Building Information Modelling (BIM) for Sustainability in Iraqi Construction Industry

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Abstract. The implementation of Building Information Modelling (BIM) has gained great attention in construction management because it provides a significant benefit such as increasing project quality, providing accurate quantity take-offs, and improving scheduling, consequently diminishing total project contingencies and costs. There is a lack of research done for either BIM application or sustainability in the construction industry in Iraq. Therefore, the goal of this research is to investigate the use of BIM applications for sustainable construction among designers and constructors in Iraq. An online survey was developed to determine the evidence for better understanding the current role of BIM by engineers and professionals as a tool in the fields of design and construction and its application toward enhancing sustainably built projects in the construction industry in Iraq. The survey results indicated that although the majority of the respondents believed that sustainable practices and BIM applications were important within their company, most still believed that the Iraqi construction firms did not apply the most recent technologies to enhance sustainability in construction in Iraq. Also, the result indicated that respondent firms were actively advised owners to apply sustainable methods during projects, however these firms were not willing to fund training courses on advanced sustainable practice developments for their staff.

Keywords: Sustainability, BIM, Construction management, Iraqi sustainable construction.

1. Introduction
In recent years, the use of Building Information Modeling (BIM) in the construction industry of design and construction has shown remarkable growth. This can be attributed to the capability of BIM to create an outstanding collaboration among different engineering disciplines. It covers a variety of disciplines such as geometry, light analysis, geographic information, quantities and properties of different construction components [1]. In fact, BIM is considered essential to Autodesk’s sustainable design method for building performance analysis. The BIM model can be used to generate many effective solutions throughout the modeling of a specific project. Consequently, BIM can be utilized to accelerate the output of the data and information gathered in simulations. The BIM technologies can result in major improvements in productivity through the integration it creates in the work of the construction project network [2]. Unlike drawings created using CAD software that is mainly presented in two-dimensional drawings, building information models consist of actual assemblies of the building instead [3].

Nowadays, as the threats of global warming are continuously increasing, sustainability has become a target for many construction projects. The construction of energy-efficient buildings has become more and more desirable. The efforts to decrease the use of energy and carbon emissions caused by conventionally constructed buildings have not met the goal of making new generations of environmental-friendly buildings, or as known globally green buildings. To reduce the influence of global warming, a need on a global scale has emerged lately. This need encouraged the construction industry to invest in sustainable development projects to reduce the global warming potential within the built environment [4]. It is predicted that the growth of sustainable communities will increase and continue due to the appropriate application of groundbreaking approaches in several fields such as
facility operations, design, and construction. Significant improvement will eventually emerge in the field of projects’ construction that assist in dimension the building’s effects on the environmental impact within both the built environment and the ecological extent.

There are many features of BIM used by architecture engineering and construction (AEC) professionals. Some of these features are supporting the processes of distributed work among different team members on the same project, generating photo-realistic simulations, and integrating the cost estimating, structural analysis applications, energy analysis with the created three-dimensional model. In addition, in the construction industry a work environment in which the association of several organizations is vital, great level of coordination is needed [5]. In such a case, BIM would be the optimum option. As for the project owners, the use of BIM on their projects can provide many advantages such as increasing the value of the building, dimensioning the schedule of the project, providing an accurate cost estimation [6]. Also, BIM provides support for construction-related tasks such as estimating and four-dimensional (4D) scheduling [7]. The transition from design to construction is much easier due to the capabilities offered by BIM. It permits a collection of information and different work process from various disciplines, establishments, and project phases through a collaborative process [8]. Such capability assists in saving both resources and time. It also aids in improving work quality and resulting in an efficient building [9].

In general, the most important feature of using BIM is that the required data for supporting performance analysis is usually collected as the design of the project is continuing. Designers can analyze the performance of a building in the very early phases of design. Consequently, a quick evaluation of the design substitutes can be driven. In recent years, BIM is progressively used, in many countries, especially in the United States, Finland, Singapore, Denmark, and Norway, as an emerging technology to aid in many engineering fields such as the design, construction, and even the operation of the buildings [10].

Although BIM is considered as is one of the most promising technologies in the AEC industry [11], its relationship with sustainability is relatively new and in the development stage. The literature on their relationship has highlighted several important issues. In 2008, Krygiel and Nies conducted a study that involves numerous improvements on BIM software in such a way that supports the principle of sustainability [3]. One of these proposed innovations is the development of BIM software interoperability and integration of a carbon accounting tracker and weather data. The aim of such improvement is to provide valuable data that are required for the next steps in improving the BIM capabilities with sustainability. Azhar performed a study on the use of BIM to enhance building sustainability [12]. In his study, the ability to select the building orientation, evaluating various skin options, and performing daylight studies for the building location on the selected site at the design stage.

To perform carbon accounting, Stadel et al. proposed the utilization of BIM capabilities along with the lifecycle cost analysis (LCA) [13]. This was supposed to be accomplished based on exporting the material schedule for a specific building and the use of plug-ins in the BIM software to calculate the carbon emissions and operational energy usage. Also, the ability, offered by BIM software, to create the design drawings and details straight from the model itself improves the efficiency and accuracy of green accreditation. In addition, the percentages of material to be reprocessed and recycled can be calculated from the schedules of building material quantities of the model. Regardless of the great work done by researchers to enhance the use of BIM to serve for sustainability, still more studies and investigations are necessary in order to achieve the optimum results. The demand for using BIM and the sustainability relationship is growing continuously. In addition, sustainable actions are essential and need to be developed repeatedly to enhance their practices. The measurements of BIM must be upsurge to fulfill a great integration of environmental analysis. Although there is an outstanding technological advancement that is predicted to support BIM and sustainability, the desire and the will of the AEC industry and owners to implement these performance tools into their practice plays a crucial role. Therefore, extensive education on these issues is needed. This can be achieved through the continuous studies on BIM’s role in sustainability and its importance in nowadays projects.
However, BIM is not well-adopted for managing and designing construction projects in Iraq. The use of BIM for projects in Iraq faces many difficulties [11]. This makes it more complicated to achieve the aim of constructing a green building in Iraq. Besides, there is a lack of awareness in the Iraqi construction industry about the benefits of implementing sustainable practices during the project lifecycle [14].

The aim of this study is to examine the current state of implementing sustainability through BIM applications in Iraqi construction projects, also the outcome of this study will present evidence for better understanding the perception of BIM by engineers and professionals as a tool in the fields of design and construction and its application toward enhancing sustainably built projects in the construction industry in Iraq.

2. Research Methodology

In order to reach the aim of this study, a survey questionnaire was developed to achieve this target. The aspects investigated in this survey were used to determine the state of sustainability in construction and how to enhance it by BIM applications. The targeted respondents in this study were engineers and professionals that are involved in the construction and design of buildings, main engineers with at least a bachelor’s degree. The questionnaire was created using google forms and sent to the respondents. The total number of the audience who received the survey questionnaire is 280 registrants. The collected results of the survey questionnaire were analyzed using statistical analysis by Statistical Package for the Social Sciences (SPSS) v23.

3. Study Results

The questionnaire was handed to 280 contacts in construction firms in Iraq. 189 responses were completed successfully which means the response rate was 67.5%. All partial responses were excluded from the resulting analyses to maintain the result consistency.

Figure 1 shows that 22.8% of the respondent were architects, 20.6% structural engineers, 15.9% general contractors, 14.8% site supervisors, 12.2% subcontractors 7.4% mechanical engineers and 6.3% electrical engineers.

![Figure 1: Respondents' profession](image)

Approximately one-third of the respondents (30.7%) have between 4-to-9-year experience in the construction industry. Furthermore, a quarter (25.9%) of the respondents have between 10-to-17-year experience and 23.8% of the respondents have 3 years or fewer construction respondents then at last 19.6% were a high level of professionalism among the respondents because they have more than 18 years of experience in the construction industry as it clearly presents in Figure 2.
Figure 2: Years of respondent’s experience in the Industry’ profession

On the other hand, figure 3 shows that approximately half of the respondents (51.9%) have 3 to 6 years of BIM experience and 36.5% have only 3 years of BIM experience while 11.6% have more than 6 years of BIM implementation in their projects.

Figure 3: Respondent’s experience in BIM

To achieve this study’s aim, the connection between project phases and sustainability through BIM was investigated by questioner the respondents about which project phase will be optimal to apply BIM applications to enhance sustainability in the Iraqi construction industry. Figure 4 explains that design phase was the optimal phase, according to 32.80% of the respondent while more than a quarter (26.46%) state that effective sustainability using BIM technology can be applied in executing phase. On the other hand, the respondents explained that it is difficult to use BIM technology to enhance sustainability in specific project phases which are performance and monitoring, postconstruction operations and closure.
The next aspect of the survey was to examine the respondent’s perceptions of the role of BIM application in achieving effective sustainability by using a five-point Likert scale. The result was collected and then evaluated using SPSS to find the mean for each statement in Table 1. The value for each point in the Likert scale was 1=Strongly ineffective, 2=Ineffective, 3=Neutral, 4=Effective, 5=Strongly effective. The detailed results can be seen in figure 5.

Table 1 Mean of each statement role of BIM in achieving effective sustainability

| No. | Role of BIM                                           | Mean |
|-----|------------------------------------------------------|------|
| R1  | Sustainable development in construction site         | 3.20 |
| R2  | Sustainable materials                                | 3.74 |
| R3  | Waste management                                     | 3.06 |
| R4  | Post-construction facility operations                | 2.46 |
| R5  | Environmental performance for sustainable building design | 3.04 |
| R6  | Energy efficiency                                    | 3.13 |
| R7  | Water efficiency                                     | 2.39 |

According to the results, the respondents believed that sustainable materials are the most important role of BIM applications to reach effective sustainability (M=3.74). Also, sustainable development in a construction site was the second statement in respondents’ choices (M=3.2) then Energy efficiency (M=3.13), waste management (M=3.06), environmental performance of sustainable building design (M=3.04) respectively. However, the respondents agreed that role of BIM applications in water efficiency (M=2.39) and post-construction facility operations (M=2.46) is not important to achieve effective sustainability.
There is a section in the survey aimed to determine respondents' organizations' perceptions of sustainability. The same approach in analyzing the Role of BIM Application in Achieving Effective Sustainability was used to analyze this section of the survey. However, a slight difference in the title of the Likert scale because it was 1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly agree.

| No. | Respondents' Organization's Perceptions of Sustainability                                                                 | Mean |
|-----|----------------------------------------------------------------------------------------------------------------------------|------|
| F1  | Organization understands the importance of sustainability.                                                                      | 3.62 |
| F2  | Organization applied recent technology to enhance sustainability.                                                            | 2.31 |
| F3  | Organization actively advises owners to apply sustainable methods during projects.                                          | 3.12 |
| F4  | Organization encourages staff to apply sustainable practices during projects.                                                   | 3.15 |
| F5  | Organization funds training courses on advanced sustainable practice developments for their staff.                          | 2.48 |

Table 2 states that the majority of respondents agreed; that their firms are understanding the importance of sustainability (M=3.62), that their firms are encouraged to staff to apply sustainable practices during projects (M=3.15) and that their firms actively advises owners to apply sustainable methods during projects (M=3.12). Despite these results, the respondents state that their firms did not fund training courses on advanced sustainable practice for their staff (M=2.4). Also, the respondents explained that their firms did not apply recent technology to enhance sustainability (M=2.31) and the detailed results can be seen in Figure 6.
4. Conclusions
In the last decades, sustainability in construction has become one of the global trends as a result of climate change and global warming side by side of the increase in the usage of BIM technology in the AEC industry. The results of this study provided insights into the current level of the usage of BIM applications to enhance sustainability in the Iraqi construction industry.

This study found that the design stage is the most vital stage in the project for the successful BIM implementation of sustainability practices by 32.80% of the respondents then (26.46%) of the respondents’ state that effective sustainability using BIM technology can be applied in executing phase. In addition, this research found that sustainable materials are the most useful sustainable approach that can be achieved by using BIM technology and rank two was for sustainable development in the construction site.

Although a majority of the respondents agreed that their firms understand the importance of sustainability, they also state that their firms did not apply BIM technology to enhance the sustainability in the construction site which represents the lack of awareness of the benefits of BIM and sustainable project site in construction firm leadership. Another noticeable result is the respondents’ firms were actively advising owners to apply sustainable methods during projects, however these firms were not willing to fund training courses on advanced sustainable practice developments for their staff.

Future studies should be done to explore the owner perspective of the AEC industry to examine their effect on support sustainable practices by applying BIM technology and how can the Iraqi government lead in this direction.

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