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Assessment and Prioritization of BIM Implementation Challenges in Residential Complexes in Iraq

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ABSTRACT

This study investigated the challenges of implementing Building Information Modeling (BIM) in residential complexes in Iraq. The research will aim at determining the most prominent challenges that have affected the implementation of BIM, evaluating the challenges based on the perceptions of the professionals, and presenting practical insights that can be used to realize successful implementation. The mixed-method research design was applied, and it included the literature review, expert interviews, and a questionnaire survey of 67 professionals who were involved in the construction projects. The identified challenges were ranked using the collected data with the help of Reliability testing and Relative Importance Index (RII). The findings are that the most threatening impediments to BIM implementation are the human and organizational factors. Particularly, the technical unawareness and BIM perception, along with the insufficiency of training and competence, were put first on the list of the most crucial challenges. Further, there was poor senior management support and the absence of an enabling organizational environment, which was noted to be a barrier to BIM adoption. Financial and infrastructural issues, such as the software and the internet connectivity, on the other hand, were considered to have a lesser effect. The conclusion is that the successful use of BIM in residential complexes in Iraq should be oriented on a complex approach with capacity building, organizational commitment and the development of effective national policies and regulatory frameworks to support the digital revolution in housing industry.

Keywords: BIM adoption, Building information modeling, Challenges, Residential complexes, Iraq construction sector.

1. INTRODUCTION

The residential complexes constitute a unique type of construction project through repeated building units, a high level of coordination demands among many disciplines and direct contacts with end-users in the operating and maintenance processes. As opposed to industrial or infrastructure projects, residential developments focus on lifecycle

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performance, cost efficacy, and standardized design aspects that enhance the probable advantage of Building Information Modeling (BIM) at the same time generating implementation pressures. In Iraq, the residential complexes are usually built on the basis of the public/semi-public system, in which there are regulatory restrictions, organizational practice, and low digital preparedness, which only exacerbates the implementation of BIM. Thus, it is crucial to research the challenges related to BIM and its application in residential complexes in order to identify context-specific obstacles that could not be entirely captured in other studies examining other areas of construction. The use of the latest technologies to enhance efficiency and productivity in the construction industry is required, particularly in the design and construction process **(Azhar, 2011; Eastman et al., 2018).** By BIM, the various types of project data, including three-dimensional design data, material data, and construction programme data, could be integrated into one digital representation, which in turn facilitates informed decision making across the project lifecycle **(Eastman et al., 2018; Bryde et al., 2013)**. In addition, digitally represented physical and functional features of construction projects can also be generated and updated with the help of BIM to find out construction clashes and predict any potential construction problems as early as possible, which significantly improves the accuracy and efficiency of designs **(Azhar, 2011; Eastman et al., 2018).** A broader spectrum of digital transformation in the construction sector brings about, also, the enabling environment of innovation and the formation of special architectural and construction technology companies due to the application of digital information technologies, such as BIM, in the construction industry **(Volk et al., 2014; Evans et al., 2020).** One of the most significant digital technologies has become Building Information Modeling (BIM) that enables optimizing the work of a project and minimizing reworking, ineffective coordination, and information deficits along with time and cost savings **(Succar, 2009; Volk et al., 2014)**. Building Information Modeling (BIM) is a team-based method, which utilizes the digital technology to enhance the management, delivery, and planning of built assets **(Psimadas et al., 2012).** Despite the numerous new technologies that have been applied in construction projects over the last several decades, the industry efficiency was extremely low. Conventional methods tend to yield no results in cost reduction or the alleviation of issues because of a lack of coordination between disciplines **(Zhang et al., 2018).** Miscommunication and lack of coordination may result in issues of a building site that are not only expensive but also time consuming to repair. The Building Information Modeling (BIM) has the capacity to cut down on the mistakes that arise due to lack of people working together and lack of coordination. Design stage of any construction project plays an important role in that the stage defines the ultimate characteristics of the project depending on the specifications given by the client to the consultant. This stage involves transferring of these specifications into plans and specifications by the consultant **(Al-Rudainy and Mahjoob, 2024**). Residential buildings in Iraq have a potential of BIM technology, which is associated with several problems. It can enhance projects and transform infrastructure into something more sustainable, yet it has a number of challenges, including cultural barriers, legal limits, and high initial expenses **(Schery et al., 2023; Paneru et al., 2023).** The most significant issues that impact the implementation of BIM in such a country as Iraq should be highlighted and that solutions should be found. This makes the stakeholders know how to take advantage of BIM technologies. With advice on the successful housing market models provided in other countries and issues concerning your location, the housing business will be able to grow and utilize it better in new buildings **(Durdyev et al., 2021).** The housing industry in Iraq could be improved with the correct application of BIM. This program will go a long way in ensuring that the country addresses its urgent infrastructure requirements in an environmental friendly way **(Hoseini et al., 2021).** Building Information Modeling (BIM) encourages the collaboration, improved communication, and common access to information across various systems through the creation of a centre of interest to input information, coordinate information, administrate information, update information and store information during project life. By doing so, the organizations will be able to handle data effectively and utilize relevant information to cope with their projects **(Saja and Sawsan, 2024).** The research is expected to determine the knowledge gap on the advantages of Building Information Modeling (BIM) in the Iraqi construction environment. The paper is dealing with some of the major concerns that make the use of BIM in the Iraqi construction industry hard, including (1) cultural resistance to new technologies among the leading personalities in the construction industry, (2) the unavailability of clear laws that favor the use of BIM, and (3) structural problems that make digital progression stall, unlike in the West and other regional settings. Such problems are quite different compared to the Western and regional settings **(Al-Rudainy and Mahjoob, 2024; Chan, 2014).**

This research is intended to find, study and rank the main issues relevant to the application of Building Information Modeling (BIM) to residential complexes in Iraq. In particular, this paper aims to analyze these obstacles through the lens of professionals who have been able to gain experience in BIM in practice, compare their significance based on the results of the empirical research and offer context-related findings that could help the decision-makers and policymakers enhance the uptake of BIM in the Iraqi residential sector.

2. BACKGROUND AND THEORETICAL FRAMEWORK

This part is the conceptual background and past research on Building Information Modeling (BIM), and its applicability to residential complexes and the obstacles that face its application in developing countries, Iraq included.

2.1 Building Information Modeling (BIM) and Its Relevance to Residential Complexes

It is known that Building Information Modeling (BIM) is a comprehensive digital process that helps in the progression, management, and provision of information throughout the lifecycle of the construction projects. Unlike the old-fashioned two-dimensional design tools, BIM makes it possible to conduct a multi-dimensional model-making process, in which geometric, technical, time, and cost-related data are all placed in a single digital environment **(Eastman et al., 2018; Azhar, 2011).** This has put BIM as a key tool in terms of improving coordination and reducing conflicts in designs, improved decision making and optimization of the project performance. BIM has specific benefits in residential complexes that are generally typified by uniform building units, many stakeholders, and strict deadlines. Research has revealed that BIM contributes to a better level of standardization of design, detection of clashes, sequencing of construction, and management of facilities in the case of residential real estate development on a large scale **(Georgiadou, 2019; Yin et al., 2019).** It has been also linked with decreased rework, better predictability of cost and improved communication between designers, contractors and clients when BIM is applied in residential projects **(Paneru et al., 2023).** Irrespective of these benefits, usage of BIM in residential buildings is still not well distributed particularly in the developing nations. Although BIM is commonly spread on commercial and infrastructure projects, the organizing, regulatory, and economic factors tend to stop its spread among residential complexes **(Durdyev et al., 2021)**. It means that the issues that have been related to the implementation of BIM are not that technical, but highly determined by the type of project and the environment of local construction.

2.2 Challenges of BIM Implementation in the Construction Industry

A lot of studies have been conducted regarding the obstacles to the adoption of BIM in the global construction industry. These issues are generally divided into human, organization, technical, financial and legal aspects. The barriers of human nature, including the absence of technical awareness, training, resistance to changes, etc., are constantly determined as the most significant restrictions to the implementation of BIM **(Chan, 2014; Eadie et al., 2013; Bamgbose et al., 2024).** The second limiting factor to BIM diffusion is organizational issues such as lack of support of senior management and enabling environment. A number of papers note that the implementation of BIM should be strategically based on the top management level, and the organization should also be restructured to facilitate the workflow **(Arayici et al., 2011; Babatunde et al., 2021).** The efforts of implementing BIM are usually disjointed and impermanent without such institutional support. There have also been cases of technical and infrastructural challenges, including poor hardware, software interoperability, unreliable internet services, and unstable power supplies, especially in developing countries **(Onungwa et al., 2017; Olanrewaju et al., 2020).** Even though these aspects may be impediments to the successful BIM application, recent research indicates that they are not always as significant as human and organizational obstacles **(Paneru et al., 2023)**. Other issues are financial constraints, that is, high initial investment costs, software licensing fees, and training expenses. Nonetheless, empirical studies have shown that cost based considerations are not necessarily determining factors when stakeholders are well aware of the long term payback and the payback on investment in case of using BIM **(Azhar, 2011; Zhou et al., 2019).** Some of the most intractable impediments to BIM implementation include legal and regulatory issues. Absence of standardized BIM requirements, ambiguity of contractual agreements, and the absence of governmental requirements have been identified to lead to a sense of uncertainty and lack of confidence among stakeholders, especially in the case of large-scale and public housing developments **(Evans et al., 2020; Schery et al., 2023).**

2.3 BIM Adoption in Residential Projects and Developing Countries

According to recent literature, BIM in residential complexes is characterized by particular challenges, which do not occur in other types of projects. Most residential projects are characterized by a large number of repetitive units, subcontractors, and constrained cost margins, implying the necessity of effective coordination and information management **(Georgiadou, 2019).** BIM has already shown great potential in computing these complexities, but the application of the concept is highly contingent on the contextical factors. BIM uptake in developing countries is often limited by institutional maturity, poor legislative systems and lack of professional competencies. Discussions in Asia, Africa, and Middle East show that the lack of national BIM strategies and compulsory requirements is a significant slowdown in the rate of adoption **(Durdyev et al., 2021; Paneru et al., 2023)**. Moreover, the cultural opposition to digital change and attachment to traditional construction methods are also the negative factors that contribute to these issues **(Salleh and Fung, 2014; Bamgbose et al., 2024)**. The existing research on the public and residential housing projects underlines that the governmental intervention has a determining influence on the BIM diffusion. Those countries with the established clear BIM policies, standards, and pilot projects showed a greater adoption and maturity rate **(Evans et al., 2020).** On the other hand, adoption of BIM is to a great extent voluntary and uneven in situations where such frameworks do not exist

2.4 Research Gap

Despite the fact that there exists a sizeable amount of literature reviewing the issue of BIM implementation in the global environment, some gaps can be seen. To begin with, a significant portion of the extant literature concerns the adoption of BIM in the overall industry, without paying much attention to residential complexes as a specific type of project. Second, the empirical studies of BIM application in Iraq are still limited, especially in the context of residential projects of large scale. An overview of the past research in the Iraqi construction environment has been the general consciousness of BIM or its possible advantages, but without prioritizing the challenges facing residential complexes in a systematic way. In addition, only a few studies have incorporated the views of practitioners to prioritize these challenges in order to have a relative importance of the challenges. Thus, an empirical study that is inclined to define, analyze, and prioritize the challenges of BIM implementation in the residential complexes in Iraq, in particular, is necessary. The filling of this gap will help enhance the current body of knowledge through offering context-specific information and effective recommendations that can guide policymakers and other stakeholders in the industry to improve the adoption of BIM in the Iraqi housing industry. Informed by the reviewed literature, the key challenges influencing BIM implementation in residential complexes were identified and categorized. **Table 1** summarizes these challenges, which were used as the foundation for developing the research instrument and analytical framework.

Table 1. Challenges of BIM Technique.

No.	Survey questions on the Challenges of using BIM	Question code	References
1	Do you believe that insufficient senior management support is a barrier to BIM implementation in projects?	C1	**(Zahrizan et al., 2013; Babatunde et al., 2021; Kori and Kiviniemi, 2015; Ezeokoli et al., 2016)**
2	Do you consider the lack of technical knowledge and awareness of BIM to be a barrier to its implementation?	C2	**(Latiffi et al., 2013; Zahrizan et al., 2013; Hamada et al., 2016; Liu et al., 2015)**
3	Do you consider the lack of access to the appropriate technology and framework to be a challenge in BIM implementation?	C3	**(Mehmet, 2011; Zahrizan et al., 2013; Obiegbu and Ezeokoli, 2014; Ezeokoli et al., 2016)**
4	Do you think that individual perception or opinion may negatively impact BIM implementation in projects?	C4	**(Zahrizan et al., 2013; Liu et al., 2015)**
5	Do you consider the lack of adequate BIM guidelines to be a challenge in its implementation?	C5	**(Zahrizan et al., 2013; Hamada et al., 2016; Akerele and Etiene, 2016; Ezeokoli et al., 2016)**
6	Do you consider the absence of an enabling environment to be a barrier to BIM implementation?	C6	**(Gardezi et al., 2014; Enegbuma et al., 2014; Hosseini et al., 2015; Abubakar et al., 2014)**

7	Do you consider that large investments in BIM upfront may be a challenge in its implementation?	C7	**(Memon et al., 2014; Gardezi et al., 2014)**
8	Do you consider the lack of a clear vision for profitability to be a barrier to BIM adoption?	C8	**(Arayici et al., 2011; Arayici et al., 2012; Memon et al., 2014)**
9	Do you consider training costs a barrier to BIM implementation?	C9	**(Ahuja et al., 2009; Azhar, 2011; Crotty, 2013; Salleh and Phui Fung, 2014)**
10	Do you consider software costs a challenge in BIM implementation?	C10	**(Salleh and Fung, 2014; Azhar, 2011; Crotty, 2013; Lee et al., 2015)**
11	Do you consider the extent of the cultural change required a challenge in BIM implementation?	C11	**(Mihindu and Arayici, 2008; Tan et al., 2019; Salleh and Phui Fung, 2014)**
12	Do you consider periodic updates with actual information from the work site and review with various disciplines a barrier?	C12	**Addition by experts**
13	Do you consider employee resistance to changing work methods a challenge in BIM implementation?	C13	**(Tan et al., 2019; Arayici et al., 2011)**
14	Do you consider legal and contractual obligations a barrier to BIM implementation?	C14	**(Arayici et al., 2011; Chao-Duivis, 2009; Azhar, 2011; Salleh and Phui Fung, 2014)**
15	Do you think that inadequate internet connectivity is a barrier to BIM implementation?	C15	**(Onungwa et al., 2017; Babatunde and Ekundayo, 2019)**
16	Do you think that frequent power outages may affect the effective use of BIM?	C16	**(Enegbuma et al., 2014; Abubakar et al., 2014; Babatunde and Ekundayo, 2019)**
17	Do you think that insufficient client demand is a challenge in BIM implementation?	C17	**(Liu et al., 2017 ; Martin et al., 2020)**
18	Do you think that compatibility and interoperability issues between software are a barrier to BIM implementation?	C18	**(Tse et al., 2005; Arayici et al., 2012; Arayici et al., 2011)**
19	Do you think that the lack of support from policymakers is a challenge in BIM implementation?	C19	**(Tse et al., 2005; Arayici et al., 2009; Arayici et al., 2011)**
20	Do you think that the current technology in Iraq is sufficient for BIM implementation?	C20	**(Liu et al., 2017 Salleh and Phui Fung, 2014)**
21	Do you think that using BIM doubles the working hours of engineers, thus representing a barrier?	C21	**Addition by experts**
22	Do you think that data and intellectual property issues may be a barrier to BIM implementation?	C22	**(Aranda-Mena et al., 2009)**
23	Do you think that the high cost of implementation is a challenge in BIM implementation?	C23	**(Olanrewaju et al., 2020; Zhou et al., 2019; Ayinla and Adamu,**

			2018; Gamil and Rahman, 2019; Hsu et al., 2015)
24	Do you think that the use of BIM is a barrier for small projects?	C24	**Addition by experts**
25	Do you think that the lack of specific BIM standards in Iraq is a challenge?	C25	**(Elhendawi et al., 2019; Bin Zakaria and Yousif,2013; Salleh and Phui Fung, 2014)**
26	Do you think that commercial and cultural changes may be a barrier to BIM implementation?	C26	**(Chan et al., 2019b; Chen et al., 2015; Salleh and Phui Fung, 2014)**
27	Do you think that the cost of exchanging data and information is a challenge in BIM implementation?	C27	**(Abubakar et al., 2014; Enegbuma et al., 2014; Tan et al., 2019)**
28	Do you believe that a lack of training and skills is a barrier to BIM implementation?	C28	**(Tan et al., 2019; Eadie et al., 2013; Chan, 2014; Aranda-Mena et al., 2009; Georgiadou, 2019; Almuntaser et al., 2018)**
29	Do you consider the reluctance of other stakeholders to adopt BIM a challenge?	C29	**(Tan et al., 2019; Akbarieh et al., 2020)**
30	Do you consider the lack of or insufficient government policies a barrier to BIM implementation?	C30	**(Evans et al., 2020; Chan et al., 2019b)**
31	Do you believe that insufficient contractual coordination may impact BIM implementation?	C31	**(Salleh and Phui Fung, 2014)**
32	Do you consider the lack of available studies on BIM and the lack of knowledge to be a challenge to BIM implementation?	C32	**(Bin Zakaria and Yousif, 2013; Gamil and Rahman ,2019; Saka and Chan, 2019; Cao et al., 2015; Hamada et al., 2016)**

Items C12, C21, and C24 were added based on expert interviews to capture context-specific challenges not sufficiently addressed in the existing literature.

3. RESEARCH METHODOLOGY

Although the following problems can also be relevant to other construction industries, the results are mostly viewed through the prism of residential construction, where the repetition of projects, user-performance-focus, and lifecycle are the key factors. A diagnostic approach has been used to define the most prominent issues concerning the application of Building Information Modeling (BIM) to the construction industry, in general, and residential developments, in particular, in Iraq. All the challenges were numerically rated to identify how much they had impacted and how important they were in BIM implementation of residential complexes. In this way, a systematic evaluation of barriers was made possible according to empirical data and not the description listing as follows:

3.1 Data Collection

The purposive strategy of expert sampling was used to select the sample of the research. The reason behind this was that the selected professionals were part of the few who had a practical hands-on experience in applying the Building Information Modeling (BIM) in actual construction works, but not just theoretical or academic exposure. By the time this study was carried out, BIM adoption in Iraq was still at its introductory phase, and the construction projects that were related to the Central Bank of Iraq (CBI) was among the few known examples where BIM was used in practice. Therefore, the choice of professionals working in such projects provided that the issues were identified with respect to real-implementation experience, which made the findings more valid and reliable. Data were gathered on the basis of literature review to outline the most crucial issues of Building Information Modeling (BIM) implementation as conducted in previous studies, interviews, and open-ended questionnaires. The interviews with experts of the construction project teams at the Central Bank of Iraq (CBI) attempted to examine their perspectives regarding the challenges of BIM and these were collected in the literature review performed above. An open-ended questionnaire was distributed to them to express their views on the challenges of using BIM, with the possibility of adding additional challenges based on their experience to design the closed-ended questionnaire. The 32 most significant challenges are shown in **Table 1**. Although the selected experts were affiliated with CBI-related construction projects, their BIM implementation experience involved building types and project scales comparable to large residential complexes in terms of coordination requirements, multidisciplinary integration, and lifecycle considerations. Therefore, their practical insights were considered relevant for examining BIM challenges within the context of residential developments in Iraq.

3.2 Design of the Questionnaire

A closed-ended questionnaire containing two components was created after the observation of the challenges in using Building Information Modeling (BIM). The initial part contained personal details, such as the name of the respondent, academic qualification, specialization, industry, and years of experience. The second section is the questionnaire that had 32 recognized BIM implementation challenges, rated by the respondents in terms of a five-point Likert scale.

3.3 Questionnaire Distribution

The questionnaire was designed, and then it was sent electronically to 67 respondents in all the disciplines of engineering (architectural, civil, mechanical, electrical, and other disciplines). The respondents represented the majority of the governorates in Iraq and on different ranks, such as consultants, project managers, site engineers, academics, Autodesk certified professionals, and others. Much attention was paid to the selection of the target sample among the individuals who used the BIM technology, and a total of 67 responses were obtained, indicating a 100% response rate. This can give a clue to the interest of the target sample in the topic of the research.

4. RESULTS AND DISCUSSION

4.1 Respondents' Demographic Information

The subsection will introduce the demographic attributes of the respondents in a short context to allow the subsequent analysis to be interpreted in context. In-depth discussion has been kept as minimal as possible to ensure that attention is given to the main research findings.

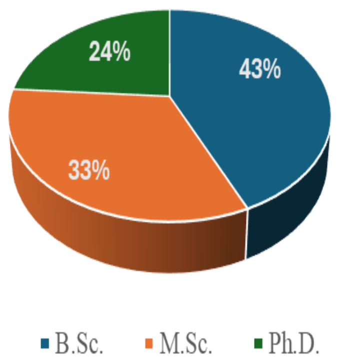

Figure 1. Percentage distribution of respondents according to scientific qualification.

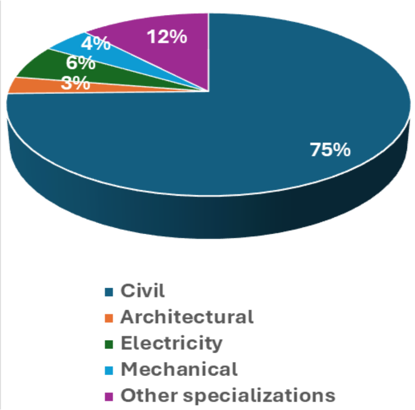

Figure 2. Percentage distribution of respondents by years of experience.

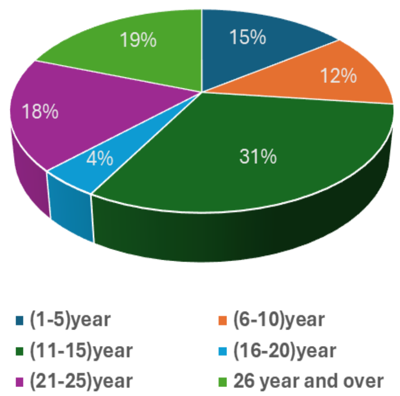

Figure 3. Percentage distribution of respondents by specialization.

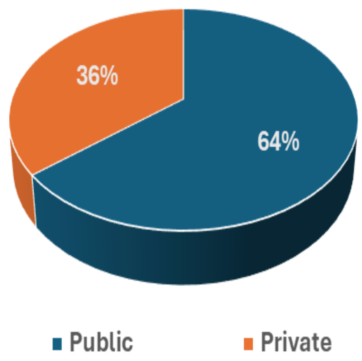

Figure 4. Percentage distribution of respondents according to Labor Sector.

4.2 Reliability and Validity Analysis

The design of any research instrument is heavily influenced by reliability. Statistical analysis must verify the reliability of the questionnaire before its application **(Princy and Shanmugapriya, 2017).** To ensure the equivalence of reliability tests and reliability assessments, reliability evaluations of the actual scores are essential. Calculating Cronbach's alpha (α) is used to assess reliability. Many social science case studies utilize Cronbach's alpha. A reliability coefficient of 0.70 or higher is generally considered sufficient **(Mohammed and Jassim, 2018)**. The validity of the questionnaire can be determined using Eq. (1) **(Noaman, 2022).**

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum_{i=1}^{K} \sigma y2}{\sigma x2}\right) \quad (1)$$

Where:
α: Reliability [Cronbach's Alpha] and K = the number of elements in the group, $\sigma y2$ = Total variation of the elements, and $\sigma x2$ = the total score variation of the element.

One of the basic requirements for developing tests, standards, and validity refers to the extent to which the items of any test measure the validity of the test. The best way to measure validity is through hypothetical validity. Validity is the square root of the reliability coefficient. The validity of a challenge can be calculated according to Eq. (2) according to the source **(Noaman, 2022).**

$$V = \sqrt{\alpha} \quad (2)$$

Where:
V= Validity and α= Reliability.

Using two statistical analysis programs (Microsoft Excel 2024 and IBM SPSS version 27), the reliability and validity of the questionnaire were assessed for the main factor. For the main factor, "Challenges of BIM Use," the Cronbach's alpha coefficient (α), which indicates reliability, was 0.9106, demonstrating excellent reliability. Additionally, the validity coefficient for the challenges of BIM use was 0.954, confirming the validity of the measurement.

4.3 Analysis of BIM Implementation Challenges

Challenges of using BIM were classified using the Relative Importance Index (RII) method, the Mean Scores (MS) method, and the standard deviation (SD) method.

4.3.1 Relative Importance Index (RII) Method

The data obtained were analyzed by determining the importance of the equivalence scale by Equation (refer with: Eq. (3)) according to the source **(Sambasivan and Soon, 2007)** to determine the importance of the factors.

$$RII=\frac{\sum W}{A*N} \quad (3)$$

Where:
RII= Relative Importance Index which it equals ranges from (0 to 1), W= Frequency of rating for each factor or option, N: Total number of respondents for each factor or option, A= the highest weights (i.e., in this case it is 5)

4.3.2 Mean Score Ranking Technique

Some data collected from responses were analyzed by using the means score technique. Point scales were used to calculate the mean score for each response factor or option. The mean scores were then used to rank options in descending order or importance. The mean score for each factor or option was calculated by using the following by Equation (refer with: Eq. (4)) according to the source **(Rashed and Al-Dhaheri, 2018).**

$$MS= \sum_{K=0}^{N} \frac{(X1*S1+X2*S2+X3*S3.......Xn*Sn)}{N} \quad (4)$$

Where:

MS = Mean Score (1≤ MS ≤5). X= frequency of each rating for each factor or option
S = weights given to each factor by the respondents and will ranges from 1 to 5 where '1' is "completely disagree" and '5' is "completely agree". N=total number of responses for that factor or option.

4.3.3 Standard Deviation Technique

The standard deviation (S) measures the value of dispersion or the difference between the mean. A lower standard deviation value indicates that the data content will be closer to the mean (also called the expected value). A variation of the high standard indicates that the content of the data is deviating over a wide range of values. The calculation of the standard deviation model (S) for each measure is based on the following by Eq. (5) according to the source **(Rashed and Al-Dhaheri, 2018)** .

$$SD=\sqrt{\frac{1}{n}\sum_{i=1}^{n}(Xi-\overline{X})^2} \quad (5)$$

Where:
SD = Standard Deviation, $\bar{x}$= the sample mean, xi= the individual sample values, n= the sample size.
Challenges of Using Building Information Modeling (BIM) Technology The module includes challenges about the challenges of using Building Information Modeling (BIM) technology for participants to evaluate. Each challenge will be analyzed using the RII, MS, and SD metrics to determine the ranking of the most important challenges of using BIM technology in residential complexes in Iraq, as shown in **Table 2** below.

Table 2. The analysis and ranking of benefits.

No	Challenge Code and Description	MEAN	Standard Deviation	RII%	Challenge Rank (RII)
1	C1	4.3	0.6	86.3	4
2	C2	4.4	0.6	88.1	1
3	C3	4.2	0.8	83.6	5
4	C4	3.7	0.9	74.9	16
5	C5	4.1	0.8	83.0	6
6	C6	4.3	0.7	86.6	3
7	C7	3.7	1.0	74.0	18
8	C8	3.8	1.0	75.2	15
9	C9	3.5	1.1	70.7	22
10	C10	3.4	1.2	67.8	27
11	C11	3.8	0.9	76.1	14
12	C12	3.6	1.0	71.6	20
13	C13	3.9	0.9	77.9	13
14	C14	3.5	1.2	70.7	22
15	C15	3.4	1.3	68.4	24
16	C16	3.4	1.2	67.5	29
17	C17	3.7	0.8	74.3	17
18	C18	3.6	0.8	72.8	19
19	C19	4.1	0.8	81.2	9

20	C20	3.6	1.0	71.0	21
21	C21	2.9	1.2	58.5	32
22	C22	3.3	1.1	65.4	30
23	C23	3.4	1.1	68.1	26
24	C24	3.1	1.2	62.7	31
25	C25	4.0	1.0	79.1	11
26	C26	3.4	1.1	67.8	27
27	C27	3.4	1.0	68.4	24
28	C28	4.4	0.8	87.5	2
29	C29	4.1	0.9	81.8	7
30	C30	4.1	0.8	81.2	9
31	C31	3.9	0.7	78.5	12
32	C32	4.1	1.0	81.5	8

The research paper has contributed to the current literature on BIM since it presents one of the first empirical studies of BIM implementation issues in residential complexes in Iraq. This research uses the residential projects with repetitive units, a high degree of coordination, and performance focused on the lifecycle, unlike past research, which takes a generalized outlook of the BIM adoption. Additionally, the results are based on the views of the early BIM adopters and those who have practical experience on the implementation front, which provides contextual evidence that can be used by policymakers and decision-makers to formulate effective policies on BIM adoption in the Iraqi housing sector.

5. CONCLUSIONS

This paper examined the issues related to the adoption of Building Information Modeling (BIM) in residential complexes within Iraq and ranked the issues according to the view of the professionals. The results confirm that human and organizational factors are the most significant obstacles to the BIM implementation. Specifically, the identified highest-ranked challenges were the lack of technical knowledge and awareness of BIM, inadequate training and skills. Moreover, a lack of sufficient support with the senior management and the lack of an enabling organizational environment were identified as major constraints to the adoption of BIM, which points to the strategic, and not necessarily technical, nature of BIM implementation. The legal and regulatory issues, such as the absence of special BIM standards and the deficiency of government policies, also proved to be significant impediments in diffusion of BIM in the Iraqi housing industry. On the other hand, financial and infrastructural issues, including software cost, internet connection and power cuts, were seen to be less influential than human and organizational barriers. In general, the paper highlights that to enhance the adoption of BIM in residential complexes in Iraq, it is necessary to focus on the capacity building process, organizational preparedness, and the creation of favorable regulatory environments that would facilitate efficient digital transformation of the residential sector.

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Credit Authorship Contribution Statement

Luay Hadi Radhi: Conceptualization, Methodology, Data curation, Writing – original draft. Sawsan Rasheed Mohammed: Supervision, Validation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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تقييم وتحديد أولويات تحديات تطبيق نمذجة معلومات المباني (BIM) في المجمعات السكنية في العراق

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الخلاصة

تتناول هذه الدراسة التحديات المرتبطة بتطبيق نمذجة معلومات البناء (BIM) في المجمعات السكنية في العراق. وتهدف الدراسة إلى تحديد أبرز التحديات التي أثّرت في تطبيق الـBIM، وتقييم هذه التحديات استنادًا إلى تصورات المختصين، وتقديم رؤى عملية يمكن الاستفادة منها لتحقيق تطبيق ناجح. تم اعتماد منهجية بحثية مختلطة شملت مراجعة الأدبيات، وإجراء مقابلات مع خبراء، وتوزيع استبيان على 67 مختصًا شاركوا في مشاريع إنشائية. جرى ترتيب التحديات المحددة بالاعتماد على البيانات المجمعة باستخدام اختبار الثبات ومعامل الأهمية النسبية (RII). أظهرت النتائج أن العوامل البشرية والتنظيمية تمثل أكثر المعوقات تأثيرًا على تطبيق الـBIM، حيث تصدّر ضعف الوعي التقني بمفهوم الـBIM، إلى جانب نقص التدريب والكفاءات، قائمة التحديات الأكثر أهمية. كما تبيّن أن ضعف دعم الإدارة العليا وغياب البيئة التنظيمية الداعمة يشكّلان عائقًا رئيسيًا أمام اعتماد الـBIM. في المقابل، اعتُبرت التحديات المالية والبنيوية، مثل كلفة البرمجيات وضعف الاتصال بالإنترنت، أقل تأثيرًا نسبيًا. وتخلص الدراسة إلى أن التطبيق الناجح لنمذجة معلومات البناء في المجمعات السكنية في العراق يتطلب اعتماد نهج متكامل يركز على بناء القدرات، وتعزيز الالتزام التنظيمي، ووضع سياسات وطنية وأطر تنظيمية فعّالة لدعم التحول الرقمي في قطاع الإسكان.

الكلمات المفتاحية: اعتماد نمذجة معلومات البناء، نمذجة معلومات البناء، التحديات، المجمعات السكنية، قطاع البناء في العراق.