a dedicated BIM implementation team. To boost confidence and excitement among building stakeholders, the government should establish a BIM cell. The BIM cell unit will be responsible for delivering a thorough report at the end of each month detailing how the monthly budget was spent. If vendors want construction stakeholders to use BIM technology, they should rethink their business models to lower entry barriers. In the construction industry, stakeholders can transfer most upstream expenses by switching to a subscription-based model or monthly payment plan over a specified time. However, daily rates should be affordable. Furthermore, the "absence of a well-defined method for exchanging operational management data" was the second highest ranked barrier to sustainable construction projects. Some individuals and businesses anticipate BIM's positive effects because they lack the expertise to adopt and effectively manage the transitory changes that come with it; these changes vary depending on the industry in which a company operates. Moreover, the "lack of skilled personnel" also acted as a prime barrier in this study. The lack of qualified and skilled workers is a barrier to the adoption of BIM, as was also shown by studies such as those conducted by [112]. There is no problem with discussing the adoption of BIM because there is no personnel for promoting its adoption in places where it is not already present. Therefore, adoption is an illusion in a region where qualified specialists are in short supply. According to Manzoor et al. [116], the adoption of BIM is hindered by the lack of coordination and organization in the contracting process, which makes it difficult to incorporate novel technology.



	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
Enhancing ventilation effectiveness	4%	4%	21%	39%	32%
Encourage the use of energy-efficient clean technology	5%	3%	22%	34%	36%
Promoting green building design, construction, and management	5%	5%	15%	40%	34%
Improving design efficiency	5%	7%	16%	36%	37%
Enhancing construction performance	6%	4%	17%	39%	34%

Figure 4. Response rates for the top five benefits.



	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
Lack of skilled personnel	5.92%	11.18%	26.97%	34.87%	21.05%
Recurring demand for increased resources, together with high costs	7.24%	5.92%	29.61%	34.21%	23.03%
Sustainability-related analysis software programs	5.92%	7.89%	32.89%	34.87%	18.42%
Absence of well-defined guidelines for utilizing BIM in sustainable construction projects	7.24%	10.53%	23.68%	35.53%	23.03%
Absence of a well-defined method for exchanging operational management data.	7.89%	7.24%	28.29%	37.50%	19.08%

Figure 5. The response rates for the top five barriers.

Comparison of the Results with the Global Perspective

On a global scale, the rapid increase in demand for building projects has led the vast majority of construction organizations to use BIM as a means of enhancing their sustainability objectives. In sustainable construction projects worldwide, the adoption of BIM has been endorsed by governmental and professional entities as a means of enhancing collaboration and cooperation among stakeholders. "Encouraging the use of clean energy-efficient technology" is a major benefit of using BIM in sustainable projects in KSA, and this finding is similar to that of a study by Santos et al. [117] in the construction sector in the UK. "Improving design efficiency" was the highest-ranked factor of BIM implementation in SC projects, which aligned with the findings in the Chinese construction sector [79]. "Promoting green building design, construction, and management" was also a prime finding by Doan et al. [45] in the construction industry of New Zealand, which is in agreement with the scenario of the KSA's sustainable construction industry.

The present study's barrier results were compared with those of other nations, including China [66], the United Kingdom [118], Nigeria [119], Malaysia [116], and Pakistan [120]. The prime barrier was the "recurring demand for increased resources, together with high costs". However, "high cost" was ranked fourth in China, third in the UK, eleventh in Nigeria, ninth in Pakistan, and fourth in Malaysia. The "absence of a well-defined method for exchanging operational management data" was ranked second in the KSA. When comparing the present conditions of Saudi Arabia and China, it was found that the primary concern in China was the "unavailability of standards and guidelines". In contrast, in Nigeria, the "unavailability of standards and guidelines" was listed as the fourth most significant issue. However, the absence of a well-defined method did not attract the interest of academics in either the United Kingdom or Pakistan. The "lack of skilled personnel" was ranked third in the KSA, while it was ranked third in Malaysia, fifth in China, third in the UK, first in Nigeria, and seventh in Pakistan.

6. Practical Implications of the Research

Several beneficial implications may be drawn from this research. First, the idea of BIM needs to be embraced by academics, government officials, and other stakeholders in the building sector if the adoption rate is to increase. The academic curriculum for courses on the built environment in Saudi Arabia and its surroundings is structured to incorporate minimal components of BIM, despite the fact that there is a shortage of skilled and educated individuals in areas of BIM technologies in the sector. Academics working in the building industry are also urged to adopt BIM, as their influence on students' BIM education is substantial. Second, if completely implemented, BIM can minimize inefficiencies in the construction sector and open the path for integrating other developing technologies that are applicable to construction. Thirdly, the government must demonstrate its commitment to BIM by fostering an enabling environment that encourages the widespread use of BIM in the building sector by making necessary adjustments to existing policies. The government might also use the discovered obstacles as a springboard for an initiative to boost BIM use in the building sector. Fourthly, Neom City in Saudi Arabia has stunning natural surroundings and is propelled by cutting-edge disruptive technology, creating a new paradigm, a living laboratory for business, and a home for an international community of dreamers and doers. Neom City in Saudi Arabia is a game-changer for city life and a cutting-edge industrial powerhouse. This study also contributes to developing the city in a proper way in the future.

Moreover, this study fills the research gaps in the existing literature by Al-Hammadi and Tian [121], Al-Yami and Sanni-Anibire [11], and Sodangi et al. [34]. These studies presented the outlook of BIM implementation in construction projects in the KSA. However, the current study fills the gap in the existing literature by exploring the benefits and barriers of implementing BIM in sustainable construction projects. The findings will also enrich the body of knowledge in the literature in the field of the Saudi Arabian construction sector.

7. Conclusions and Recommendations

In recent years, BIM has emerged as a game-changing innovation for sustainable construction practices in the Saudi building sector. Therefore, the present study aims to examine the benefits and barriers of BIM implementation for the sustainable construction industry in Saudi Arabia. A thorough examination of the existing literature was conducted in order to identify the various factors that contribute to the benefits and barriers of BIM implementation in sustainable construction projects. The barriers and benefits are prioritized according to the relative importance index (RII). Among the 28 benefit factors, "improving design efficiency (RII = 0.788)", "encouraging the use of clean energy-efficient technology (RII = 0.786)", "promoting green building design, construction, and management (RII = 0.786)", "enhancing construction performance (RII = 0.783)", and "enhancing ventilation effectiveness (RII = 0.782)" were the top five benefits of BIM implementation in sustainable construction projects. Conversely, "recurring demand for increased resources, together with high costs (RII = 0.720)", "absence of a well-defined method for exchanging operational management data (RII = 0.713)", "lack of skilled personnel (RII = 0.708)", "organizational challenges, policies, and project strategies (RII = 705)", and "absence of well-defined guidelines for utilizing BIM in sustainable construction projects (RII = 0.704)" were the top five barriers to the incorporation of BIM in the sustainable construction industry of Saudi Arabia. Furthermore, opinions on mitigating the barriers were also discussed, as they can be overcome with the training of workers, a well-defined management system, and minimization of the high cost of resources.

In addition to filling a knowledge gap, this work theoretically contributes by providing a useful reference for stakeholders to use in overcoming these obstacles and knowing the benefits of utilizing BIM technology in sustainable construction projects. To the authors' knowledge, this is the first study to examine ways of identifying benefits and obstacles to the widespread use of BIM in environmentally conscious construction projects in Saudi Arabia. This research recommends implementing a BIM-based research methodology with live, active projects to help stakeholders accomplish sustainable building projects efficiently. This research also suggests that researchers can use the same set of quantitative and qualitative data to develop a variety of somewhat different frameworks. While this study was successful in achieving its goals and objectives, it is not without flaws. The first caveat is that the research was only performed in Saudi Arabia; therefore, the results may not hold true in other nations due to cultural variations. Second, in order to learn more about how to remove obstacles to implementing BIM, the sample size of the quantitative research might be increased. Finally, these caveats provide a path for future researchers to validate our work via case studies of successful building projects.

Furthermore, this study explores the benefits and barriers of sustainable construction industry in the KSA and provides some suggestions and recommendations for further study. The potential course of action for the government is the contemplation of a reduction in the tax and other administrative expenses associated with project development for small and medium contractors that use BIM. It is recommended that small and medium contractors be required to obtain BIM certification and provide substantial proof of BIM implementation in construction projects as a requirement for the renewal of their construction licenses. Moreover, additional research can be undertaken to investigate the long-term effects of sustainability practices and BIM implementation within the construction sector. Researchers can evaluate whether the initial advantages effectively lead to long-term positive results that encompass environmental, economic, and social aspects. Furthermore, a mixed-method approach that involves the integration of quantitative analysis techniques, such as surveys and statistical analysis, with qualitative analysis methods, such as case studies or life-cycle assessment, is recommended. This approach facilitates a more comprehensive understanding of the intricacies entailed.

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Data Availability Statement: The data supporting these findings are available within the article.

Conflicts of Interest: The author declares no conflict of interest.

Appendix A

Sample Questionnaire

Part 1—General Information

1.1 What is your Position?
- ○ Project Engineer
- ○ Design Engineer (Architect/Eng.)
- ○ Site Engineer
- ○ Owner
- ○ Academic
- ○ Other

1.2. Department

1.3. Age in Years.
- ○ 20–25
- ○ 26–30
- ○ 31–35
- ○ 36–40
- ○ 40+

1.4. Gender
- ○ Male
- ○ Female

1.5. Experience (Years)
- ○ 1–5
- ○ 6–10
- ○ 11–15
- ○ 16–20
- ○ 20+

1.6. How familiar are you with the concept of BIM (building information modeling)
- ○ Very Strong
- ○ Strong
- ○ Moderate
- ○ Weak
- ○ Very Weak

Part 2—Benefits and Barriers

Description of the scale for the effect rank from 1 to 5, where 1 stands for strongly disagree, 2 for disagree, 3 for neither agree nor disagree, 4 for agree, and 5 for strongly agree.

Benefits Factors	Effect (1–5)	Barriers Factors	Effect (1–5)
Monitoring performance	① ② ③ ④ ⑤	Lack of a collaborative working environment	① ② ③ ④ ⑤
Controlling energy usage	① ② ③ ④ ⑤	High cost of application	① ② ③ ④ ⑤
Promoting a decrease in carbon emissions	① ② ③ ④ ⑤	Lack of skilled personnel	① ② ③ ④ ⑤
Enhancing ventilation effectiveness	① ② ③ ④ ⑤	High cost of training staff	① ② ③ ④ ⑤

Benefits Factors	Effect (1–5)	Barriers Factors	Effect (1–5)
Evaluation of water harvesting	① ② ③ ④ ⑤	Market readiness for innovation	① ② ③ ④ ⑤
Support for effective resource management	① ② ③ ④ ⑤	The industry's reluctance to move away from traditional methods of working	① ② ③ ④ ⑤
Providing thermal building life-cycle analysis	① ② ③ ④ ⑤	Lack of experts	① ② ③ ④ ⑤
Providing lighting building life-cycle analysis	① ② ③ ④ ⑤	Recurring demand for increased resources, together with high costs,	① ② ③ ④ ⑤
Evaluating optimal opportunities	① ② ③ ④ ⑤	Inadequate in-depth expertise and know-how to operate sustainability-related analysis software programs	① ② ③ ④ ⑤
Encouraging the use of clean energy-efficient technology	① ② ③ ④ ⑤	Absence of well-defined guidelines for utilizing BIM in sustainable construction projects	① ② ③ ④ ⑤
Enhancing material wastage reduction	① ② ③ ④ ⑤	Absence of a well-defined method for exchanging operational management data	① ② ③ ④ ⑤
Promoting green building design, construction, and management	① ② ③ ④ ⑤	Organizational challenges, policies, and project strategies	① ② ③ ④ ⑤
Necessary technology for achieving CO_2 goals	① ② ③ ④ ⑤	Inaccurate energy analysis predictions	① ② ③ ④ ⑤
Improving design efficiency	① ② ③ ④ ⑤	Insufficient data to accurately capture sustainability-related information	① ② ③ ④ ⑤
Reducing the overall project costs	① ② ③ ④ ⑤	Lack of a comprehensive framework and implementation plan	① ② ③ ④ ⑤
Enhancing construction performance	① ② ③ ④ ⑤	Industry's resistance to change from traditional working practices	① ② ③ ④ ⑤
Promoting productivity	① ② ③ ④ ⑤	Increased liability	① ② ③ ④ ⑤
Improving the management procedure throughout the entire life span of buildings (design, construction, operation, maintenance, and management)	① ② ③ ④ ⑤	Lack of senior management support and attention to sustainable practices	① ② ③ ④ ⑤
Reducing project delivery time	① ② ③ ④ ⑤	Varied market readiness across organizations and geographic locations	① ② ③ ④ ⑤
Examining renewable energy sources that reduce the cost of energy	① ② ③ ④ ⑤	Lack of legal framework and contract uncertainties	① ② ③ ④ ⑤
Determining the optimal options for decreasing energy and resource utilization	① ② ③ ④ ⑤		
Predicting energy savings	① ② ③ ④ ⑤		
Promoting financial and investment opportunities	① ② ③ ④ ⑤		
Enhancing project safety and health performance	① ② ③ ④ ⑤		
Increasing building life	① ② ③ ④ ⑤		
Smoothening the transition from design to implementation, post-design, and, finally, maintenance	① ② ③ ④ ⑤		
Enhancing individuals' quality of life	① ② ③ ④ ⑤		
Enhancing the construction industry's brand image and competitive advantage	① ② ③ ④ ⑤		

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