Exploring the Impact of Implementing Building Information Modelling to Support Sustainable Development in the Lebanese Construction Industry: A Qualitative Approach

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Exploring the Impact of Implementing Building Information Modelling to Support Sustainable Development in the Lebanese Construction Industry: A Qualitative Approach

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Abstract
Building Information Modelling has been identified as a new and revolutionary tool capable of improving the performance of the construction sector. With a growing population and overurbanization, there is an increasing demand for construction projects in Lebanon, thus hindering the environment and consuming natural resources. The Lebanese construction sector has been neglecting the importance of sustainable development; however, this research adopts a qualitative approach to explore the influence of implementing Building Information Modelling in the Lebanese construction industry to support sustainable development. The aim of this research is to develop a framework for the successful implementation of BIM by examining the barriers limiting BIM implementation in terms of economic, social, and environmental sustainability also referred to as sustainability pillar. Interviews were carried out with construction professionals in Lebanon to understand the definition, benefits, barriers, and current sustainable performance to further examine the implementation of BIM. The framework is divided into seven components that will unlock the possibility of implementing BIM in the Lebanese construction industry to achieve sustainable growth.

Keywords
Building Information Modelling (BIM); Architecture Engineering and Construction (AEC); Lebanese construction; Sustainable Development; Sustainability pillars.

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1. Introduction

Widely criticized as a fragmented industry, the architecture, engineering, and construction (AEC) industry has been on the receiving end of many adverse comments questioning its poor quality, lack of collaboration, and disregard for innovation. By investigating the relationship between design management, innovation, and the role of BIM, Elmualim and Gilder (2014) emphasized the desperate need for change in the construction industry. Evidently, Building Information Modelling (BIM) presents the opportunity to elevate innovation in the AEC

industry. BIM has been defined as the process of creating and managing building data through three-dimensional (3D) visualization and real-time dynamic building modelling (Stacks et al., 2018). According to Elmualim and Gilder (2014), a questionnaire survey aimed at investigating whether people consider BIM as an innovative tool capable of improving the AEC industry, or whether BIM is not capable of reaching such expectation, showed that 63% of respondents believe that BIM will significantly improve the overall construction practice. However, many barriers still hold the successful implementation of BIM, such as lack of capital investment, of which 20% of respondents seem to have this problem, 15% responded by saying that the benefits of BIM do not outweigh its cost, and finally, 37% of respondents did not seem to be interested and have no reason for implementing BIM themselves. Unfortunately, this way of thinking has set the AEC industry on a path of severe consequence. An example that elaborates these consequences is the heavy consumption of natural resources and raw material to supply the rising demand for construction projects, which has placed a substantially large pressure on today's environment.

Hurlimann et al. (2018) highlighted that the AEC industry has limited control over the negative environmental impacts it is responsible for, mainly because of its position in the building supply chain. The AEC industry is responsible for construction; however, another industry is responsible for the operation, therefore the AEC industry sets a short-term plan to minimize risk and maximize profit, thus neglecting its impact on the environment. As a result, the AEC industry has been a major contributor for significant environmental pollution and resource exploitation, even though sustainable construction has been receiving positive attention and aspiration, yet it still requires major performance changes (Yin et al., 2018).

Nevertheless, Building Information Modelling has presented itself as a repository capable of narrowing fragmentations between building delivery professionals and aid in improving the outcome of any construction project (Fadeyi, 2017). Furthermore, the growing interest in BIM shown by the rising number of academic research and journal publications over the past years highlights the key role BIM is undergoing to deliver a better sustainable value (Chong et al., 2017). Several developed countries, such as the UK and the US, have realized the importance of sustainable development and the negative environmental consequence resulting from the AEC industry. For that reason, these developed countries have taken initiative to develop the Framework for Sustainable Strategic Development promoting the importance of using new technology, such as BIM, and its development through new university program courses, as well as, BIM association for better sustainable practice such as modular coordination, material substitution, and reduced demolition (Alwan et al., 2017). Nevertheless, there are many barriers that remain unsolved and hinder the proper implementation of BIM, especially in developing countries (Chan et al., 2019). When dealing with sustainability, there are many factors that need to harmonize to achieve true sustainability such as social, economic, and environmental sustainability also known as the sustainability pillars (Fischer et al., 2017). Each sustainability pillar presents its own benefits and challenges; therefore, it is necessary to uncover possible BIM tools to further enhance each of the sustainability pillars. The result will prompt sustainable development in the AEC industry with the aid of Building Information Modelling.

Highlighting the fact that the rapid development of society and technology is deteriorating the environment, the AEC industry is a major contributor to many negative impacts on the environment. Lebanon, a developing country, is witnessing improvement in its economic activity compared to previous years. Unfortunately, rising economic activity in a country heavily dependent on the construction sector usually implies more construction projects

(Majdalani et al., 2006). Since Lebanon has low awareness of sustainability, rising population and construction activity will result in more negative environmental impacts on already existing problems. As a result, the implementation of BIM in developing countries such as Lebanon, still face many challenges to improve social, economic, and environmental sustainability. The relation between BIM and sustainable development remains unclear, even though, the subject has received tremendous attention and expanding research, many issues remain unsolved such as weak interoperability between BIM applications, lack of support in the construction and operation phases of the project life-cycle, lack of industry standards, low industrial acceptance, and unclear project delivery method (Lu et al., 2017). According to Gerges et al. (2017), BIM adoption and implementation in Lebanon is relatively low. Only 7 companies in Lebanon responded to have been involved in construction projects using BIM, contributing to a total of 2% involvement. As a result, the study shows that Lebanon is one of the lowest BIM users in the Middle East. Over the past decade in Lebanon, BIM is being used as a tool for 3D visualization, clash detection, and quantity surveying (Awwad and Ammoury, 2013). Lebanon has yet to scratch the surface of BIM's potential in elevating the construction industry. The reluctance to change the construction process has had a significant impact on Lebanon's sustainable performance, thus, sustainable construction in Lebanon is considerably primitive compared to the surrounding region (Srour et al., 2010). The low awareness levels on the importance of sustainable development, as well as, the low implementation rate of BIM have created many complications for the Lebanese AEC industry.

Therefore, the aim of this research is to develop a theoretical framework for the successful implementation of Building Information Modelling (BIM) and explore its impact on Sustainable Development in the Lebanese construction industry. Working on identifying the major contributors of the Lebanese construction sector prompting the need for sustainable development, exploring the environmental attributes of BIM that impact social, economic, and environmental sustainability will aid in developing and validating a framework the implementation of BIM to support Sustainable Development in the Lebanese construction sector.

2. Literature Review

The following section will take a closer look at previously discussed research and literature, to highlight the relation between innovation and the construction industry. This section will demonstrate how the construction industry has negatively influenced the environment thus inspiring the need for sustainable development. As well as, introduce and define Building Information Modelling whilst exploring the barriers and limitations preventing BIM's successful implementation. In addition, examine Lebanon's current sustainable performance, by looking into Lebanon's geographical environment and historical records, and interpret Lebanon's need to improve sustainable construction. Moreover, take a closer look at the understanding of Building Information Modelling and its role in the Lebanese construction sector.

2.1. Innovation in the Construction Industry

The construction industry became aware of the concept regarding sustainable development from the ongoing threat of growing population and over-urbanization. The rapid economic growth galvanized the increasing demand for building construction. In general, buildings consume more than 30% of total global energy (Berardi, 2017) and an immense amount of raw material, such as 70% of global timber (Nguyen et al., 2017). Supplying energy to the

construction sector relies majorly on fossil fuels. The continuous consumption of fossil fuels to supply energy, fiercely increased carbon emissions from 280 ppm to 391 ppm in 2011, eventually rising over 400 ppm in 2014 (Yue et al., 2015). Confirmed by Berardi (2017)the research evaluated trends for population growth and fossil fuel consumption to predict future patterns. By comparing the industry, transport, and building sector in several countries between 1990 and 2050, (Berardi, 2017) highlights the rising energy consumption and over-exploitation of natural resources, specifically in the building sector. As time progresses, population and energy consumption seem to increase in several countries, even though the ascending rates are not similar in all countries, it is clear that population and energy consumption are directly proportional to one another and are simultaneously rising, causing major environmental impacts (Berardi, 2017). Worldwide awareness towards environmental impacts of resource depletion, energy shortage, climate change, and greenhouse gas emissions sparked concern about energy consumption trends placing tremendous pressure on the construction industry. As a result, the term sustainable construction has become more familiar in the global construction market. Sustainable construction aims to achieve safe and secure buildings with minimum impact on society, environment, and economy. In other words, satisfying the needs of the current generation without jeopardizing the needs of future generations, while focusing on ecological and socio-economic building systems (Karunasena et al., 2016). As part of the sustainable initiative, Green Building Technology (GBT) has been perceived by many governments as a pioneer strategy in sustainable development, capable of reducing the negative environmental impacts of the AEC industry. Green Buildings is a resource-efficient building practice that acknowledges the value of natural resources, as well as improve the quality of life (Darko and Chan, 2018). Research by Darko and Chan (2016), followed the Green Building research trend, showing the attention that Green Building development has witnessed over the previous years, and highlighting the rising number of Green Building research papers and contributions being made worldwide, highlighting the significant impact on sustainable growth. The research examined many Green Building research interests such as project delivery method, certification, energy performance, and technological development, however, concluded by stating that even though Green Building development has been the centre for many types of research and academic publication, yet it is not considered as a primary concern when it comes to practical implications. Sustainability is still being overlooked as a primary attribute in the construction practice, nonetheless, the more academic pursuit will lead to further knowledge and awareness, eventually leading to the higher implementation of Green Building technologies and sustainable growth, through the understanding and development of BIM Critical Success Factors (CSFs) (Awwad et al., 2020).

Innovation has been a key factor in the success of many industries. However, for many years, the construction industry has rarely contributed to innovation. When compared with other industries such as the pharmaceutical or automotive industry, the construction sector does not seem to strive in the technology department (Kamal et al., 2016). Despite the fact that innovation has shown an increase in productivity and gives a competitive advantage, the AEC industry showed little interest in investing for the development of the construction process. As a result, the AEC industry has been perceived as an underperforming industry that fails to deliver the optimum project value. Several pieces of research explore the reason behind such low-value performance, highlighting the lack of communication and coordination between directors, henceforth, a recurring issue (Selçuk Çıdık et al., 2017).

2.2 Sustainable Development in the Lebanese Construction Sector

Lebanon's over urbanization along with the surge in its population due to neighbouring refugees have resulted in unprecedented deterioration of its natural habitat. According to Faour (2015), the reconstruction period after the Lebanese civil war has led to massive unplanned urbanization polluting surrounding countryside, mountains, rivers, and coastlands. In addition, Lebanon witnessed an unexpected increase in population by 30% from Syrian refugees since 2012 (Ammar et al., 2016). Therefore, according to Kareiva et al. (2007), a sudden increase in population over a short period of time usually results in a negative impact on the environment and losses in biodiversity. Lebanon has witnessed anthropogenic disturbances in its biodiversity and is dire need to preserve its ecosystem, suggesting a framework to preserve the ecological environment, as well as stating the critical the situation currently is in Lebanon, as a result, Lebanon is in desperate need to consider a different approach for its urbanization strategy, hence the need to consider sustainable construction and development (Bou Dagher-Kharrat et al., 2018).

As a developing country with a history of war and vast structural damages, Lebanon is witnessing a noticeable economic growth compared to previous years and therefore is expected to take on several new construction projects in the nearing future. According to the Lebanese Order of Engineers, the rising number of construction permits being issued shows a relatively wide potential to expand the construction industry in Lebanon (EIU ViewsWire, 2016). Unfortunately, due to its poor economic statues, the Lebanese construction industry faces several major issues, such as delays in construction projects and cost overruns, which overshadow the importance of sustainable development. Sustainable development has not been considered as a priority, and with the continuous consumption of natural resource to supply energy, negative environmental impacts were inevitable. Therefore, in the hope of attempting to control these negative impacts, Green Building development should be investigated as mitigation to support sustainable development.

The construction industry, known for generating high levels of pollution, has the potential to reduce the negative environmental impacts and overconsumption of raw material. Although the Middle East region lacks natural resources and struggles from unresolved political and social issues, it is attempting to redirect construction to a more sustainable manner. The Middle East witnessed a growing population and an improving tourism sector over the past years, hence, the increasing demand for construction and building projects. Issa and Al Abbar (2015) examined the opportunities and challenges for introducing Green Building codes in several countries in the Middle East, such as Qatar, UAE, and Lebanon, as part of sustainable development. The Middle East region is faced with many challenging circumstances, such as:

- natural problems due to high temperatures, dry climate, and low availability of freshwater
- lack of awareness of sustainable development, even though there is a high level of education in the region, however, the focus primarily remains on improving the economic situation
- overconsumption of natural resources and raw material
- retrofitting of existing buildings to be more energy efficient is considered as a lucrative process, and due to the current economic situation, is not considered as a feasible option

In Lebanon, the Lebanese Green Building Council (LGBC) a non-profit non-governmental organization adopted the ARZ building rating system and focused on energy efficiency and

water conservation. Unfortunately, due to the country's minimal sustainability awareness and political instability, the rating system was not considered mandatory and was only included in a few projects. Lebanon's economic growth and population increase resulted in the rising demand for building construction and infrastructure. However, with the country's low level of awareness in sustainable development, Lebanon experienced a significant increase in the level of pollution and carbon emissions, placing the Lebanese community under tremendous risk. The table below represents the rising economic growth, increasing population, and escalating levels of carbon emissions with respect to time.

Table 1 Rising economy, population, and carbon emission with time ("World Development Indicators | DataBank," 2020.)

Time Data	1990	1995	2000	2008	2012	2016	2018
GDP (billion $)	2.838	11.719	17.26	29.228	44.231	51.239	56.639
GDP Growth (%)	26.5	6.4	1.3	9.2	2.1	1.6	0.2
Population (million)	2.80	3.52	3.84	4.76	5.53	6.71	6.84
Population Growth (%)	2.8	3.6	2.5	-0.1	6.3	2.7	0.5
Energy use (kg oil/capita)	697.1	1249.7	1277	1139.8	1294.7	-	-
CO_2 emissions (ton/capita)	2.9	3.8	4.0	3.6	4.1	-	-

As shown in Table 1, Lebanon witnessed significant economic and population growth over the past 30 years. Hence, the demand for fossil fuels to supply energy rises, and since Lebanon has not yet considered prioritizing sustainable development in the construction industry, carbon emissions continue to escalate as energy consumption remain unsupervised. As a result, Lebanon is in desperate need to re-examine its sustainable strategies otherwise, living conditions will be more difficult than they already are. Research by Mezher (1997) explores the environmental problems threatening Lebanon's well-being. The research identifies several contributing factors for environmental deterioration such as:

- Lack of solid waste management, where waste being generated from the construction or demolishing of buildings are being left untreated in open land
- Water and air pollution, due to electrical plants and cement factories releasing chemicals in nearby streams or into the atmosphere
- Lack of managerial, professional, and technical skills
- Shortage of capital
- Damaged infrastructure
- Primitive technology as well as an absence of research, development, and innovation
- Government corruption, social and political instability

Supporting this claim, research by El Asmar and Taki (2014) states that Lebanon's economy is emerging from a crisis and there are remarkable developments in commercial, residential, and industrial properties. Unfortunately, through simple observation, realizing that these developments remain inadequate to sustainable standards is very clear. Houses remain to be built with no regards to sustainable regulations, eventually leading to a more chaotic natural landscape, air, water, and noise pollution. The lack of interest in national land-use planning, coordination of environmental management, and updating environmental regulations resulted in urban aesthetic pollution and chaos. A case study examined the city of Zouk Mosbeh, a heavily populated coastal area in Lebanon. The findings show a high level of air, water, acoustic, solid waste, soil, and aesthetic pollution. As a result, there must be a change of attitude towards sustainable development, and the government should consider its integration in social, economic, and environmental strategies. A "bottom-up" approach was recommended, which supports collaboration and cooperation between directors and the public giving equal opportunities in the participation of policy formulation and implementation, however, authority remains in the government's hands (El Asmar et al., 2012).

2.3 Sustainability Pillar and Building Information Modelling

The sustainability pillars breakdown the concept of sustainable development into three major categories economic, social, and environmental sustainability, defining how each aspect plays a definitive roll in contributing to a better sustainable outcome by analysing each aspect individually. According to Chong et al. (2017) and Khan et al. (2016) , each category presents its own challenges, but offers the opportunity for measuring sustainability:

- Social sustainability: it is based on people's ability to live in a fashion that best provides their needs without harming future generations. The outcomes are favourably achieved when considering client satisfaction. In the AEC industry, public health and safety are critical factors to improve social sustainability. Furthermore, improving communication between the workforce and the community result in safer and more productive management. Therefore, it is necessary to change the AEC industry, and the best way to achieve the right conditions is by recruiting and training talented individuals through which improvements can be made.
- Economic sustainability: it is more complicated to quantify economic sustainability since there have not been many data recorded demonstrating economic sustainable development (Gibbs and O'neill, 2014). However, it is imperative to highlight the importance of saving from the life-cycle cost and construction time of any built facility, in order to invest in more innovative construction techniques and training programs. Key Performance Indicators (KPI's) aid in measuring performance and can help utilize new construction material, new building technology, new contract forms, and integrated communication.
- Environmental sustainability: the process of reducing greenhouse emissions, minimizing waste generation, air pollution, noise pollution, and water consumption to improve the quality of life for the current generation and guarantee a future one. Using Environmental Performance Index (EPI) and lean construction, the AEC industry can mitigate and lower the negative impact on the environment, thus achieving better sustainable outcomes, more energy conservation, and an overall healthier living environment.

The sustainability pillars provide a relative insight on sustainable development, however implementing Building Information Modelling can aid each of these aspects throughout the project lifecycle. However, the use of BIM in sustainable development has not been developed to full potential and therefore could not be integrated properly in any of the sustainability pillars. With growing concern over sustainable development and the rising growth of BIM, merging the concept and technology together could improve the sustainable performance of the AEC industry. To understand the influence of BIM in sustainable growth, there is a need to establish a relation between the two concepts, therefore Lu et al. (2017) examined previous journals and different types of BIM application to propose the "Green BIM triangle". In the research, green buildings were recognized as a leading method to improve sustainable development in the AEC industry. Green buildings could improve energy performance, lighting analysis, and construction waste generation, therefore the nexus between green buildings and BIM presents a great opportunity for developing sustainable construction. There are two major criteria linked with green BIM, first Building Information Modelling which falls under "BIM attributes" that assist in visualization, analysis, simulation, document management, and integration with various databases. Second is green buildings, which fall under "green attributes" that consider the elements of study to achieve better Green Building development, both in correlation with the "project phases". Green attributes focus on the elements that could be improved using BIM software such as energy, thermal comfort, carbon emissions, water, material waste, daylighting, natural ventilation, and acoustic analysis, while project phases address the dimensions presented throughout the project life-cycle such as design, construction, operation, maintenance, and demolition (Chong et al., 2017; Lu et al., 2017).

3. Methodology

The research methodology will introduce the adopted approach this research will follow. An extensive literature review was carried out using a range of information collected from books and peer-reviewed journals from libraries and internet-based sources. The literature review examines the negative environmental impact that resulted from a lack of sustainable construction and limited BIM implementation in the Lebanese AEC industry. After identifying the key issues disclosed in the literature, qualitative research was selected to build up three case studies, where every case study will be based on semi-structured interviews with BIM and sustainable development experts in the Lebanese AEC industry. Based on the data collected, the analysis technique will require the use of qualitative software (NVivo) to analyse and interpret the information gathered throughout the data collection process. The discussion will aim to relate the literature will the information gathered to finalize the outcome.

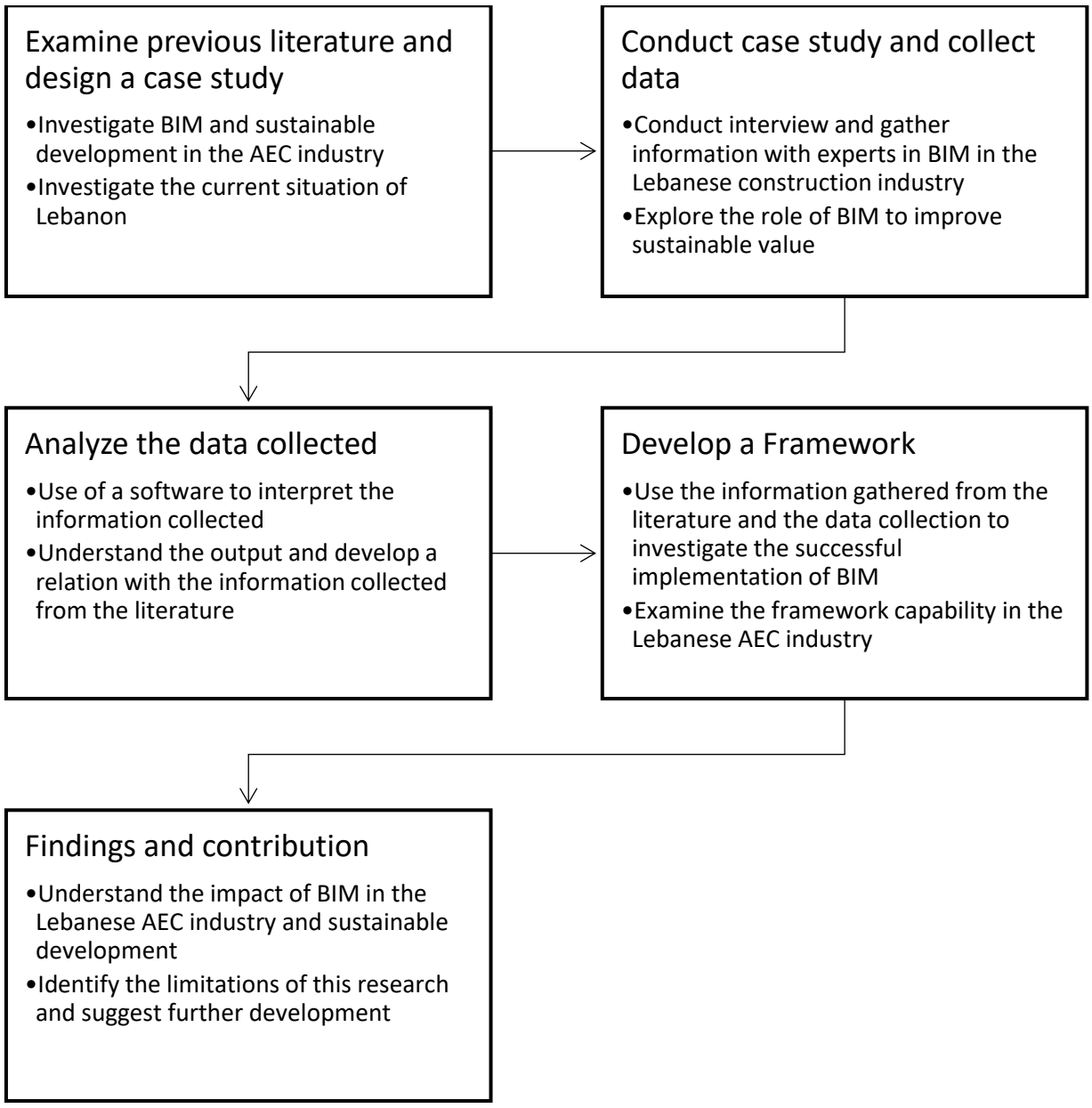

Figure 1 The Stages of the adopted research design

3.1 Interview Protocol

The data collection introduces the company profiles and the role of the participants in their respective company

Table 2 The Interview Protocol

Target	Stage	Question	Purpose
BIM and Sustainable development experts	Understanding	Are the clients aware of the importance of sustainable construction and the role BIM could have on the outcome?	Identify the existing level of awareness.
	Mapping	What are the main sustainable aspects considered during the design phase of the project?	Identifying key components.
	Mapping	How can BIM aid in improving the design of the project and what is the expected outcome on the sustainable aspects?	Understanding the market.
	Mapping	What BIM tools are currently being used in this company, and what are the requirements needed to push for the next level?	Identifying key components.
	Limitation	What could be considered as the main critical success factors for the company to achieve successful implantation of BIM?	Establishing the barriers and limitations.
	Limitation	Can you provide a percentage of the company investment into BIM implementation and sustainable awareness? Can this figure be improved and what are the requirements?	Future direction for the research.
	Framework	As part of developing a framework for BIM implementation, what BIM aspects could be utilized and linked with sustainable development for further research?	Validating the framework.
	Framework	What are the key factors to achieve better sustainable performance in relation with BIM implementation and can they be mapped throughout the project lifecycle?	Validating the framework.

3.2 Interview Participants

The interview targets different levels of BIM experts for the purpose of evaluating different perspectives and understand different opinions for the unsuccessful BIM implementation strategies so far.

Table 3 The role and number of participants

Classification Code	Role in Company	CA	CB	CC
DR1	Director	2	2	1
DR2	Department Manager	1	1	1
DR3	Procurement Manager	1	1	1
DR4	Research and Development	1	1	1
EN1	Project Manager	1	2	2
EN2	BIM Expert	1	1	2
EN3	Draftsman	3	1	2
CR1	Contractor	-	2	-
CR2	Site Engineer	-	1	-
Total		10	12	10

4. Data Analysis

4.1 BIM definition in the Lebanese Construction sector

On a global scale, Building Information Modelling has been identified as an innovative tool capable of changing the construction industry. However, based on the interviews conducted in the previous chapter, each case study identified BIM in a different light, especially when every participant presented a different definition for BIM. Based on these case studies, different project participants have a different understanding of BIM, as presented the following table 4.

Table 4 BIM defection based on the role of project participant

Project Participant	Aspects of BIM definition		
Director	Information storage and accessibility	3D visualization	Coordination and collaboration
Project Manager	Improve project management	3D visualization	Create unified platform
Designer	3D visualization	Information storage and accessibility	Decision making process
Contractor	3D visualization	Create unified platform	Site layout and management

Based on the information presented in table 4, different project participants defined BIM on different attributes. There are four major project participants, directors, project managers, designers, and contractors. Based on their need to improve their project performance, BIM is denied as a tool that can provide the necessary attribute for its given field of use. The histogram provided in figure 2 represents the BIM attributes that have been commonly used for different project participants based on their highest frequency.

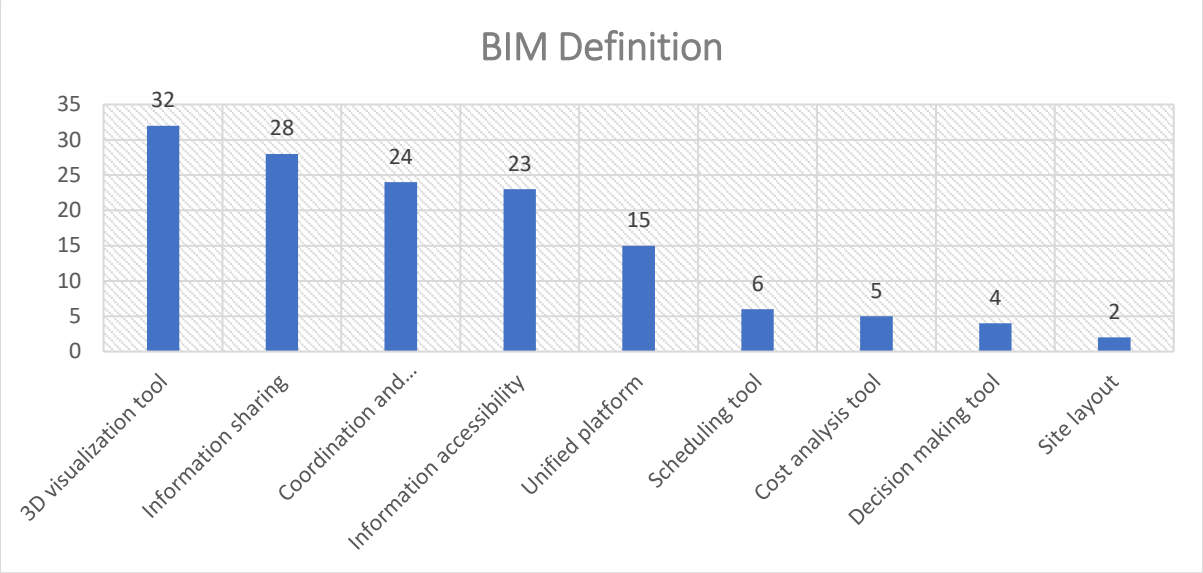

Figure 2 Word frequency identifying BIM definition based on the role of participant

Based on figure 2, in the Lebanese construction industry, BIM is defined as a visualization tool capable of generating 3D models of the project. In addition, these models are data-rich and can be easily accessible by different project participants. This definition can be interpreted from figure 2 which shows that the highest frequency of BIM definitions focused on visualization and information sharing. Referring back to the interviews, every case study highlighted the importance of the Level of Detail (LOD), which represents the level of detail in a model. The case studies established that the LOD is the level input fed into a BIM model and as a result, the higher the LOD is larger the output. The fact that the majority of interviews identified the LOD to be a key part of the BIM definition, justify the BIM definition to be model based. As of today, the LOD is the standard that defines the BIM model, therefore, as a result, the Lebanese construction industry complies with BIM as a modelling tool to improve visualization.

The information gathered shows that the Lebanese construction sector is working on improving the comprehensive nature of a construction project. The inability to visualize the target makes it challenging to undergo any alterations or improvements to the project. As a result, interviewees agreed that the first and most critical definition of BIM is to provide a simulated environment for the project. The fact that project participants have a different definition of BIM does not imply a lack of knowledge, yet it opens up a variety of different opinions. The similarities between the case studies show that BIM definition is related to the defining entity and the project phase. Referring to the case studies that directors, managers, engineers, and contractors define BIM in a different manner that related to the project phase. Looking at a simple project life cycle consisting of the design, construction, and operation phases, 3D visualization plays a different part according to the project participants.

4.2 BIM Benefits in the Lebanese Construction Industry

Building Information Modelling is showing great potential in the construction sector. With new and innovative methods of carrying out tasks, BIM has the characteristics of great change in the Lebanese construction industry. The case studies have shown many potential benefits of implementing BIM in the Lebanese construction industry. Based on these case studies BIM benefits can be divided based on the project participants and the role they play in the project. The case studies presented different project participants with different goals and expected

outcomes of implementing BIM in the construction sector. Based on the information presented in the case studies, BIM benefits can be divided into four categories based on the project participants and there need for BIM in the construction project. The following table summarizes the BIM benefits with respect to that project entity.

Table 5 BIM benefits for the project participant

	Project Participant			
BIM Benefits	Directors	Project Managers	Designers	Contractor
Generating 3D models	✓	✓	✓	✓
Facilitate the decision-making process	✓			
Energy analysis and simulation			✓	
Information sharing and exchange	✓	✓	✓	✓
Management of project information	✓	✓		
Improve accuracy of as-built drawings			✓	✓
Clash detection		✓	✓	
Real time scheduling		✓		
Accurate cost estimation	✓	✓		
Facilitate building documents and approval	✓			
Create a platform of collaborative sharing	✓	✓	✓	✓
Improve resource management and planning		✓		✓
Improve site layout, health, and safety		✓		✓

Facilitating integrating sustainable construction	✓	✓	✓	
Minimize carbon emissions and reduce waste generation	✓		✓	✓
Improve investment opportunities	✓			
Improve overall project performance and deliverables	✓	✓		✓

Similarly to Ullah et al. (2019), the information provided in table 5 shows the benefits of implementing BIM in the Lebanese construction sector based on the interviewees' response in the case studies. Several BIM benefits apply to the same project participants, yet, the use of these BIM tools may differ. Nevertheless, the majority of interviews agree that BIM shows great potential to improve the overall performance of the project.

4.2 BIM Barriers for Sustainable Development in the Lebanese construction sector

Building Information Modelling is reshaping the Lebanese construction sector. BIM is offering all project participants a chance to develop the construction process and improve the construction industry. Nevertheless, such great innovation always comes with great challenges and limitation. BIM implementation is a challenge to any construction industry, especially in developing countries such as Lebanon. Many barriers restrict the successful implementation of BIM, and from the examined case studies these barriers can be divided into three categories Economic, Social, and Environmental. Unlike the benefits of BIM, barriers and limitation apply to all project participants simultaneously, so to properly understanding the barriers of BIM, it will be beneficial to consider the impact of that barrier on the BIM implementation process rather than the party it influences. As a result, the table provided below, table 6, will introduce BIM barriers in the Lebanese construction industry.

Table 6 Economic, Social, Environmental Barriers of Sustainable constriction

Factor	Barrier
Economic	- Lack of investment in the BIM process - High initial cost for BIM software - Uncertainty for the return of investment - High costs for training programs and education - High salaries for people familiar with BIM, that are higher than the average employee - Low growth rate for the Lebanese construction sector - Transparency - Lack of director involvement

Social	- Reluctance to change and adoption of new technology - Long learning process - Lack of client demand due to low awareness and knowledge of BIM tools and processes - Lack of experience and skills with BIM in the workforce - Low levels of research and education - BIM is not included in the higher education curriculum - People familiar with BIM do not work in the Lebanese construction industry
Environmental	- Little knowledge and awareness on the impact of BIM on sustainable development - Lack of sustainable development tools - Lack of standardization and organizational involvement - No consideration for environmental parameters - Low BIM use in green projects - No framework for the implementation of BIM in sustainable construction

4.3 BIM application in sustainable development

A growing concern in the Lebanese construction industry is the lack of demand and awareness on the importance of sustainable construction. From the case studies, it can be deduced that due to lack of technological development and low overall performance achieving such high standards of construction is difficult. As a result, clients tend to focus more on time and money while neglecting quality and sustainability. The lack of technology and innovation has left the Lebanese construction industry stagnant, and the fact that BIM itself has low awareness levels in Lebanon shows little potential for sustainable construction. The relation between BIM and sustainability has become clearer, so due to lack of BIM implementation for many of the previously mentioned reasons, raising the quality of construction is difficult, as a result, achieving sustainable standards of construction has become farfetched and unachievable.

4.3.1 Economic Sustainability

When dealing with economic sustainably, the main target is to attempt and reduce unnecessary costs, while prolonging the life of the project with minimum impact, hence the term sustainable. Sustainable construction has been a recognized as negligible task in the Lebanese construction sector. One of the main reasons is due to lack of financial capability. However, this negligence has caused severe economic conditions as of today. Due to lack of planning and consideration, the Lebanese economy has fallen short, and construction sector has witnessed a serve financial cutback. Hence there is a need to consider an alternative more sustainable approach.

From the information gathered on BIM and its impact on the construction industry, implementing BIM will be the first step in achieving and improving the economy through sustainable construction. It is by identifying the benefits of BIM and the requirements for sustainable construction, the qualities will merge and impact the performance. The table below will demonstrate the BIM attributes and their impact on economic sustainability.

Table 7 BIM attributes for economic sustainability

BIM Attributes	Economic Sustainability Impact
Visualization	- Through 3D modelling and improved visual representation, the decision-making process becomes simpler and thus reducing uncertainties. By eliminating the risk of uncertain decisions, project will be carried out with more accurate estimations. Accurate designs lead to better executions, thus eliminating unwanted costs. - Reducing mistakes will result in lower costs of redoing the work, and these funds could be reallocated to more innovative tasks, such as designing green spaces or solar heating systems. Instead of investing money to correct errors, eliminating these errors will increase funding to consider more sustainable and long-lasting materials. - Improved visualization through BIM modelling, can aid in integrating sustainable models with long lasting material which can also lower operation costs in the future such as maintenance and refurbishment.
Analysis and Simulation	- A key benefit of BIM is running simulations and analysis that can aid in predicting future outcomes. For example, clash detection simulations help foresee upcoming errors and devise solutions or alternatives before occurrence. Thus, reducing unwanted costs and wasted material. - 4D scheduling and 5D cost estimation are another form of project simulation using BIM, using aim to reduce project durations and eliminate human errors that might cause delays and cost overruns. Eliminating errors reduce costs, and as a result increase project budgeting for more sustainable design and execution. - Energy analysis can facilitate sustainable design, and through that create a more sustainable execution process which will lower operation costs. In certain cases, investing a larger sum of money in present times will lead to lower costs in the future. Yet by improving design and execution through BIM, the money invested today will be through reallocated funds saved by eliminating unwanted errors in the early stages of the project life-cycle.
Information management	- BIM's single platform creates a communication line for all project participants, thus facilitating interaction and reducing misunderstands that will result in errors that will eventually require alterations. A unified platform is a method of cutting unwanted costs and creating an opportunity for further development. Improving the quality of information improves the quality of the project. - Quality is linked with sustainability, in this case, opening a line of new information which can be cost efficient and environmentally sustainable. Therefore, creating a product of higher value could be achieved with lower costs.

Project integration	- BIM could be regarded as a language, and similarly to any international financial market, there is a risk of fluctuations between project participants. However, when working under the same cloud, projects will operate smoother and easier. - Integrating BIM tools in sustainable construction aims to create a common language and a single standard between project participants. Single platforms could be achieved through single investments, which can be maintained through a single process. Common project utilities show a well-integrated system of design and execution, which can be economical for the project with lower changes of unwanted costs, whether in project initiation or completion.

The BIM attributes are the tools can be used through the implementation of BIM in the Lebanese construction sector. These BIM tools can impact sustainable development, by improving the construction process. The focus of these tools is to eliminate unwanted costs and re-evaluate the distribution of funds for more sustainable aspects. Cutting down on errors and mistakes, while facilitating the design and execution phase, will lead to more funds in sustainable sectors, such as improved simulations and integrations.

4.3.2 Social Sustainability

Construction projects do not have a lot of room for testing with trials and errors, that is why every construction project is regarded as a prototype with its own unique features. A key variable that impacts the project is the society that surrounds it and works with it. This variable of society could be a positive or negative influence on the project, for that reason social sustainability has become a concern when working the confines of a construction project. As a tool BIM does not have a direct relation with social factors, yet it holds the capability to improve social sustainability and the value of the project. In Lebanon majority of construction projects are done in the capital Beirut, which is also the highest rated in noise and air pollution. The point is that random construction in Lebanon has created an uneasy living situation for the surrounding society. As a result, BIM tools can improve the sustainable construction standards if applied correctly.

Similarly, to the above section, the following table will relate BIM attributes to the social sustainability impact. The following table focuses on eliminating cultural differences and create an organized environment for the BIM implantation process by improving awareness on sustainable construction and encourage the use of technological innovations. Customer satisfaction could be used as a method to measure social sustainability, since it focuses on delivering the best value for the society.

Table 8 BIM attributes for social sustainability

BIM Attributes	Social Sustainability Impact
Visualization	• Visualization has been identified as the most beneficial BIM tool, creating visual representations of the project, and aiding the decision-making process. Facilitating this process, assures director involvement and ensures better quality for the project. • Social sustainability improves the environment surrounding the project, and BIM offers an accurate site-layout, which can preserve the natural topography of the land. As a result, surroundings will not be affected negatively throughout the project lifecycle. • Moreover, through visualization, improving the site layout can increase security and safety throughout the project, making the environment more pleasant and increasing comfort.
Analysis and Simulation	• With BIM, running multiple scenario analysis has become simpler and more accurate. The fact that BIM tools can analyse detailed aspects of the construction project, offers the opportunity to redesign overlooked conditions of the project. • Eliminating noise pollution during construction and improving the overall acoustical performance are simple example of how BIM tools can provide additional comfort for the project and its surroundings. • By examining different site conditions, BIM tools can create a more efficient and sustainable atmosphere for any construction project, ensuring longer customer satisfaction.
Information management	• Information is the critical term in BIM, and for that reason the information provided throughout the project can influence the overall performance. The decision-making process does not only impact the project location and layout, it also aids in selecting less harmful material. • Effective choice of material can reduce pollution and hazards in and around the project, therefore BIM information could play a critical part when ensuring the stability of performance. • Using renewable resources will eventually reduce pollution and create a better environment for society.
Project integration	• BIM facilitates the integration of project information throughout the project lifecycle. Thus, making the work simpler and more efficient, and based on that, society finds BIM integration a key element for future projects. The ability to create a single platform for sharing information, will increase participation by all groups involved, thus creating a more pleasant work atmosphere, which eventually will result in a better outcome. • A collaborative process of work can create a long-lasting preserved environment, by simply involving all director in the project processes. Whether in the design or execution phase, constant communication

between all participants, as well as the surrounding population, can result in more sustainable project.

4.3.3 Environmental Sustainability

With such low awareness on the importance of sustainable construction, the Lebanese construction industry has been a major contributor to many environmental issues rising in Lebanon. Environmental sustainability's aims to reduce the consumption of natural resources today, in order to provide a more environmentally friendly future. Unfortunately, Lebanon lacks knowledge and awareness on the value and importance of sustainable construction or sustainable development in general. The issue is that Lebanon is not a naturally resource rich country, which means that they have limited resources with little flexibility and no margin for errors, otherwise the losses will be difficult to restore.

The Lebanese construction sector has taken an initiative towards green building development, and as initiated the concept of sustainable construction. However, they lack the technology and capability to execute the work as expected. Therefore, BIM might be the missing component for the Lebanese construction industry to evolve and develop a more realistic suitable development plan.

Environmental sustainability has to be carried out through the entire project lifecycle. Therefore, based on the information gathered from the case studies, the project lifecycle can be divided into three parts the design, construction, and operation phase. Each phase can focus on certain aspects of environmental substantiality. Along with the appropriate BIM attribute, that are similar to economic and social sustainability, environmental sustainability can be achieved as represented in the table below.

The table below shows that the design phase focus on design to achieve low energy consumption and selecting the appropriate construction material. While the construction phase focuses on minimizing carbon emissions and reducing waste generation. Finally, the operation phase highlights the importance of lowering pollution by improving on solar lighting and natural ventilation systems.

BIM attributes apply throughout the project lifecycle, therefore, through the visualization and 3D modelling capability of BIM during the design phase, environmental sustainability can be improved by facilitating the decision-making process to identify the appropriate contractors and suppliers that can execute the work, based a more complex low energy consuming system. Through BIM, more advanced design can be developed to attempt and lower energy consumption for the project, in addition, the designs can specify recycled material to improve the environmental situation in Lebanon. During the construction phase, BIM models can be used to develop a proper site layout, preserving the natural land and lowering impact on the natural built environment. In addition, proper site layout, could reduce waste generation, through proper storage and expert execution.

Table 9 BIM attributes for environmental sustainability

	Project Life-cycle					
	Design		Construction		Operation	
Green Attributes BIM Attributes	Low energy	Construction Material	Carbon emission	Waste generation	Solar Lighting	Ventilation
Visualization	Advanced design tools for with visual specs for daylight adjustment and reduced energy consumption systems	Facilitate the decision-making process and provide multiple suppliers with recyclable and non-toxic material	Proper site layout to lower for the efficient use of equipment.	Accurate site layout for proper storage of equipment and material to minimize loses	Benefiting from daylight adjustment to store heat and reduce energy consumption and improve thermal comfort	Creating designs to incorporate natural ventilation systems
Analysis and Simulation	Energy simulation and alternative methods of achieving better value with lower consumption	Accurate estimation for construction duration to minimize impact of material on the natural landscape	4D scheduling and simulation for a day by day progress report to lower excessive consumption of energy	Clash detection simulation to avoid unexpected errors and rework leading to destroyed material and excessive waste	Multiple scenario analysis using BIM tools to preserve heat and reduce dissipation and losses	MEP simulations for efficient and sustainable operation
Information Management	Access to information by all project participants for proper utilization and alteration to fit environmental standards	Benefiting from the existing information provided by the natural built environment to avoid misuse of materials	Contractors ease of access to information and supplies to reduce equipment energy consumption	Provide accurate BOQs and quantity measurements to avoid excessive material wastes	Preserved information for future alterations and rehabilitation works that might require the use of recycled material	Support facility management and effective maintenance work for future rehabilitation works
Project Integration	Collaborative design with multiple alternative scenario and effective participation	Larger supply chain with stakeholder involvement to facilitate the decision-making process	Working with low energy consuming material and equipment to minimize air pollution	Contractor's involvement and reuse of building material	Capability for different project participants to carry out the necessary work to insure thermal comfort	Collaborative work between different project participants to provide a clear and more efficient distribution system

During the operation phase, BIM designs are more accurate and realistic, therefore, BIM can use new characteristics that were not available before, such as daylight adjustment that can store solar heating instead of consuming energy, as well as, create an accurate ventilation system.

BIM has the capability to run different analytical models with different materials during the design phase, as a result optimal performance design could be achieved before the execution of the project. Even during the construction phase, BIM's simulation can be used for the optimal performance equipment performance. BIM's capability to provide an accurate execution of the project can aid in lowering energy consumption, as well as, carbon emersions, water consumption, and waste generation. Environmental sustainability is an on-going process and therefore requires constant modification through updating the performance with constant data analysis. As a result, the operation phase can continue to perform at optimum conditions with minimal environmental impact.

Information is the key to many of the BIM attributes. The information should be shared consciously throughout the project lifecycle. As information remains accessible, modifications can made to the designs and the natural ground can be preserved. As well as, accurate estimations could provide an overall performance index during the construction phase. As consumption of resources remains limited, environmental sustainability could be developed with continuous modifications. Even during rehabilitation projects, BIM information could be easily accessible and modified to fit the new project objectives without compromising the integrity of sustainable development.

Project integration throughout the project lifecycle remain the only sustainable element within the control of the project participants. Collaborative work can lead to improved quality and overall performance. Even during the operation phase, participant collaboration could maintain sustainable performance after maintenance, as intended the original design.

5. Theoretical Framework

Underlining the components necessary to implement BIM in the Lebanese construction sector, provide a clear path for adopting a strategy of BIM implementation. The roadmap created by these components, pave the way for a step-by-step execution plan for BIM implementation whilst evaluating its impact on sustainable performance.

The barriers represent the first component of the BIM framework. These barriers where divided into three categories economic, social, and environmental. From the information gathered throughout this research, economic barriers are the financial factors that are limiting BIM implementation in the Lebanese construction, such as:

- Lack of investment in technological advancements
- High initial cost for starting up with BIM
- Uncertainty and High risk when working in the low levels of BIM
- High training cost for new employees
- High employee salaries for worker familiar with BIM
- Low growth rate for the Lebanese construction sector
- Open transparency for contractors and project participants
- Low director involvement especially with company directors

Social barriers are the limitations resulting from people's perspective and acceptance of BIM in the construction sector. These barriers are:

- Reluctance to change and adopt new technology
- Lack of knowledge and awareness on BIM use
- Long learning process which employees do not have the patience for
- Low working force due to unfamiliarity with BIM tools
- Not included in the university curriculum thus the lack of knowledge
- Limited research shows lack of interest or development
- Lack of experience and skill does not push for BIM adoption

Environmental barriers are the limitations resulting from the lack of interest in sustainable and green construction. Barriers such as:

- Low awareness levels on the importance of sustainable development
- Lack of frameworks integrating BIM and sustainable development
- Limited environmental parameters to work within
- Lack of sustainable development tools
- Lack of standardization and regulation
- Lack of Green BIM and use of technology for Green construction

Nevertheless, introducing BIM in the Lebanese construction industry will introduce new tools and capabilities to mitigate these barriers and open new opportunities to manage construction projects differently. Tools such as:

- Visualization
- Design coordination
- Facility Management
- Integrated Site Layout
- Scheduling and Cost estimations
- Information Management
- Coordination and Collaboration
- Energy Analysis
- MEP System Modelling

Once these tools have been fully integrated in a construction project, the outcome will result in an improved sustainable project. Sustainability will be categorized based on the sustainability pillars. From economical perspective BIM will result in:

- Reduce rework levels
- Aid in selecting economical material
- Facilitate refurbishment projects
- Facilitate the decision-making process
- Reduce construction time
- Reduce cost of errors
- Clash detections
- Lower Operation cost

From a social perspective, social sustainability will improve by:

- Improving worker productivity
- Improving health and safety
- Improving visual aesthetics
- Facilitate access of information

- Enhance trust between project participants
- Facilitate participation and involvement
- Improve thermal comfort
- Improve surrounding environment and persevere the land

Environmental sustainability will be achieved through:

- Selecting sustainable construction material
- Improving HVAC system
- Improved solar lighting
- Reuse of construction material
- Lowering energy consumption
- Reduce air pollution
- Reduce waste generation
- Reduce noise pollution
- Reduce water consumption

Combining the barriers that limit BIM implementation with the appropriate BIM tools, will result in the desired outcome. As a result, the following figure shows economic, social, and environmental barriers that have been introduced to BIM tools.

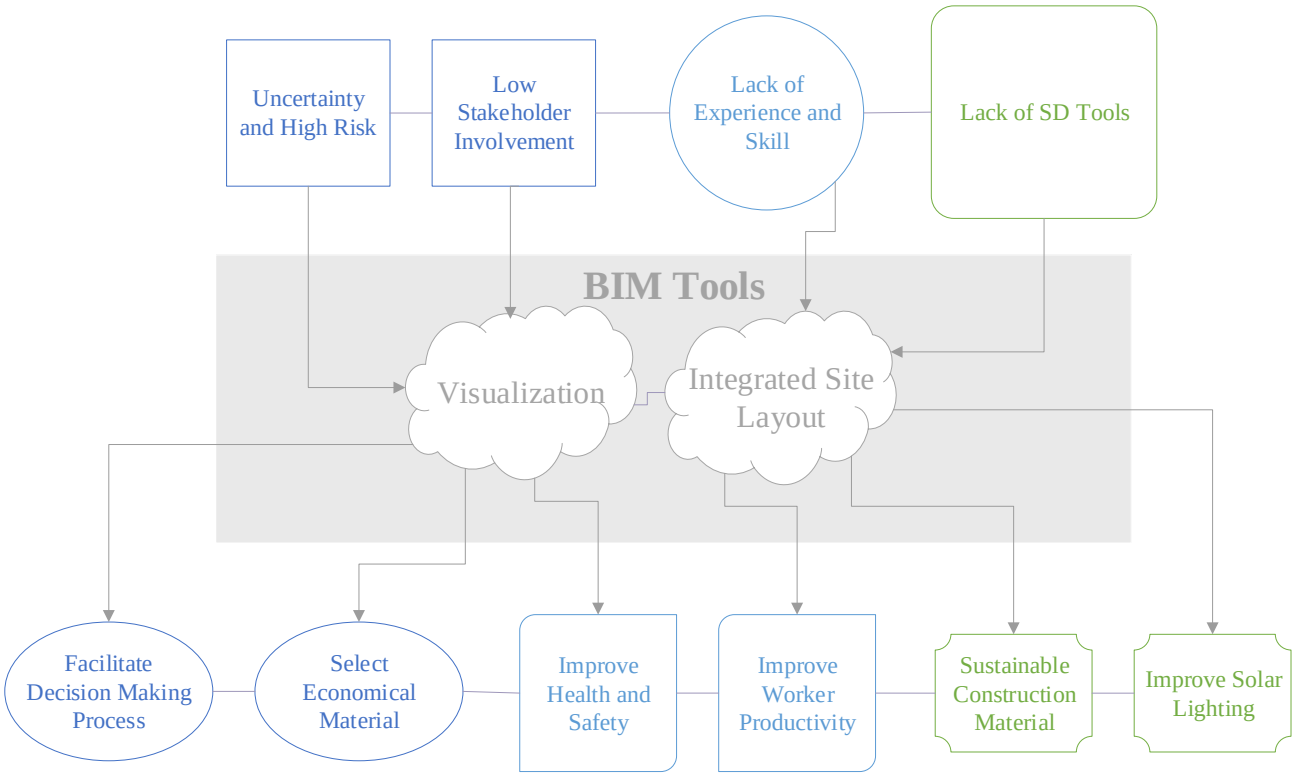

Figure 3 Function of proposed framework

Based on the figure 3 uncertainty and high risk, along with low director involvement are examples of economic barriers, while lack of experience and skill is an example of a social barrier, while lack of sustainable development tools is an example of environmental barriers. Combining these barriers with the appropriate BIM tools will create an alternative sustainable outcome. Visualization and integrated site layout are an example of BIM attributes that can produce a more sustainable result for the project. Once these barriers have been incorporated with BIM tools, the excepted outcome will show an easier decision-making

process and thus more economic selection of construction material. As a result, this will be an advancement in economic sustainability. While improving health and safety along with improving worker productivity are an example of social sustainability development, and finally improving environmental sustainability by selecting sustainable construction material, reuse of recycled material, and improving solar lighting.

The above figure is an example of specific economic, social, and environmental barriers that have been integrated with some BIM tools to generate a developed sustainable outcome from economic, social, and environmental perspective.

Combining all seven layers of economic, social, environmental barriers with the relevant BIM tools that will result in economic, social, and environmental sustainability with generate the desired framework as a guide for BIM implementation in the Lebanese construction sector as shown in the following figure.

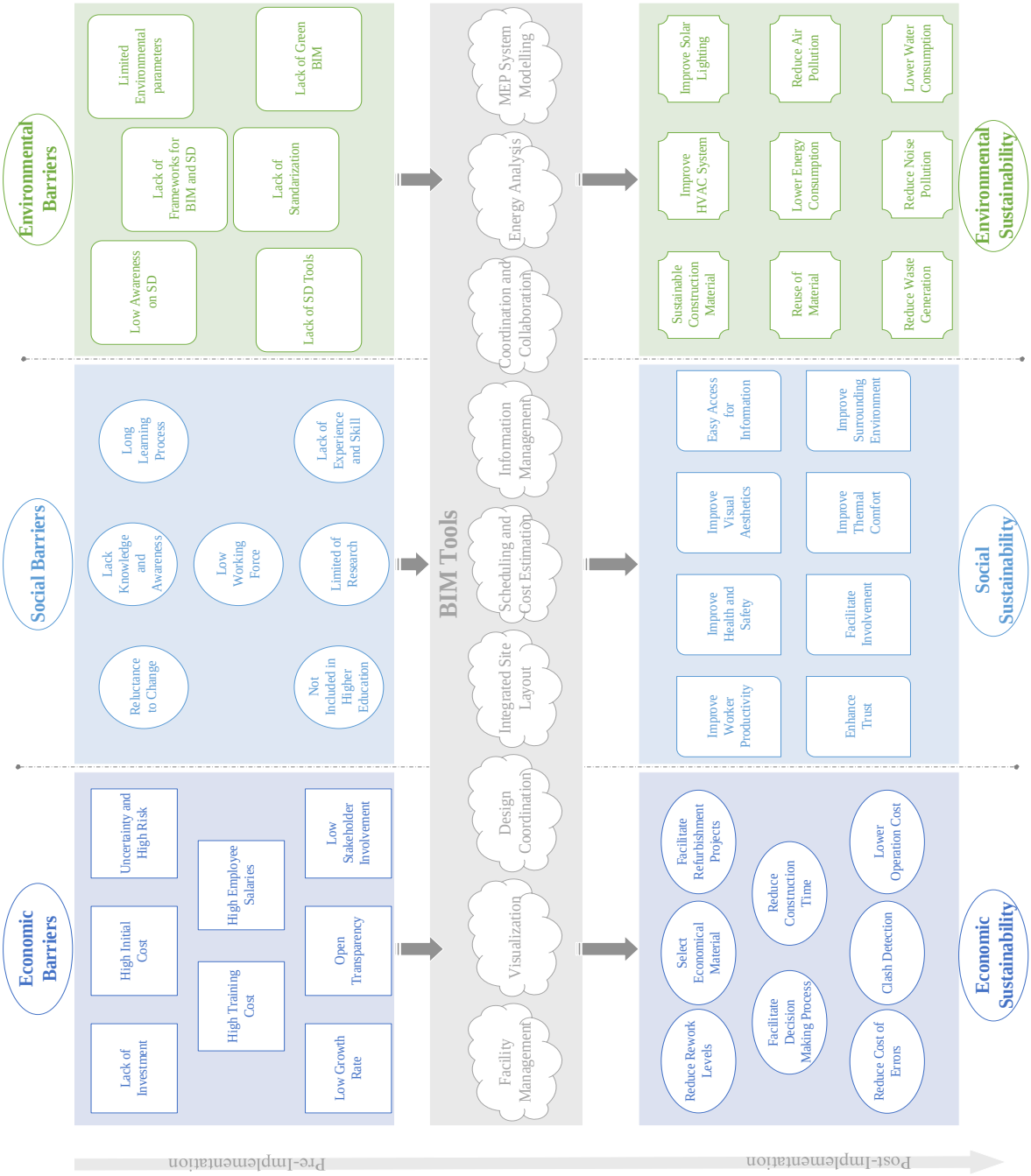

Figure 4 Proposed theoretical framework

The above figure 4 is a representation the theoretical framework developed by analysing the barriers that limit BIM implementation in the Lebanese construction sector, and identifying the BIM tools and attributes that can aid in overcoming and reducing the impact of these barriers, as shown in the figure this is referred to as the pre-implementation phase of the timeline. With the proper tools working to reduce the impact of these barriers, sustainable development can be achieving by incorporating these BIM attributes in the construction industry and focus on using them for the benefit of economic, social, and environmental sustainability. As a result, adopting this framework will aid sustainable development in the Lebanese construction industry by introducing BIM as a tool capable of doing so.

6. Conclusion

The research presented the following conclusions, first, BIM can be introduced as a revolutionary technology that can change the construction industry, however, very few countries have begun to implement it and use its full capabilities. Lebanon, a developing country, has yet maximize BIM's potential in the construction industry. Many barriers limit the adoption of BIM in the construction industry, thus rendering the Lebanese construction industry stagnant and incapable of growth. The low performance levels of the Lebanese construction sector have led to severe negative consequences from sustainable perspective, as a result, the growing population and over urbanization have over-used the available natural resources and destroyed the Lebanese environment. As a result, urging the need for change and adoption of new technology.

From previous literature, BIM shows promise when introduced in sustainable construction. This researched aimed to develop a strategy to implement BIM and explore its influence of sustainable construction. Based on this information, the analysis shows that BIM in the Lebanese construction industry, is still very primitive and people have little knowledge about the subject. In addition, companies also have limited knowledge on sustainable development, hence the low demand for BIM in construction projects.

The findings show that BIM barriers are a result of economic, social, and environmental issues which limit the implementation of BIM in the construction sector. This limitation, in return, dictates the outcome of the project. Sustainability can be divided based on its pillars of economic, social, and environmental sustainability. The fact that BIM barriers and sustainability pillar operate under the same categorization was used to introduce BIM tools that can limit the barriers and impact the sustainable outcome.

As a result, the research identified seven main components for the proposed framework of BIM implementation, based on participant knowledge and experience with BIM in Lebanon.

The categorization of the BIM barriers, based on the information gathered throughout this research, aided in developing a framework of the successful implementation of BIM.

The theoretical contribution highlights the key terms and concepts used in this research. BIM is a relatively new concept in Lebanon with limited research and knowledge about the topic, and the same can be said about sustainable development. Considering a research that joins the two topics together requires a thorough examination of the two topics.

The theoretical contribution focuses on increasing the knowledge of BIM and sustainable construction, hence highlighting the definitions of the terms and exposing the importance of addressing the issues related to the BIM barriers and negative consequence that result from lack of sustainable planning.

From a theoretical perspective, the research explains the definition of BIM, as well as, examines the role, benefits, and barriers of the topic in the Lebanese construction industry, which based on the existing literature, is very limited. The research shows the relation between BIM and sustainable construction in terms of technological advancement, which are currently missing in the Lebanese construction industry, thus prompting the need for further understanding and development on the concepts of BIM attributes and Green attributes.

The findings presented in this research, propose a theoretical framework for BIM implementation, can limit the barriers of BIM and achieve sustainable construction. The framework developed a link between the BIM barriers, the BIM tools, and sustainable construction, which companies could consider when implementing BIM in the construction industry. The significance of this research on theoretical knowledge is that it combines the little knowledge existing on BIM in the Lebanese construction industry, and the importance of achieving sustainable construction through a proposed theoretical framework of BIM implementation.

The practical contribution focuses more on the adoption of BIM for sustainable construction in Lebanon. Therefore, the research highlights the BIM tools that are currently being used by construction companies and discusses the BIM maturity levels for future development. The findings show different perspectives based on different levels of project participants and provides the experience of project members with BIM and sustainable construction. The distribution of BIM barriers into economic, social, and environmental barriers gives a practical understanding BIM's current operating levels.

The research shows that BIM capabilities can generate a new process of construction, focusing on improving the managerial environment, thus providing a new outlook on the construction process. In addition, the finding show that BIM adoption will improve the quality of design and execution which is directly linked to achieving a form of sustainable construction. The expected BIM benefits are starting to become clear in the Lebanese construction industry, as there is an increase for BIM-based projects on Lebanon.

The proposed framework draws a relation between BIM and sustainable construction, by identifying the barriers, tools, and outcomes.

The current state of BIM knowledge requires further development and a more hands-on strategy for implementation, which based on the findings in this research, were used to develop the practical tools for the development of the framework.

The research aimed on developing a framework for the successful implementation of BIM to achieve sustainable construction in the Lebanese industry. A challenging aspect of the research was the limited research on BIM in the Lebanese construction industry. Due to the primitive nature of the Lebanese construction industry, as well as, the low levels of awareness on BIM, carrying out this research presented limited studies on BIM in the Lebanese construction industry. The same could be said about sustainable development. Limited knowledge and practice of sustainability made this research limited on the relation between BIM and sustainable construction.

The Lebanese construction industry have recently begun the BIM implementation process. Many factors limit BIM's proper implementation, and many unknowns and variables remain a challenging aspect of BIM. Sustainable construction is the future of the industry, and companies worldwide are pushing the use of BIM. Nevertheless, in every industry there are challenges, barriers, and limitation which will hinder the use of technology.

The Lebanese construction industry is growing, and thus raising the standards of construction, so it is at this point that industry should improve its overall performance. Thus, future

research should further examine the implementation of BIM in the construction sector. This research focused understanding BIM and develop a relationship with sustainable construction in a qualitative research approach. Future research might consider a quantitative research method to quantify the BIM the rate of successful BIM implementation and BIM use in the construction industry.

This research shows that there is a relation between BIM and sustainable construction, where there are many factors that contribute to improving the sustainability aspect of the construction industry by introducing BIM in the construction management process. Future research could further investigate the internal and external factors that could further improve sustainable construction and focus more on the BIM tools that could aid in doing so.

Finally, a research for introducing BIM on Lebanese higher education could further raise the knowledge and awareness levels of BIM, as well as, train future generations to work with BIM and achieve better quality, since one of the key barriers found in this research is the limited knowledge and awareness levels of BIM and sustainability.

References

Alwan, Z., Jones, P., Holgate, P., 2017. Strategic sustainable development in the UK construction industry, through the framework for strategic sustainable development, using Building Information Modelling. J. Clean. Prod. 140, 349–358. https://doi.org/10.1016/j.jclepro.2015.12.085

Ammar, W., Kdouh, O., Hammoud, R., Hamadeh, R., Harb, H., Ammar, Z., Atun, R., Christiani, D., Zalloua, P.A., 2016. Health system resilience: Lebanon and the Syrian refugee crisis. J. Glob. Health 6. https://doi.org/10.7189/jogh.06.020704

Awwad, K.A., Shibani, A., Ghostin, M., 2020. Exploring the critical success factors influencing BIM level 2 implementation in the UK construction industry: the case of SMEs. Int. J. Constr. Manag. 1–8. https://doi.org/10.1080/15623599.2020.1744213

Awwad, R., Ammoury, M., 2013. Surveying BIM in the Lebanese Construction Industry. The International Association for Automation and Robotics in Construction (IAARC), Montréal, Canada, pp. 963–971. https://doi.org/10.22260/ISARC2013/0105

Berardi, U., 2017. A cross-country comparison of the building energy consumptions and their trends. Resour. Conserv. Recycl. 123, 230–241. https://doi.org/10.1016/j.resconrec.2016.03.014

Bou Dagher-Kharrat, M., El Zein, H., Rouhan, G., 2018. Setting conservation priorities for Lebanese flora—Identification of important plant areas. J. Nat. Conserv. 43, 85–94. https://doi.org/10.1016/j.jnc.2017.11.004

Chan, D.W.M., Olawumi, T.O., Ho, A.M.L., 2019. Perceived benefits of and barriers to Building Information Modelling (BIM) implementation in construction: The case of Hong Kong. J. Build. Eng. 25, 100764. https://doi.org/10.1016/j.jobe.2019.100764

Chong, H.-Y., Lee, C.-Y., Wang, X., 2017. A mixed review of the adoption of Building Information Modelling (BIM) for sustainability. J. Clean. Prod. 142, 4114–4126. https://doi.org/10.1016/j.jclepro.2016.09.222

Darko, A., Chan, A.P.C., 2018. Strategies to promote green building technologies adoption in developing countries: The case of Ghana. Build. Environ. 130, 74–84. https://doi.org/10.1016/j.buildenv.2017.12.022

Darko, A., Chan, A.P.C., 2016. Critical analysis of green building research trend in construction journals. Habitat Int. https://doi.org/10.1016/j.habitatint.2016.07.001

EIU ViewsWire, 2016. Lebanon economy: Quick View - Construction sector activity picks up - ProQuest [WWW Document]. URL https://search.proquest.com/docview/1807046351?accountid=27870 (accessed 4.6.20).

El Asmar, J.-P., Ebohon, J.O., Taki, A., 2012. Bottom-up approach to sustainable urban development in Lebanon: The case of Zouk Mosbeh. Sustain. Cities Soc. 2, 37–44. https://doi.org/10.1016/j.scs.2011.10.002

El Asmar, J.-P., Taki, A.H., 2014. Sustainable rehabilitation of the built environment in Lebanon. Sustain. Cities Soc. 10, 22–38. https://doi.org/10.1016/j.scs.2013.04.004

Elmualim, A., Gilder, J., 2014. BIM: innovation in design management, influence and challenges of implementation. Archit. Eng. Des. Manag. 10, 183–199. https://doi.org/10.1080/17452007.2013.821399

Fadeyi, M.O., 2017. The role of building information modeling (BIM) in delivering the sustainable building value. Int. J. Sustain. Built Environ. 6, 711–722. https://doi.org/10.1016/j.ijsbe.2017.08.003

Faour, G., 2015. EVALUATING URBAN EXPANSION USING REMOTELY -SENSED DATA IN

LEBANON. Lebanese Science Journal, Lebanon.
Fischer, D., Haucke, F., Sundermann, A., 2017. What Does the Media Mean by 'Sustainability' or 'Sustainable Development'? an Empirical Analysis of Sustainability Terminology in German Newspapers Over Two Decades. Sustain. Dev. 25, 610–624. https://doi.org/10.1002/sd.1681
Gerges, M., Austin, S., Mayouf, M., Ahiakwo, O., Jaeger, M., 2017. AN INVESTIGATION INTO THE IMPLEMENTATION OF BUILDING INFORMATION MODELING IN THE MIDDLE EAST Amr Saad BIM Implementation Consultant, BIM PROJECTS, Egypt; amrsaad@bimprojects.net Tamer-El Gohary Senior BIM and planning engineer, Journal of Information Technology in Construction (ITcon).
Gibbs, D., O'neill, K., 2014. The green economy, sustainability transitions and transition regions: a case study of boston. Geogr. Ann. Ser. B, Hum. Geogr. 96, 201–216. https://doi.org/10.1111/geob.12046
Hurlimann, A.C., Browne, G.R., Warren-Myers, G., Francis, V., 2018. Barriers to climate change adaptation in the Australian construction industry – Impetus for regulatory reform. Build. Environ. 137, 235–245. https://doi.org/10.1016/j.buildenv.2018.04.015
Issa, N.S.C., Al Abbar, S.D., 2015. Sustainability in the Middle East: achievements and challenges. Int. J. Sustain. Build. Technol. Urban Dev. 6, 34–38. https://doi.org/10.1080/2093761X.2015.1006709
Kamal, E.M., Yusof, N., Iranmanesh, M., 2016. Innovation creation, innovation adoption, and firm characteristics in the construction industry. J. Sci. Technol. Policy Manag. 7, 43–57. https://doi.org/10.1108/JSTPM-03-2015-0011
Kareiva, P., Watts, S., McDonald, R., Boucher, T., 2007. Domesticated nature: Shaping landscapes and ecosystems for human welfare. Science (80-.). 316, 1866–1869. https://doi.org/10.1126/science.1140170
Karunasena, G., Rathnayake, R.M.N.U., Senarathne, D., 2016. Integrating sustainability concepts and value planning for sustainable construction. Built Environ. Proj. Asset Manag. 6, 125–138. https://doi.org/10.1108/BEPAM-09-2014-0047
Khan, E.A., Dewan, M.N.A., Chowdhury, M.M.H., 2016. Reflective or formative measurement model of sustainability factor? A three industry comparison. Corp. Ownersh. Control 13, 83–92. https://doi.org/10.22495/cocv13i2p9
Lu, Y., Wu, Z., Chang, R., Li, Y., 2017. Building Information Modeling (BIM) for green buildings: A critical review and future directions. Autom. Constr. 83, 134–148. https://doi.org/10.1016/j.autcon.2017.08.024
Majdalani, Z., Ajam, M., Mezher, T., 2006. Sustainability in the construction industry: a Lebanese case study. Constr. Innov. 6, 33–46. https://doi.org/10.1108/14714170610710613
Mezher, T., 1997. Sustainable development strategies for Lebanon. Sustain. Dev. 5, 55–64. https://doi.org/10.1002/(SICI)1099-1719(199708)5:2<55::AID-SD68>3.0.CO;2-L
Nguyen, H.-T., Skitmore, M., Gray, M., Zhang, X., Olanipekun, A.O., 2017. Will green building development take off? An exploratory study of barriers to green building in Vietnam. Resour. Conserv. Recycl. 127, 8–20. https://doi.org/10.1016/j.resconrec.2017.08.012
Selçuk Çıdık, M., Boyd, D., Thurairajah, N., 2017. Innovative Capability of Building Information Modeling in Construction Design. J. Constr. Eng. Manag. 143, 04017047. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001337
Srour, I., Chehab, G., Awwad, E., Chong, W.O., 2010. Use of Sustainable Techniques in Lebanese Construction Industry. Second International Conference on Sustaibale

Construction Materials and Technologies, Ancona, Itlay.
Shibani, A., Hassan, D. H. & Shakir, N. S., 21 Nov 2020, The Effects of Pandemic on Construction Industry in the UK: Mediterranean Journal of Social Sciences. 11, 6, 13 p
Shibani,A.Pervin,M.2017 Analysis of traffic accident severity on Great Britain roadways and junctions .International Journal of the Built Environment and Asset Management 2 (1), 37-66
Stacks, R., Eastman, C., Lee, G., Teicholz, P., 2018. BIM Handbook, 3rd edition.
Ullah, K., Lill, I., Witt, E., 2019. An Overview of BIM Adoption in the Construction Industry: Benefits and Barriers. Emerald Publishing Limited, pp. 297–303. https://doi.org/10.1108/S2516-285320190000002052
World Development Indicators | DataBank [WWW Document], n.d. URL https://databank.worldbank.org/reports.aspx?source=2&country=LBN (accessed 4.7.20).
Yin, B.C.L., Laing, R., Leon, M., Mabon, L., 2018. An evaluation of sustainable construction perceptions and practices in Singapore. Sustain. Cities Soc. 39, 613–620. https://doi.org/10.1016/j.scs.2018.03.024
Yue, T.X., Zhao, M.W., Zhang, X.Y., 2015. A high-accuracy method for filling voids on remotely sensed XCO2 surfaces and its verification. J. Clean. Prod. 103, 819–827. https://doi.org/10.1016/j.jclepro.2014.08.080