T.C.
ISTANBUL GEDİK UNIVERSITY
INSTITUTE OF GRADUATE STUDIES

REALIZING THE DESIRED BENEFIT OF SUSTAINABLE CONSTRUCTION PROJECT MANAGEMENT BY WORKING ON THE APPLICATION OF BIM

MASTER'S THESIS

Oday Muwafaq Abdullah ABDULLAH

Engineering Management Master in English Program

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İSTANBUL GEDİK ÜNİVERSİTESİ
LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ MÜDÜRLÜĞÜ

Yüksek Lisans Tez Onay Belgesi

Enstitümüz, Engineering Management Department İngilizce Tezli Yüksek Lisans Programı 191281002numaralı öğrencisi Oday Muwafaq Abdullah ABDULLAH'ın "Realizing the Desired Benefit of Sustainable Construction Project Management by Working on the Application of BIM" adlı tez çalışması Enstitümüz Yönetim Kurulunun 27/07/2021 tarihinde oluşturulan jüri tarafından *Oy Birliği* ile Yüksek Lisans tezi olarak *Kabul* edilmiştir.

Öğretim Üyesi Adı Soyadı

Tez Savunma Tarihi: 27/07/2021

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DECLARATION

I, Oday Muwafaq Abdullah ABDULLAH, do hereby declare that this thesis titled as "Realizing the Desired Benefit of Sustainable Construction Project Management by Working on the Application of BIM" is original work done by me for the award of the masters degree in the faculty of Engineering Management. I also declare that this thesis or any part of it has not been submitted and presented for any other degree or research paper in any other university or institution. (27/07/2021)

Oday Muwafaq Abdullah ABDULLAH

DEDICATION

At the outset, I thank God Almighty, who bestowed upon me and helped me to submit this work without any help or power from me. I hope this work will be good for the community, I also extend my thanks, gratitude, and appreciation to everyone who contributed to this research by providing advice, advice, or information, In particular, the thesis advisor: Asst. Prof. Dr. Umut H. İNAN and the thesis Co-advisor: Prof. Dr. Abdul-Rahim I. AL-HADIDY For the efforts they made with me during their supervision of my writing of the letter, and I thank all my friends and acquaintances, Especially my colleague who gave me a helping hand and supported me, Engineer Muhannad Al-Touma.

The first to whom I would like to dedicate is my beloved mother who always supported me with everything she could, and her supplication who did not leave me throughout my life, and my beloved wife Hadeel Al-Bani, who was the best support for me in the course of study and all the efforts I made to complete this study, and for my beloved children Abdullah and Abdul Rahman, for their unparalleled encouragement to me, gave me a strong incentive to complete this study.

PREFACE

This thesis “Realizing The Desired Benefit Of Sustainable Construction Project Management By Working On The Application Of Bim” was submitted as part of completing the requirements for a master's degree in engineering management for the student Oday Abdullah.

July 2021 **Oday Muwafaq Abdullah ABDULLAH**

TABLE OF CONTENTS

Page

ABBREVIATION

AIA : American Institute of Architects
AEC : Architecture, Engineering, and Construction
BIM : Building Information Modelling
CAD : Computer-Aided Design
CPM : Construction Project Management
EISA : Energy Independence and Security Act
FM : Facility Management
5D : five-dimensional model
4D : four-dimensional model
GSA : General Services Administration
GIS : Geographic Information System
GSAS : Global Sustainability Assessment
GBA : Green Building Assessment
GBCA : Green Building Council of Australia
GBI : Green Buildıng Index
GBS : Green Building Studio
HQE : High-Quality Environmental
IT : Information Technology
IPMA : International Project Management Association
JGBC : Japanese Green Building Council
KM : knowledge Management
LEED : Leadership in Energy and Environmental Design
LCA : Life-Cycle Cost Analysis
PM : Project Management
PMI : Project Management Identification
QS : Quantity Surveyor
RFID : Radio Frequency Identification
RFI : Request for Information
7D : Seven-dimensional model
6D : Six-Dimensional Model
SFM : Sustainable Facility Management
3D : Three-dimensional model
2D : Tow-dimensional model
PMBOK : Project Management Body of Knowledge
USGBC : American Green Building Council
BREEAM : Buildıng Research Establishment Environmental Assessment Method
CASBEE : Comprehensive Assessment System for Built Environment Efficiency

LIST OF TABLES

LIST OF FIGURES

Page

REALIZING THE DESIRED BENEFIT OF SUSTAINABLE CONSTRUCTION PROJECT MANAGEMENT BY WORKING ON THE APPLICATION OF BIM

ABSTRACT

Sustainable construction has become popular in many countries of the world that are trying hard to reduce the use of energy based on oil and natural gas due to their high cost and significant impact on environmental pollution. Sustainable building is not a luxury, but rather one of the things that help create a clean environment as well as achieve long-term financial gains by reducing energy use and preserving raw materials that everyone is looking for, and this is a legitimate right for the present and future generations. Many experts and academics are proposing that BIM is a universal solution to fix the problems of the AEC sector.In the construction industry, BIM is the technological and coordinated development process that results in a modern, sophisticated, and informative representation (that goes beyond the idea of 3D representation) that allows stakeholders to efficiently design, build, operate, and manage construction projects. A comprehensive, sophisticated and trustworthy data source may be used to support better choices and reduce risks in sustainable building projects. Sustainable construction projects can provide a comprehensive, intelligent, and reliable data source to support better decisions and mitigate risk Subsequent early projects. This thesis examines the possibility of using modern technology represented by BIM to enable sustainable construction project management to achieve its desired goal of controlling cost, time, quality, environment, community safety, and comfort, particularly in the context of the construction industry through the effective use of the best available technologies and innovations to improve the sustainable construction industry. Thus improving the environment. In order to know this, theoretical research was conducted for the characteristics, benefits, and challenges of BIM and sustainable construction and their relationship with project management and their relationship with each other by searching in previous studies of scientific research, articles, research papers, and scientific conferences that pertain to the research elements in the first four chapters of the thesis, and that to know the strengths that help in achieving the goal of the research and the weaknesses that hinder achieving that goal. An electronic questionnaire was also conducted on these points, which was sent to engineers in the field of construction and project management with all their scientific specializations for the purpose of knowing the extent of the impact of these points on the management vocabulary of major sustainable construction projects such as cost, time, quality, environment, safety and welfare of society, and the results of the questionnaire were discussed in chapter five, where the final results obtained indicate that the use of BIM application increases the efficiency of sustainable construction project management, and that was through the conclusions and recommendations in the sixth chapter of the thesis.

Keywords: *Building Information Modeling, BIM, Sustainable construction projects, Management.*

SÜRDÜRÜLEBİLİR İNŞAAT PROJELER YÖNETİMİNİN İSTENİLEN FAYDALARINI YAPI BİLGİ MODELLEMESİ UYGULAMAI ÜZERİNDE ÇALIŞARAK GERÇEKLEŞTİRİLMESİ

ÖZET

Petrol ve doğal gaza dayalı enerji yüksek maliyetleri ve çevre kirliliği etkileri nedeniyle kullanımını azaltmaya çalışan dünyanın birçok ülkesinde Sürdürülebilir bina popüler hale geldi. Sürdürülebilir bina çok lüks olmayabilir fakat daha temiz bir çevre yaratılmasına yardımcı olur , enerji kullanımını azaltarak ve herkesin aradığı hammaddeleri koruyarak uzun vadeli finansal kazançlar elde etmeye sağlar ayrıca hem şimdiki hem de gelecek nesillerin meşru bir hakkıdır. Yapı bilgi modellemesi (YBM) son zamanlarda mimarlık, mühendislik ve inşaat (MMI) endüstrisinde geniş ilgi gördü ve , MMI endüstrisinin eksikliklerini gidermek için birçok akademisyen ve araştırmacı tarafından (YBM) kullanılması evrensel bir çözüm olarak önerildi. Yapı bilgi modellemesi (YBM), inşaat projelerini etkin bir şekilde tasarlamak, inşa etmek, işletmek ve yönetmek için bilgi açısından zengin, modern, son teknoloji (3D temsil fikrinin ötesinde) oluşturmak için teknolojik ve koordineli bir geliştirme sürecidir. Daha iyi kararları desteklemek ve proje risklerini azaltmak için kapsamlı, akıllı ve güvenilir bir veri kaynağıdır, böylece sürdürülebilir inşaat projelerini yönetmek için daha iyi bir model sağlar. Bu tez, sürdürülebilir inşaat projelerinin yönetimini, özellikle inşaat sektörü bağlamında, maliyet, zaman, kalite, çevre ve toplum güvenliği ve konforunu kontrol etme hedefine ulaşmak için YBM tarafından temsil edilen modern teknolojiyi kullanma olasılığını incelemektedir. sürdürülebilir inşaat endüstrisini geliştirmek için mevcut en iyi teknolojilerin ve yeniliklerin etkin kullanımı böylece çevreyi iyileştirmek. Bunu bilmek için, daha önceki bilimsel araştırmalar, makaleler, araştırma makaleleri ve bilimsel konferanslardaki araştırmalar yoluyla YBM ve sürdürülebilir inşaatın özellikleri, faydaları ve zorlukları ve bunların proje yönetimi ile ilişkileri ve aralarındaki ilişkileri hakkında teorik bir araştırma yapılmıştır. Araştırmanın amacına ulaşmasına yardımcı olan güçlü yönleri ve bu hedefe ulaşmayı engelleyen zayıf yönleri bulmak için tezin ilk dört bölümünde araştırmanın unsurları ile ilgili. Bu noktalar üzerinde, tüm bilimsel disiplinlerdeki inşaat ve proje yönetimindeki mühendislere, bu noktaların (güçlü ve zayıf yönler) büyük sürdürülebilir inşaat projelerini yönetme kelime dağarcığı üzerindeki etkisinin kapsamını bulmak için gönderilen bir elektronik anket de yapılmıştır. maliyet, zaman, kalite, çevre, güvenlik ve toplum refahı gibi bu elektronik anketin sonuçları tartışıldı tezin beşinci bölümde. Nihai sonuçlar, YBM uygulamasının kullanımının, tezin altıncı bölümünde yer alan sonuç ve öneriler yoluyla sürdürülebilir inşaat proje yönetiminin verimliliğini artırdığını göstermiştir.

Anahtar Kelimeler: *Yapı bilgi modellemesi (YBM), Sürdürülebilir inşaat projeleri, Yönetim.*

1. INTRODUCTION

1.1 General Introduction

Construction project management has become more difficult due to the increased complexity of these projects (Travaglini, et.al, 2014).

The intersection of interests and the large number of beneficiaries of that interest is the most difficult part of the project management process, besides that this administration is the most important and essential link between acceptance of the completed project and its occupancy and the requirements of clients. The project, its knowledge and skills, in addition to the techniques and tools necessary to design and present events to meet the perceptions and requirements of the project beneficiaries (Mwanaumo et al., 2015). Due to the continuous development in construction in all its stages, CPM is obligated to keep pace with and understand that development and modernity, in addition to knowledge of how to deal with safety and risk management in addition to contract management along with time management, cost and quality (Rokooei, 2015).

The method of producing plans, documents, and design data for projects in building and construction, and their transfer between the various parties of the project, whether workers in the project or the beneficiaries of it, witnessed a global transformation. The effects of this pattern of transformation show that the use of BIM technology and operations will increase in various fields such as simulation, collaboration, and other knowledge-based applications (Forgues, 2014).

Many experts point out that the implementation of modern technologies contributes to increasing the efficiency of managing construction projects is necessary as much as the need for information management in managing these projects (Boton and Forgues, 2018). On the basis of these data, it is important to integrate modern project management approaches. It is still better to focus on solving this problem, rather than dealing with it. As a matter of fact, BIM techniques and knowledge based technology are essential to solve this problem in practice. The increasing pressure on technical, environmental and social construction requirements is being placed on the sustainable building industry. There is an interlocking network of progressive technologies that support the achievement of this such as information networking and BIM.

For the most part, BIM and IT (or, more specifically, BIM and knowledge technology systems) are believed to have a positive impact on CPM performance. Long-term benefits include significant reductions in time and expenditures, increased economic, social and environmental standards, and project management in practice.

1.2 Search problems

The construction sector in most countries of the world is one of the most complex sectors and the least efficient in terms of adherence to pre-determined plans to complete construction within the constraints (time - cost - quality). The management of these projects is always criticized in the construction sector, which is known for its many diversities and problems.

The rationale for this, as explained by construction management scholars, is that construction projects are considered restricted projects, meaning that they have a definite beginning and end (Knibbe, 2009). In that specific period, a group of companies that have different goals and visions will contract temporarily to obtain the final product, which is the project, whether it is a building, a factory, or an infrastructure road. Then this partnership ends to the end of the project. This dispersed environment often results in many problems and conflicts before, during, and after the implementation of the project (Thomas and Yiakoumis, 1987). Many studies and articles have appeared that have dealt with this issue and seek to find a radical solution to it by improving the efficiency of project implementation, reducing waste, and increasing productivity at the lowest cost and highest quality. But design changes, delays, and cost increases remain. So where is the problem?

Below is a review of some of the problems in the design and implementation phases (Knibbe, 2009).

1.2.1 Design stage problems

1. Poor perception of the project owner and consequently the difficulty of understanding or imagining the final form of it and not fully understanding its requirements and desires in the early stages, so change orders are issued randomly and not considered to add or remove part of the project, which results in an increase or decrease in the materials used in addition Changes in the charts. This leads to delays and increases in the specific time and cost of the project.
2. The efficiency of the cost estimation process is decreasing for several reasons, including the semi-manual inventory of construction quantities. Which leads to inaccuracy and high error and omission.
3. Inaccuracy in determining the total project time due to the fact that the design process is carried out in isolation from the scheduling stage.
4. The lack of an efficient mechanism to ensure coordination between the plans in the event of changes in the design.

1.2.2 Implementation phase problems

1. Considering the contractor the last party to be included in the construction projects, which results in the issuance of a large number of inquiries during the implementation phase, or the so-called Request For Information (RFI), and a large number of inquiries is a clear indicator of two things:
    a. The design lacks all the information needed by the contractor to implement the project.
    b. Weak experience of the contractor in implementing some parts of the project, especially the modern, large, complex, and high-tech projects.
2. Poor coordination between the various project works and services and weak communication channels between the project parties. Consequently, collision points and overlap between works are not discovered except in the implementation phase, which results in an increase in the processing time that can be avoided in advance, which in turn affects the time period and the total cost of the project.

The world is witnessing development and acceleration in various fields, as it uses modern technologies and advanced technology that were not previously used. It has contributed to the acceleration of production processes and the development of the efficiency of the products used that suit the market requirements.

If we drop that on the construction sector, the nature of modern construction projects undoubtedly differs greatly from the nature of projects in the past, and the requirements of modern projects have become more complex than they were in the past, and therefore modern technologies that are appropriate for current projects must be adopted.

1.3 Research Hypothesis

The process of managing sustainable construction projects is one of the interactive processes that require effort in managing several different specialties with different levels of knowledge and experience, which means saving total time and cost, improving economic standards, and managing sustainable projects in progress. The main hypotheses of the research were laid out as follows: With the growth in the level of BIM implementation, does BIM have a positive impact on the efficiency of sustainable construction project management, and has the efficiency of sustainable CPM increased? Data were collected by means of a questionnaire. It is used for the comprehensive and faster disclosure of facts, attitudes, values, opinions, etc.

The researcher's hypothesis is based on studying each of the building information modeling and sustainable or green building and their relationship with each other and with project management to find out the benefits and challenges for each of them, and then take advantage of those details by comparing them with the data obtained from the questionnaire and knowing the extent of their impact on project management for sustainable buildings.

1.4 Research objectives

The research aims to study the impact of using BIM systems on sustainable CPM by providing a perception of the most important determinants of sustainable CPM and its relationship with BIM and determining the desired benefit from that. The key performance indicators were defined based on the scientific review of available research in this area.

1.5 Search tools

Research tools have been chosen that are consistent with and reinforce the work methodology, namely:

1.5.1 Theoretical study

The researcher conducted a scientific review to reach a level of satisfaction and confidence in the importance and usefulness of this research, by presenting several previous studies by researchers dealing with issues related to building information modeling systems and sustainable CPM and discussing methods of managing the changes that occurred during the implementation phase. The scientific background on CPM and sustainable building and building information modeling has come from the following:

Access to a number of publications and books that deal with these topics.

Access to research and published articles related to project management, BIM systems, and sustainable building (green).

See the BIM software package in general and the BIM software package related to sustainable building in particular.

Attending online educational lessons on the Internet dealing with the research topic.

1.5.2 Questionnaire

The researcher conducted a survey to validate the research hypothesis and as a supportive step for the search for factual information on the impact of using BIM systems in managing sustainable construction projects, the survey provided feedback from workers in the construction industry. It was distributed by e-mail and the web without personal interviews due to the Corona pandemic, and the questionnaire contained a brief definition of the BIM application and a request for the participants' cooperation and information for the purpose of research.

The main objective of sending the questionnaire was to correlate research data with theoretical studies on the impact of the use of BIM systems on the determinants of sustainable construction project management.

The questionnaire contained simple and understandable questions about the use of the BIM application and its impact on the determinants of sustainable project management in terms of saving cost and time, improving economic standards (revenues and profits), and improving management processes. (Respondents) used a Likert scale to estimate the extent of the impactb(1 - Strongly agree, 2 - Agree, 3- Neutral, 4- Disagree, 5- Strongly disagree).

The research sample consisted of engineers of all specializations and academics (managers of their projects). The research sample consists of the participants in construction projects (investor, contractor, designer). The questionnaire was released via the internet by sending the electronic questionnaire to the selected sample. A total of 135 participants were asked. The number of respondents reached 100 At a rate of 74 persentage everyone who answered was using BIM technology.

The statistical analysis of the collected data was done using the SPSS statistical analysis program, and the results were presented and discussed in the fifth chapter.

2. REVIEW OF LITERATURE

2.1 Background of Sustainable Development

The literature review presents the current state of research into 1; the use of (BIM) in construction and management processes, 2; the creation of commercial value with (BIM), and 3; potential methods of assessıng the business value of (BIM) from sustainability.

The construction process Participants face a constant challenge to present successful projects despite weak manpower, budgets and accelerated timelines, in addition to the problems inherent in waste issues, As a result of the AEC fragmented nature.

Project cost control approaches Adoptıng is the solution that the AEC building industry has wanted as well as the reasonable completion period of a project with efficiency and access to waste disposal (Azhar et al., 2008b), building Information Modelling is one such technique. (Azhar et al. 2008a) recorded BIM's recent broad involvement in AEC. Building management, structural analysis, and architectural design are 3 different stages with specific goals for the building engineering activity. Combining building with design practices is possible thanks to the abundance of IT in the sector of construction through integrating BIM technology and 4D (Zhenzhong et al., 2008).

In view of the differences in context, perception and expertise in the AEC field, it allows practitioners and researchers to describe BIM in diverse manners (Khosrowshahi & Arayici, 2012). BIM is an tactic to IT which may require, in the form of storage data, the management and execution of an integrated digital representation of the various stages of the project life cycle (Gu and London 2010). (Eastman et al., 2008) have on the one side asserted that (BIM) is a mechanism that enables representatives of the project team to gain a unique collaborative capacity, not only a method during the whole project from the original planning phases to execution and work. (BIM) is job closely linked to the management elements of work cultures and habits of various types (Ahmad et al., 2012).

BIM is the progressive development in the model (n dimensions) that was created through a computer and the use of that model for the purpose of simulating a facility design in addition to its construction and operation. That is, it is a process that takes place through-out life-cycle of the facility by practicing design in addition to virtual construction (Lorch, 2012).

BIM has rapidly risen to prominence in construction during the last decade because of the success of its collaboration practices The main reason for the industry's involvement with BIM was to provide them a shared communication channel for all contractors, manufacturers, and even for designers, and also on top of that for builders. Project members also use the plan to facilitate the circulation of ideas and information (Hergunsel, 2011). This allows for and adds to the flow of conversation by allowing separate team members to easily collaborate and for greater connection (Lorch, 2012).

There is a range of applications in BIM that are broad, from design to construction all the way to operation (Baldwin, 2012). For the development of the design process, BIM is important by managing the changes that take place in the design. It is effective in examining, developing and updating all proposals (plans, sections, elevations) when there are changes (CRC Construction Innovation, 2007). (BIM) promises major improvements in construction efficiency and quality (Ashcraft, 2008). Generally, in order to change the way that architects, engineers, professionals, contractors, and other building staff work in constructions, BIM is working on that day (Mandhar & Mandhar, 2013). One of the most important factors of BIM's benefit is that it represents, in an accurate engineering form, the parts of a facility in a data-integrate environment (CRC Construction Innovation, 2007). Buillding value can increase and project duration be reduced with improved facility maintenance and management, reliable cost estimates and ready-to-market construction achieved through the use of BIM (Eastman et al., 2011).

Achieving the desired benefit from the use of BIM can only be achieved through its proper implementation at the organizational level as well as its integration at the AEC level (Khosrowshahi & Arayici, 2012). When implementing BIM there are many problems that previous studies have shown in the fragmentation of the AEC-industry and this all correlates with the many different barreirs that represent an obstacle to effective BIM adoption (Mandhar & Mandha, 2013). Generally speaking, knowledge barreirs, process barreirs, technical barreirs, administrative barreirs, cultural barreirs, and legal barreirs may be a barrier to the non-accreditation of BIM in the AEC-industry in addition to barreirs that may prevent training and education (Löf & Kojadinovic, 2012).

The literature review presents the current state of research in 1; the use of BIM in construction and management processes, 2; the creation of commercial value using BIM, and 3; the assessment of BIM businesses with potential approaches from a sustainability standpoint. That is, it serves as a cognitive basis for the subsequent selection of possible concepts to answer the proposed research question and gives an understanding of the findings and current discussions on the topic.

The concept of builldıng information modeling (BIM) has been adopted in Building design, planning and construction, and interest in BIM is growing continuously (Brooks & Lucas, 2014). Through this development, the collaboration with models from various disciplines in Architecture, Engineering and Construction AEC is constantly improving and shifting towards integration into a digital environment including data about for example: land areas, buillding regulations, material details and consumption characteristics (Matarneh et al., 2019). Even if there were still challenges, it allowed for reduced schedule and budget overruns that made it possible to explore design options before starting construction, and to increase site safety (Brooks & Lucas, 2014).

In order to realize value from using BIM in operation and maintenance, a similar strategy has been proposed: define intangible value expectations (such as making better decisions, simplified processes, or better information about assets) and translate them into semi-tangible (for example fewer errors, Reduced budget / schedule or increased accuracy in forecasts) then tangible factors (such as reduced effort, cost, and time of operations), which can be measured in different ways depending on organizational capabilities and needs (such as return to invesment, savings on investment ratio or key performance indicators or with a process designation) . However, for an return to invesment analysis, it is difficult to consider intangible factors that are just as important to a company or project as tangible metrics. Another problem is that it can be costly and time consuming and there is no model or standard for calculating a return on investment (Hoffer, 2016).

Research also indicates that implementing BIM in the operational stage supports value creation and is beneficial for building maintenance (Cavka et al., 2017). However, integration lags here and the needs of owners and facility managers are often neglected when building the model during the design and construction phase (Matarneh et al., 2019). This leads to the possibility that BIM will not be fully exploited anywhere even though major expense in the life-cycle of the facility occurs during the operational phase, accumulating around 60 percent of the total project cost (Akcamete et al., 2010). In this context, the idea of a "digital twin," an accurate digital representation of physical possessions that can ultimately exchange information with a real-life, leads to many opportunities for more efficient construction (Brooks & Lucas, 2014).

In an iterative process, the measured values should then be compared to the business goals set at the outset to identify benefits and identify areas for future action (Munir et al., 2018). The appropriate selection of metrics in this process is strongly influenced by the operational level, i.e. strategic, tactical, and operational buillding s management (Parsanezhad & Song, 2016).

Although often considered one of the slow adopters of new technologies, the construction industry has begun to explore new approaches to design and construction to exploit the possibilities that come with a shift in mind-set and technological opportunities (Lindblad & Guerrero, 2020). Many stakeholders with different needs and disciplines are part of the projects and want to meet their demands for information and integration as building construction becomes more difficult and complex to manage (Lindblad & Guerrero, 2020).

The previous papers examined either methods for assessing the value of BIM in design and construction or in sustainable facility management (SFM) (AlFalah and Zayed, 2020). The paucity of studies that include a comprehensive approach in order to assess and maintain the operational value of BIM from an environmentally and economically sustainability perspective.

2.2 Understand the Concept of BIM

From a different point of view (Azhar, 2011) describing BIM as a robust modern technology that provides all-in-one 3D computerized engineering (CAD) functions and digitally creates an accurate virtual Building model. BIM has also been designated as a fundamental component of the required knowledge process transition during the built environment lifecycle (Causeway, 2011).

Several years ago, BIM was adopted as a popular standard, which continues to spread worldwide. This is a very exciting advance for the construction, engineering and architecture, and it may be the basis for a whole new market in the construction, design, and architecture industries (Stanley and Thornell, 2014). The potential of BIM operations continues to grow as it produces more efficient results, allowing us to do things that we would not otherwise be able to accomplish (Joannides et al., 2012). For many construction project delivery companies, BIM is the only type of solution capable of solving next-generation construction problems (Azhar et al., 2008a). The construction industry is moving from the old system paradigm to a new innovation paradigm, focused on scale and speed. Better and use PM tools, known as project machine modeling, aim to use digital modeling more efficiently (Nassar, 2010).

The concept of BIM is the development, use, and simulation of the structure and function of a facility through computer software modeling. The resulting knowledge Building model is a numerical description of the architecture and functional characteristics of an organization from which various usage expectations are taken into account. It acts as a shared source of knowledge of information about an organization and provides a consistent framework for decisions and supports communication between multiple parties involved in different stages of the life-cycle (Smith, 2007). The same concept occurred in (Gu and London, 2010), where (BIM) is an information technology methodology that involves the use and preservation of a comprehensive digital representation of all building details in the form of a data inventory for multiple stages of the project life cycle.

BIM has been described in a different way by (Dzambazova et al, 2009), and it is the handling of knowledge across the entire design cycle from early conceptual production through building management to facilities. For others, BIM is just a type of 3D computer modeling (Ellis, 2006). Eastman, in his BIM Handbook, treats BIM as a human practice, that is, a simulation more than an entity or an automated solution (Eastman et al., 2011).

RIBA indicated that BIM should be an acronym for "Building information management", while "BIM (M)" applies as BIM and information modelıng management (RIBA, 2012). However, it must be understood that BIM is not precisely described, but there are several ways to present what BIM is. (Khosrowshahi and Arayici, 2012) have agreed to the meanings of BIM by many professionals and organizations indicatıng their interpretations, histories and viewpoints, united in opinion with (Eastman et al., 2011) and (Hardin, 2009). Determined on the basis of the functions of the special method (BIM) (Abbasnejad and Maud, 2013).

In a more comprehensive concept, BIM can be defined as a way of using information technology to share, model, review, collaborate, and manage a hypothetical building model in the building life-cycle (Ahmad et al., 2012). (Smith and Tardif, 2009) united in opinion with (Hardin, 2009) they state that BIM is a pioneering technology in CAD that has changed architecture, research, development and building management. The BIM integrates all building materials with information that includes information about their production, pricing, supply, installation, labor cost, and maintenance service (Smith and Tardif, 2009).

According to (Eastman et al., 2011) BIM, is a technology that produces one or more virtual modeling techniques in digital form with precision that allows for improved analyzes and controls across construction phases rather than through manual methods. This computer model is ideal for use in the construction, engineering and procurement phases. BIM is a methodology that aids in planning and building homes. In light of these meanings, then, for the purposes of this analysis, we must consider BIM as an approach that involves the use of various techniques in order to collect, use and later share knowledge of the project. BIM can be described as a computer model that includes both textual data, graphical data, and tables. An Excel spreadsheet can be used for modeling, construction simulation and / evaluation. Organizations maintain and oversee the simulated building life-cycle (Ahmad et al., 2012).

According to several BIM reports, there is an urgent need to improve awareness and understanding (BIM) in the AEC industry. Lack of information about BIM has resulted in poor technology uptake and inadequate adoption management (Mitchell and Lambert, 2013).

Several studies, including those by (Khosrowshahi, Arayici 2012), (Elmualim and Gilder, 2013), have found that there is a low understanding of BIM and even its advantages. In the AEC industry. They also discovered that there is a lack of understanding of the financial significance of BIM in the corporate world. More specifically, there is a significant lack of knowledge of BIM (Basic Concepts of BIM) and its functional applications in the project life cycle. There is still a dearth of technological expertise required of practitioners in order to use the BIM program, and a loss of understanding of how to utilize the BIM program to aid in construction processes.

According to (Gu et al., 2008), BIM is widely mistaken. (Newton & Chileshe, 2012) observed in their research in South Australia that a large proportion of respondents had little or no knowledge of the meaning of BIM and that consumption was very poor. (Mitchell and Lambert, 2013) came to the same conclusion, claiming that Australians are not aware of BIM and its unique strengths in the construction sector.

In a dissertation conducted in Ireland by (Crowley, 2013), there was an exception. They were specifically related to the two volumes (QS) understanding and using (BIM). Survey results showed that 73 percentage of the sample (105 responses) were only aware of BIM but did not use it. 24 percent were aware of BIM but did not use it in their work; And only 3 percentage were not aware of BIM.

2.3 Application of BIM

Participants now focus on the productive function of new development projects in order to ensure the implementation of high-quality construction projects. Due to BIM's ability to foster partnerships across many disciplines, its use in the construction sector has risen in recent years. BIM may help speed up the production of information from a variety of simulations, which can then be used to define product development requirements and guidelines. Essentially, this ensures that BIM can be used to produce a variety of effective alternatives in project modeling. Instead of the two-dimensional (2D) image of the structure usually provided by computer aided design (CAD) drawings, the building knowledge model consists of the real assemblies of the building (Krygiel and Nies, 2008).

BIM capabilities enable seamless change from design to output, where knowledge gathering and decision-making take precedence over documentation and material handling. Through a collaborative approach, (BIM) encourages the functional processes and knowledge acquired by various disciplines, multiple organizations, and different project phases (Grilo & Jardim-Goncalves, 2010). As a result, time and money are saved, efficiency increases, and facilities generally become more functional (Suermann & Issa, 2009). BIM allows AEC building professionals to: 1; encourage distributed work processes for the multiple team members working on the same project alongside prototyping of the initial design stage; 2; Create highly realistic images and animations; And 3; integration of the (3D) model with cost-energy estimation and environmental modeling (Khemlani, 2007). (BIM) has the potential to integrate and adapt specific aspects of the AEC sector that are believed to be separate building functions (Krygiel & Nies 2008).

Owners may gain the following advantages from using BIM in a project: improved construction value, reduced project schedule, accurate and timely cost forecasts, program implementation, market ready infrastructure, simplified facility maintenance and management (Eastman et al., 2008).

As a result, BIM technology is being used in an increasing number of modern construction projects (Jeong et al., 2016; Ghaffarian et al., 2017). Arguments for BIM implementation focus mostly on cross-organizational coordination and the application of technology. BIM innovations offers, according to some scholars, a forum to initiate data change in construction (Roundtable, 2005; Yilmaz et al., 2019). On the other hand, others believe that successful applications (BIM) need a technological upgrade to match the operation of a dynamic building project. They also show that complex BIM technologies can be used in initially small areas. As a result, visualization and conflict analysis are the cornerstones of an effective partnership and they demonstrate the feasibility of using BIM for automated building design assessment. To aid the intuitive design instructions, different aspects of the effects can be visualized (Röck et al., 2018).

Scientists viewed the topic from the standpoint of technical implementation. The majority of these studies aim to examine and improve the integration of the BIM technology framework through enterprise networks (Shafiq et al., 2013). (Doan et al., 2019), for example, has conducted some studies aimed at eliciting the views of important New Zealand participants about green building implementation and its relationship to the successful partnership with BIM technology on Realistic Applications (BIM). In projects and the importance of integrating BIM and GIS in green buillding s. The results revealed that the robotic architecture could be improved technically to encourage BIM adoption within AEC (Wang, Pan and Luo, 2019).

2.4 Architecture, Engineering, and Construction (AEC) and Project Management

The different meanings of "project" do not lead to a common definition. A project, according to PMI, is a "temporary endeavor undertaken to create a unique product, service, or outcome" (PMBOK, 2013). The project is classified by "application of expertise, skills, resources, and techniques to project activities to meet project requirements" In this definition, project is defined as "application of information, tools, skills, and techniques to project activities to meet project requirements" (PMBOK, 2013). (Shenhar and Dvir, 1996), PM has been seen as an integrated method for conveying several disciplines and processes in order to create operational coherence within this assumption. In the field of PM, the prevalence of these two main concepts supports information sources in the scientific and social sciences (Söderlund, 2004). In AEC, PM interfaces have a large number of issues. AEC projects are becoming increasingly large and complex, and the vast amounts of data and knowledge generated from these projects can be daunting if not handled properly (Mok et al., 2017). Moreover, the project requires collaboration between people from different disciplines and the involvement of a number of stakeholders, and one of the most important roles for project managers is to organize interdisciplinary collaboration. When a project is large-scale and complex, the two problems collide. As a result, to deal with the instability and ambiguity of the project, an organized systematic strategy is needed (Atkinson et al., 2006). PM's progress may be ignited by searching for answers to new challenges from both technological and philosophical perspectives.

2.5 BIM in Construction Management

According to (Eastman et al., 2011) BIM, is "a human process that ultimately requires significant improvements in procedures in construction." Some researchers define (BIM) as “a set of interacting policies, processes, and technologies” (Succar et al., 2012), or “a digital representation of a buillding , an object-oriented 3D model, or a repository of project information” (Miettinen and Paavola, 2014). , As well as "the creation and use of numerical representations of the physical and the functional" (Miettinen and Paavola, 2014). BIM has been demonstrated in a number of ways, and consistent meaning may not be appropriate in all circumstances. BIM has been viewed in many papers as a term that includes meaning and method rather than underlying technology (Lu et al., 2014). By introducing various situations, such as business, organization, and mission, (Poirier et al., 2015) emphasized the profound regulatory influence of BIM. Through a comprehensive analysis that reinforced the various aspects of BIM, (He et al., 2016) described management research in BIM. In addition, (Chen et al., 2015) used a construct built from a similar literature study to correlate (BIM) with the construct method. (BIM) in the sense of software has been studied in many researches.

In the AEC industry, development is traditionally conducted as projects, and PM is commonly used to coordinate efforts throughout the AEC phase. (BIM) is a transformative technology that leads to hybrid practices in building information management and project construction coordination (Gledson, 2016; Davies et al., 2017). It is worth considering the ability of BIM to improve PM performance. In the same way, PM and BIM are important tools in the AEC method. They are used to increase the effectiveness of the management process, facilitate collaboration and teamwork for project participants, and improve project interoperability from a life-cycle perspective. Furthermore, since the BIM solution requires the delivery of simulated construction molds, and construction projects require infrastructure delivery, the potential for PM and BIM implementation integration should be explored.

The BIM value in PM is well known. Notably, BIM should be used to enhance knowledge processing performance in the beginning. BIM assists in enhancing communication, promoting interdisciplinary collaboration, and improving implementation of integrated projects as an integrated technology for knowledge processing (Azhar, 2011; Bryde et al., 2013; Porwal and Hewage, 2013). Moreover, since BIM is a process technology (Succar et al., 2012; Miettinen & Paavola, 2014; Murphy, 2014), it has the potential to influence project operations and achieve the model transition (Taylor and Bernstein, 2009; Froese, 2010; Azhar, 2011). On the other hand, the systematic deployment of BIM in AEC software remains a functional problem. Since it includes systematic processes for project organizations, policies and regulations, project integration (BIM) does present difficulties (Mancini et al., 2017). The use of BIM in projects has a minimum and is not widespread (Cao et al., 2014; He et al., 2016). BIM is designed to be an information and communication technology that integrates interdisciplinary collaboration across the project life cycle, but its advantages and feasibility have not yet been fully realized (Liu et al., 2017). Moreover, many countries have taken measures to enhance the use of BIM in public programs. Due to the stringent standards of government regulations; many projects use BIM only to comply with regulations rather than add value to the construction phase. Exploring an interactive approach to BIM and PM, focusing on the example above, appears to have enormous potential. Connecting (BIM) to (PM) provides new insights into the implementation of (BIM) in the sense of AEC projects and leads to the role of the study (BIM) in improving (PM).

The strengths of BIM technologies apply to building ventures, since each item plays the same roles and fulfills the same requirements, BIM technology's capabilities on construction projects correlate to the PMBOK areas. BIM technology is one of the most effective and versatile tools for PM in the building industry (Duncan, 2005) in this situation, there was a lot of debate regarding the BIM and PM incorporation process. BIM unifies the records, strategies, and efforts of all project participants. BIM is also an object-based environment that will categorize and break down various aspects of a building into different classes, similar to how project scope management works (Rokooei, 2015). Despite the broad scope of PM, BIM may be seen as a key and efficient term that corresponds to PM expertise fields. Specific views regarding the BIM have ignited some of the most heated arguments about its application. According to a study (Lahdou and Zetterman, 2011), the results of a building project would be unsatisfactory if project team participants may not really trust in the value of BIM and its benefits. According to a report, the performance of BIM on a building project is calculated by the project managers' degree of expertise. The advantages of BIM are equal to the users' degree of expertise (Qian, 2012). Another study identifies five topics that are expected to have an effect on the usage of BIM in PM in Canada. Canada was one of the first countries to use BIM (Willis and Regmi, 2016). Contractors and subcontractors work closely to calculate the expense and time performance of a building project using BIM in construction PM. Another collection of scholars offers a unique perspective on BIM and PM in the building industry (Travaglini, et al; 2014). BIM is more than just a piece of software. BIM stands for constructıng knowledge modeling.

It is a sociotechnical method, a mixture of technologies and social and institutional implications. It signifies a two-way partnership between PM and the customer, BIM can be viewed as a PM tool. BIM is a control and knowledge mechanism, according to the national BIM study and the BIM society. Relationship technology and project managers are other points of view. The project manager plays an important part in the planning process, and his actions and strategies have an effect on the project's outcomes (Ballard, 2000). The project manager is responsible for a variety of tasks, ranging from administration to team leadership. The success of the project is one of the reasons that the project manager needs a unique range of qualifications and competencies (Huemann, et al; 2007).

In the building industry, project managers must blend technological expertise with digital capabilities to ensure efficient collaboration and cooperation across multiple project members (Dainty, et al; 2005). Twenty technological competencies and elements, as well as fifteen behavioural competency elements, were described by the International PM Association (IPMA). It's a mix of interactive (including BIM) and so-called management skills (Caupin et al., 2009). One of the most often used techniques of building PM is the BIM tool.

This is particularly valid throughout the design stage. However, there are several other technologies that are related to or unrelated to BIM technology. Pressure on digitalization and the use of progressive knowledge-based technologies is one of the latest developments in the building sector. According to an international report, digitalisation in the building sector decreases costs and improves project bankability (Chakravarty et al., 2015). Many BIM apps and software are geared toward professionals. There is some ethical deformation within them, and some facts and methods are hidden. Users provided several knowledge sources. There are digital apps that allow use of smartphones and smart devices to gain further knowledge (for example, at the feasibility management and stage) (Schoolestani et al., 2015).

Any of this is accomplished by the use of an information management platform. The obtained data is used by the machine to provide improved performance in the future. Successful Information Management may further improve the exploitation and potential of BIM technology and other knowledge-based technologies. In conjunction with BIM technologies, knowledge-based technologies implie constantly managing all information to satisfy different criteria in an enterprise, and doing so using a progressive platform like BIM. It's a catch-all word for a broad spectrum of interconnected roles (Quintas et al., 1997).

In general, not just BIM, including all advanced technology, plays an impor-tant part in PM in the building industry. Both technology must be applied as part of a comprehensive approach (Kamara, et al; 2002). The advantages of BIM technology are many. Despite the fact that BIM is gaining widespread acceptance among architects and project managers for productive and successful design and construction management during the design stage, BIM implementation in operations during the post-construction stage is still in its early stages. One of the most important activities is knowledge management.

However, several information technologies have been designed to leverage the development of content, with the primary goal of application being knowledge exchange with text images only. The study suggests a modern management framework for project managers and engineers on building sites to enhance information exchange relevant to construction utilizing BIM (Jan, et al; 2013). BIM isn't the only knowledge-based application approach for building PM. One of the most relevant methods is BIM technology. However, the new digital era makes use of and provides other resources. In construction PM, it's critical to choose knowledge technologies based on so-called "levels of knowledge technology."

The procurement of products for individual building works is a common illustration of the first phase of knowledge-based technologies in construction PM. When choosing materials for a particular method (for example, plastering), the knowledge framework can display all of the materials required for the job. It is a fundamental approach to information technology. The second degree includes applications and technical solutions. A common example of building PM software is cost management software. Knowledge structures included further options for coping with particular material work and material problems in expense accounting and bill of quantities. Another collection of knowledge-based levels demonstrates cutting-edge modern and progressive technologies. Virtual and augmented reality, as well as machine learning, are all options. AR programs offer easy access to data and details, aiding project managers in evaluating corrective measures to mitigate costs and delays induced by performance differences (Bae, et al; 2013).

Technology advancements such as smartphones and mobile apps have created new opportunities for the growth and implementation of virtual reality in this sector. In this technology, construction PM has a big potential. Construction PM Applications and technologies that utilize a learning machine methodology are expected to see a wider demand for improved performance CPM. The biggest difference between a knowledge-based approach and a machine-based approach, according to experts and specialists in this area, is the data collection method.

More methodological methods are included in the learning approach, and the findings indicate new patterns (Bupe, 2016). Machine learning has expanded through several areas, influencing a broad spectrum of technologies including content exploration, data analysis, natural language processing, and information retrieval, among others. In the coming years, the application of machine learning in the building sector would be important. Internet of Things (IoT) software and solutions are manifestations of emerging technology. Smart buildings are one of these developments (Baranyai, et al; 2013).

In fact, BIM technology is focused on a low level of information technology. In terms of material structure, there are a number of questions to consider. The issue is characterized by a lack of cost knowledge. That is to say, changes in materials or configuration are not projected in the bill of quantities or expenditure. Many of these advances improve productivity (that means profit and revenues). After that, the key research topic is identified. What impact do these technologies have on PM efficiency in the building industry?

2.6 BIM in Sustainable Building

At present, there are many problems facing sustainable development around the world, including the inability to organize full life-cycle information and undertake data review to share with project members(Gourlis and Kovacic, 2017) .

(BIM) will manage and store energy use data for construction projects, as well as provide accurate work flow information during construction projects (Najjar et al., 2017). The BIM framework (Construction, 2014) allows users to quickly import, extract, search and transform data. BIM technology, through its visual properties, will help alleviate these limitations and achieve energy-saving goals (Ilhan and Yaman, 2016). As a result, it is important for consumers to ensure that the technology is actively used with green buillding , thus promoting sustainable global sustainability.

Several researchers have published numerous studies on construction sites, integrating BIM with sustainability assessment methods, including the potentially significant gains in integrating BIM technologies and sustainable construction (Gao, Koch and Wu, 2019; Liu et al., 2017; Pezeshki, Soleimani and Darabi, 2019). Several scientific articles have been conducted on the convergence of sustainable development and (BIM) in the past two decades.

No academics conducted analyzes. (Timothy, 2018), for example, looked at the significant challenges to building stakeholders while trying to integrate (BIM) and sustainable activities in the construction phase. Industry's aversion to shifting from traditional business methods, long coping time with new technology, lack of knowledge of the systems and workflows needed for BIM and sustainability are the three major barreirs (Olawumi et al., 2018). (Gao 2019) A study on the use of BIM technologies and the building energy model in the design process of energy efficient buillding s (Construction, 2014).

(Kota et al., 2014) focused on the use of (BIM) technology in the daily simulation of green building and evaluation of success based on a simulation study using (BIM) technology for sustainable buillding . (Wong and Zhou, 2015) presented a study of BIM implementation in sustainable design in terms of building life cycle.

(Lu et al., 2017) Examining the use of BIM for sustainable development throughout the life-cycle of a construction project. (Curry et al., 2013) Focus on the economic calculation over the life cycle, Process and implementation (BIM) and integration of life-cycle assessment. This approach will help convert project data more smoothly while still providing input for all tools. From a sustainable architecture point of view (Antwi-Afari et al., 2018) compared knowledge in BIM technology to actual applications in sustainable construction and discovered that implementing BIM would reduce construction costs and increase work performance.

2.6.1 What's the link between BIM and sustainability

Since BIM and sustainability are both recent cultural concepts in the AEC sector, their connection is only just beginning to understand its full potential. In an effort to provide the next step in improving its capacity with sustainability, (Krygiel & Nies, 2008) suggested several developments within (BIM), such as improvements in technical interoperability and inclusion with carbon accounting scale and weather information.

Designers must evaluate the building as a fully integrated dynamic development and development phase, according to (Holness, 2006), due to the movement in sustainability towards zero energy buillding s and reduced carbon emissions.

proposed has been combining BIM capabilities with life-cycle cost analysis (LCA) to perform carbon accounting by outsourcing the building materials plan and measuring operational energy consumption and carbon emissions using add-on software (BIM) (Stadel et al. 2011). However, as the market for both BIM and sustainability grows year by year, there is a need for more advanced and scalable platforms to maintain the current degree of achievement.

In an effort to grow in the current targets set by green building classification systems, sustainable efforts must be improved. BIM's capabilities should be expanded to integrate environmental science and enhance interoperability. In the future, technological advancements will help both sustainability and BIM set high expectations. On the one hand, AEC industry and customers must be able to incorporate these efficiency technologies into the quality of their operations. Moreover, the participants must be willing to collaborate with each other in order to obtain the best possible joint effort towards sustainable building projects.

2.6.2 Application of (BIM) and sustainable design

1. **Optimization of design:** According to the diverse workloads encountered by design team within the building sector, achieving optimum design is quite challenging. The use of (BIM) will greatly aid in the achievement of sustainable development by design optimization. The optimization is a process of finding the best options for a set of minimal success parameters (Wang, 2005). Due to Geyer (Geyer, 2009), optimizing a solution will contribute to better results and a greater understanding of design speed.
2. **Facility management (FM):** Involvement by FM towards the end of the building lifecycle has been standard practice in handing over facilities to clients (Azhar, 2011). (BIM) has proven to enhance architecture and development, and it is now beginning to grow into facilities management (Gleason, 2013). As opposed to the expense of planning and development, the overall lifecycle cost of running and managing a plant is greater. This is why construction firms are paying more attention to functional (BIM) expertise in order to run theır buildings more effectively. (BIM) in FM is relatively young sector, and there’re little ideas available. BIM's facilities operations efforts are mostly centred on a new construction (Kincaid, 2003).
3. **Delivery of integrated project:** Integrated PM is the method of getting every one of the partners, programs, commerce structures, and practices together to collaborate collaboratively and produce the best results possible by information sharing. Due to the building industry's adversarial and fractured existence, (BIM) has not been completely applied (Ilozor and Kelly, 2012). Assisting construction companies in order to reduce duplication, reduce prices and increase efficiency, are the goals for delivering the project in an integrated manner (Guide, 2007).
4. **Reducing the waste and the materiality needs:** The building sector has experienced a significant setback as a consequence of pollution, which has made the world unsustainable. In the building sector, inconsistency and unclear facts are the leading causes of errors and delays. As a consequence, explicit storage is needed to exchange project details amongst participants (Van Nederveen et al., 2010). (BIM) tackles the dilemma by ensuring that the correct knowledge is accessible at the right moment (Tolman, 1999).

5. **Integrative bio-climatic design:** We can define BIM as a tool that has the main objective of relating sustainable architecture to integrated design and the life cycle of a building (Bonenberg and Kapliński, 2018). Bioclimatic architecture, according to (Zr and Mochtar, 2013), is a biodiversity philosophy which addresses human and environment relation-ships throughout the design phase. The aim of bioclimatic architecture is to achieve optimum comfort while reducing energy usage and running costs (Yeang, 1996).
6. **Design for deconstruction:** Deconstruction's of design according to Crowther (Crowther, 2005), supports a variety of methods, including content recovery, recycling, and reuse. (BIM) is increasingly being integrated with technology like Big Data, RFID, GIS, and others (Ajayi et al., 2017). About the benefits of (BIM) in building industry, it is application at life's end is neglected (Akinade et al., 2015).
7. **Reducing costs when risk is reduced:** Since 5D (BIM) implementa-tion allows for project cost management, it is gaining big trust for construction stakeholders. The building industry has found the use of (BIM) to reduce danger in the construction phase (Ruikar, 2016). The history of (BIM) and technology related to (BIM) for risk control has been reported in a variety of studies (Chen and Luo, 2014; Hadikusumo and Rowlinson, 2004; Zhang et al., 2013). There have been several reports compared (BIM) and conventional approach of risk management.
8. **Enhance the timetable:** BIM like a computer image of a facility's functional and physical characteristics (Smith and Edgar, 2008). (BIM) technology most dependable applications for creating a 4-dimensional model from a 3-dimensional model over time-table. (BIM) 4D Modeling has an ability to boost not just the planner's and construction team's expectations, but likewise the preparation and scheduling phase (Barati et al., 2013).
9. **The built-in power is low:** Recycled and labour-intensive structure is described as sustainable when matter and power use during construction, occupation, upkeep, and demolition are measured (Moakher and Pimplikar, 2012). By integrating analysis (BIM) and tools for the seamless evaluation of building results, (BIM) offers a stronger opportunity for building analysis. (BIM) assists builders in using more safe products, such as those with a lower

embodied energy profile, in order to achieve sustainable architecture. Because of its favorable effect on the delivery of both quantifiable and unquantifiable content, (BIM) aids in the reduction of labor-intensive material selection.

3. BUILLDING INFORMATION MODELLING

3.1 Introduction

"Building Information Modeling" technique is one of the most recent in construction engineering knowledge, and it's an integrated application that compiles all project information into a single model. It is considered a central database that feeds all project parties and contains all project documents, whether they are plans, specifications, tables of quantities, or the timetable for the implementation of project work. It provides users with accurate, coordinated and available information during the project phases and all the functions necessary to complete the building through an electronic virtual model that simulates reality. These systems have become widely used by project parties during its life cycle, such as owners, designers, contractors and project managers, as shown in Figure (3.1).

The implementation stage is considered one of the most important stages of the project in terms of commitment to time, cost and quality.

Figure 3.1: BIM Life Cycle
Source: Jiang, X., (2011)

3.2 The Concept and Definition of BIM Systems in the Construction Industry

The National Building Information Model Standard ™ (NBIMS) defines (BIM) as "a digital representation of the functional and physical characteristics of the building (NIMBS Committe, 2007). It is considered a participatory knowledge resource for obtaining origin information, which is considered a basis for decision-making during the project life cycle, starting from the concept stage or preliminary study to the demolition stage." Electronically, because BIM systems are a process and technology used to create the electronic model.

3.3 The Definition and Potential of BIM Technology

Several studies and articles already attempted to describe BIM, resulting in ambiguity and lack of clarification across the word. Therefore, in this research, we will find an appropriate definition of BIM as a first step.

To describe BIM, (Siebelink et al., 2018) looked at a number of journals. They define BIM as "an object-based, multidisciplinary method aimed at promoting cooperation between partners and the aggregation of object related data across an asset's life cycle." This purpose is aided by technology, which allows for the capturing of Buillding objects in 3D representations.” This description is consistent with Succar's, which stresses that BIM more than just modelling applications.

BIM, according to Succar, is a "system of interconnected strategies, procedures, and technology that generate a methodology for managing critical design of Buillding and project Informa-tion in digital format over the life cycle of a building" (Succar, 2010).

If we analyze the acronym (BIM), we will find the following: 1; the product (all types of buildings and construction such as schools, homes, factories, houses, and towers, this also includes roads, bridges, and other various facilities); 2; the buillding operation Informa-tion (the availability of Informa-tion and data related to the type of Buillding and all of its constituent elements.

Each element has its own Informa-tion that we can program to define it as its entity in these programs and identify it through them); 3; a framework (a visual model of the attached Informa-tion and a live characterization of the properties of the elements help Informa-tional management, meaning function and collaboration business systems that enhance the consistency and efficiency of exchange, restoration, model enquiry, organisation, and maintenance) (NBIMS-US, 2007; Ahmad et al., 2012). The American Institute of Architects (AIA) also defined BIM systems as a Building Information Management as follows: a process that provides benefits that are evident through the electronic model, and includes centralization of information, visual communication of building elements, sustainability, and integration efficiency between various disciplines, quality control and site organization. And obtaining more accurate implementation plans. ” (Eastman et al., 2011).

The principle of building information modeling systems is based on automating project data from building elements, estimating costs, specifications, quantities of building materials, analyzing thermal loads, heating and cooling systems, construction loads, and others within a central database.

As the construction process needs to document all the necessary information in the fastest and easiest ways that ensure the quality of the outputs and the non-repetition of work. Thus, enhancing the use of electronic models in construction processes carries and returns to save time and money, reduce claims and raise construction productivity, especially in complex projects that have become difficult to control with the current methods.

The digital representation of the BIM equips the building, by default, with all its components and properties. Once the model is completed, we can obtain the necessary information to analyze the structure, build it and link it with time to get the fourth dimension 4D and link it also with costs to get the fifth dimension 5D, and the model is also used for facilities management during the 6D investment phase which contains all the project information, especially those used during the investment phase Such as product data, suppliers, manufacturers, the information needed for maintenance, specifications for items, specifications about details of mechanisms, for example, faults, and maintenance company information with a direct link, or for example programming water flow paths within pipes and directing them to backup paths when any problem occurs, etc.

Also, the application of environmentally friendly sustainable building systems has been reached in the seventh dimension 7D and also includes analysis of the building's thermal loads, material depreciation, global warming, and other environmental factors surrounding the building, also called Green BIM these dimensions are visualized in Figure (3.2).

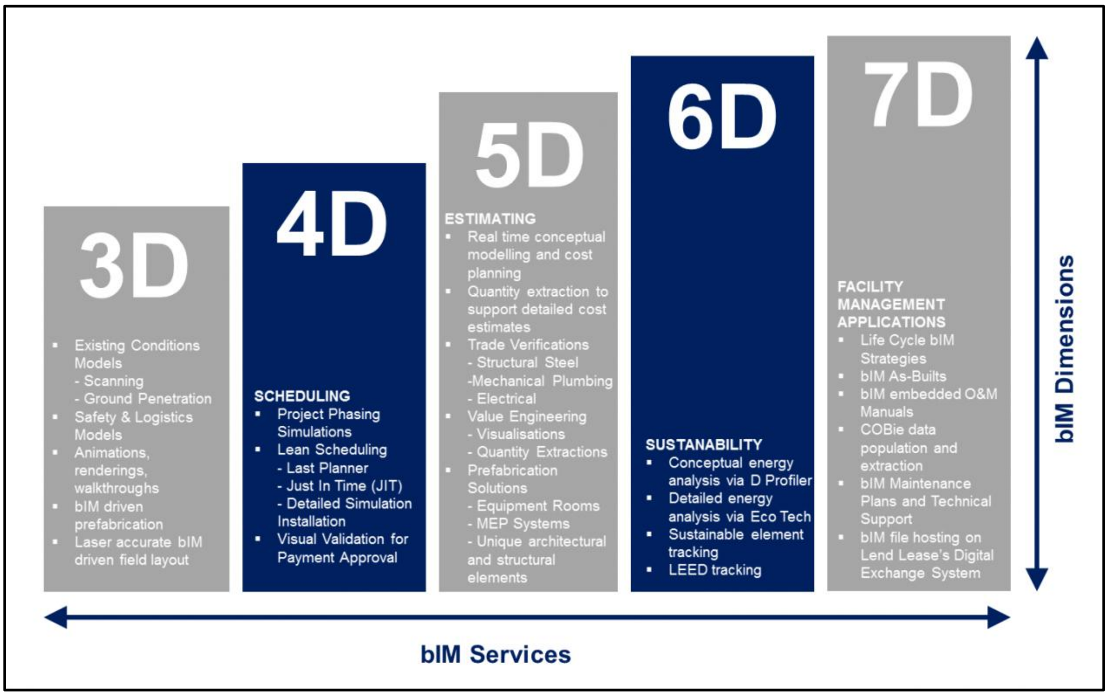

Figure 3.2: Green BIM Dimensions
Source: https://www.firstinarchitecture.co.uk/the-advantages-of-bim-and-its-future

The concept of dimensions has been developed with BIM systems to include all stages of construction during its life cycle with infinite dimensions nD (Ariño et al., 2012) as shown in Figure (3.3) for the development of BIM processes and tools compared to CAD systems. CAD was basically an iterative and partial automation of the manual drafting process when a large proportion of construction documents and shop drawings were prepared by computers rather than being drawn onto drawing boards by hand.

The development continued with the introduction of computer-aided design. Another generation of software solutions designed with current technology was needed to take full advantage of the features that information automation technology provides to the construction industry.

This next-generation information-centric software is provided by BIM Systems, based on CAD Systems. BIM can also be utilized for sustainability in Buillding process, as well as for other reasons such as task scheduling and optimization throughout the project's major phases, such as preparation, architecture, construction, repair, and operations. With BIM, a building's CO2 foot-print can be measured by taking into consideration the releases of CO2 by the building's structures and services (Tan et al., 2018).

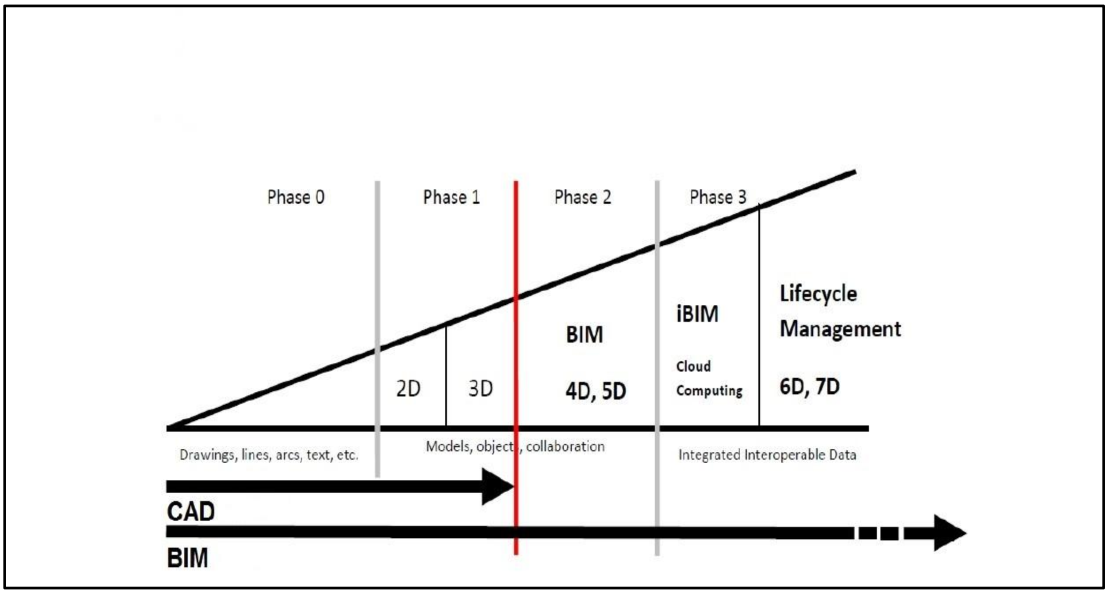

Figure 3.3: Development of BIM Processes and Tools Compared to CAD Systems

Source: Nisbet and Dinesen, (2010)

3.4 Parametric Modeling of BIM Elements Compared to CAD Elements

The possibilities of three-dimensional modeling were developed with computer aided design (CAD) tools at the beginning of the 1980's, but it was just a three-dimensional representation of the building with lines, circles and straight lines that were meaningless and lacked the ability to enter properties and components of physical elements.

Adding a gap between the three-dimensional model and the two-dimensional diagrams due to the lack of automatic linkage between them, so the concept of BIM systems was developed to reinforce the idea of parametric modeling, which defines building elements as elements that simulate reality in terms of dimensions, characteristics and components that make them.

3.4.1 Computer-aided Design (CAD)

The method of work in CAD systems is based on the representation of building elements through electronic diagrams, as the elements are an assembly of lines, arcs and circles to produce the desired shape. As the elements are easily categorized by layers with different properties of color and thickness, for example the windows are present with their own layer in a special color also to distinguish them from the rest of the elements. It is known that the architectural plans are the starting point for the work of the rest of the disciplines, and changes in them will be accompanied by changes in the structural, electrical, mechanical, health and other plans. In addition to estimating costs, quantities and the timeline. Using CAD systems, all of these changes will be made manually for each scheme separately, which takes a long time and is subject to errors and omissions. For example, a wall drawn using CAD tools has length, thickness and height, and any change in one of those dimensions requires the user to manually change all the elements associated with that dimension, including the quantities.

Consequently, the schemes in CAD systems are independent entities from each other, and the responsibility for modification rests with the designer, as modification in one of them requires modification with the rest, in addition to modifying costs, quantities and timelines, as shown in figure (3.4).

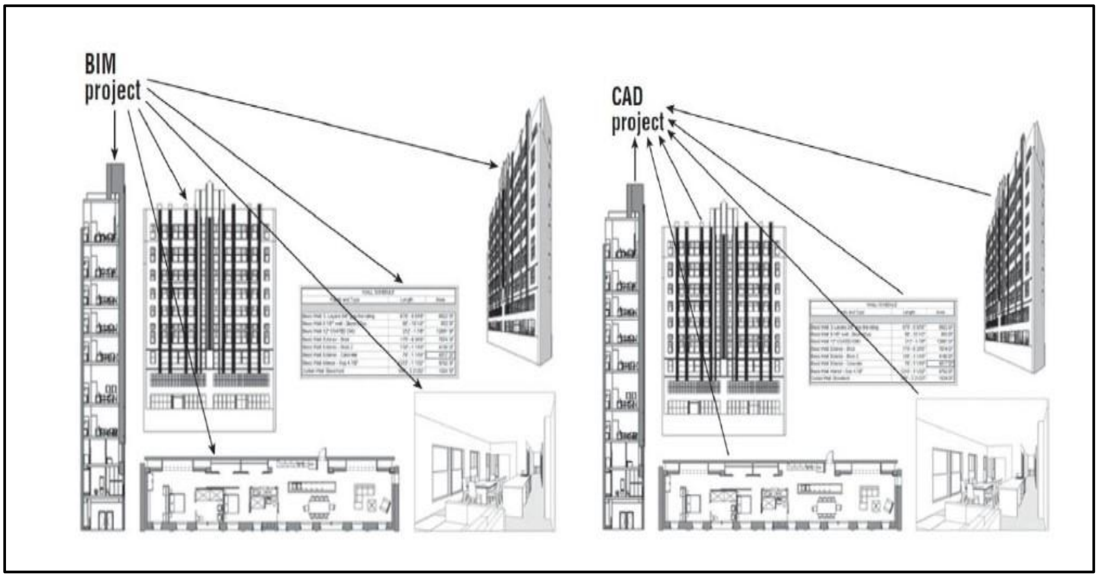

Figure 3.4: Modifying Costs, Quantities and Timelines
Source: Krygiel and Nies, (2008)

3.4.2 Building information modelling (BIM)

The elements in the BIM concept are represented by parameters and rules for connecting the elements together. Objects are known for their engineering properties (length - width - height ...) and other characteristics such as spatial and geographic information, component materials, code requirements, prices, quantities, manufacturer, supplier, and other non-graphic information.

Whereas, the elements are not distinguished by layers or colors, but are classified as named elements such as windows, and we can identify the properties of the window such as the component materials, specifications, dimensions and details of it. Which can be modified easily by changing the values within its properties instead of erasing, adjusting, enlarging and minimizing lines and curves by traditional methods. Whereas, the elements were classified according to the specifications of the Construction Institute (CSI or Uniformat) with rules governing the relationship of the elements between them (Vandezande et al., 2011).

These rules determine the mechanism of linking the elements or the extent of their convergence, parallel or orthogonality and allow the automatic updating of all the elements associated with the change in the design, and thus abbreviate Great effort and time and reduces the risk of omissions and errors that often occur by traditional methods, especially in large and complex projects, so we find that the linking process is very effective to avoid errors and save time and coordination between the plans as a whole, as shown in figure (3.4).

On the level of comparison, creating a project with the BIM system needs more time than the CAD system at the beginning of construction, but as a result of defining the characteristics of each element from the beginning, this will save a very large time when extracting all the documents and papers necessary to implement and finish the project, unlike the CAD system.

Since everything has advantages and disadvantages, when experts discovered the shortcomings of the CAD system, they thought and created the concept of BIM. For example, one of the drawbacks of the CAD system is that it does not discover drawing errors and problems except at the time of implementation, and also the difficulty of resolving conflicts during implementation because it hardly distinguishes between architectural drawing lines and drawing lines of conditioning extensions, for example.

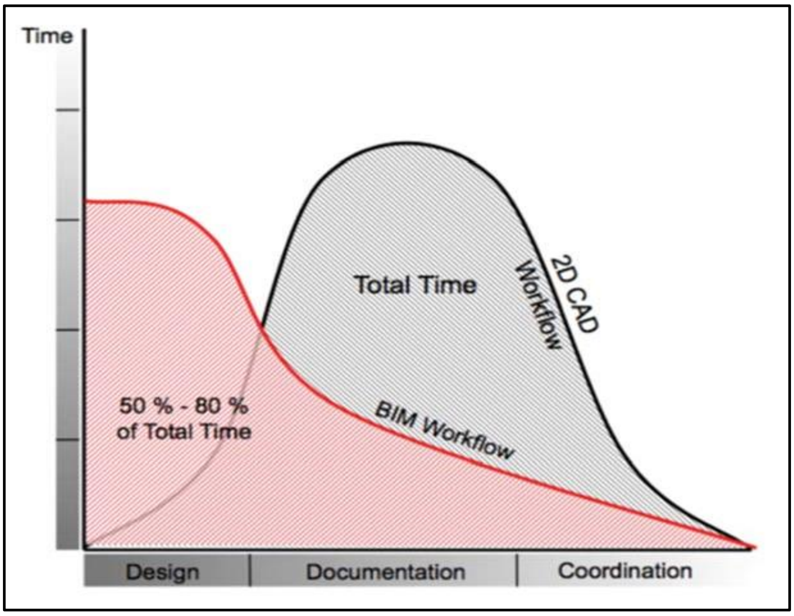

Figure 3.5: A Graph Showing the Time Used in the CAD and BIM Program

Source: https://cadeshack.com/what-is-bim/ aviable at 03/03/2021

3.5 The importance of BIM systems to project parties

BIM systems provide construction support and benefits to every part of the project. Figure (3.6) shows the effect of using BIM on each of the project parties during the building life cycle.

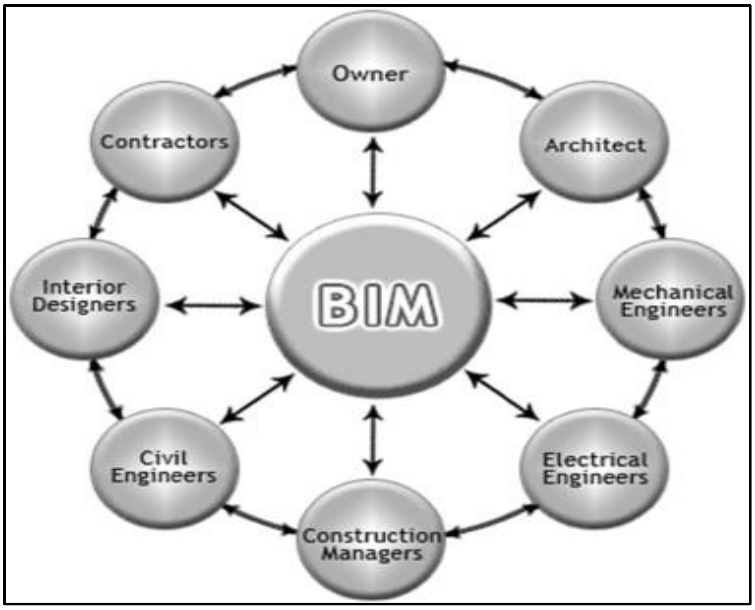

Figure 3.6: Effect of Using BIM on Each of the Project Parties

Source: Kubba, (2012)

3.5.1 Owner

The project owners evaluate the success of the project by achieving three factors (cost - time - quality). Upon researching the methods of delivery of construction projects, it was found that the (Design - Build) method is the best in terms of commitment to the time period and reducing costs and claims (Songer and Molenaar, 1997).

Studies have shown that the efficiency of the construction process is low through non-compliance with the three factors. A study conducted on construction projects in Australia showed that 67 percentage of the projects exceeded the estimated time of the project and 22 percentage of them did not meet the required needs, up to 10 percentage. And another study conducted in the United States of America showed that 45 percentage of the projects exceeded the cost by 5percentage. Also, a study conducted in Britain showed that 26 percentage of construction projects exceeded the cost and time limit by 5 percentage (Koskela, 2000).

It was found that BIM systems reduce the project completion time significantly through several studies and research, including the research that the researcher Kaner (Kaner et al., 2008) conducted a study on a project designed and implemented using BIM systems and compared with traditional work methods using the current systems, as it is by systems BIM A project block has been implemented in 23 days. With reference to traditional working methods, the time was estimated at 35 days. That is, 33 percentage of the time was saved. Whereas, BIM systems accelerate the design process by avoiding duplication of work and raising its level through fruitful cooperation between the project parties, thus avoiding conflicts and lack of information during the implementation phase. It is inefficient in traditional working methods using two-dimensional diagrams, through which work steps must be followed in an iterative sequence.

In order to assess the cost-effectiveness of reducing the cost resulting from the use of BIM systems, a large-scale comprehensive study (Kaner et al., 2008) was conducted, including six studied cases using BIM systems, which spent great efforts in evaluating their performance using BIM, and the results were as follows:

1. The high productivity of workers, which contributed to a time savings of 30 percentage – 10 percentage.
2. A significant decrease in change orders and requests for inquiries from the contractor, which became almost non-existent due to the reduction of conflicts and the reduction of rework cases.
3. Reducing the total cost of the project by about 7 percentage.

   Thus, the use of BIM systems will enable project owners to achieve the following (Eastman et al., 2011):

   a. Analyzing and comparing different designs, alternatives and materials used. This will enable the construction process to be improved Estimate costs and times early in the project.
   b. Automatic extraction of project information that is documented and accurate. For example, the construction quantities associated with the modelled elements and thus allow the owner to see his own changes and their direct reflection on the cost in the early stages and their impact on the total cost of construction.
   c. Project time has been reduced by coordinating different tasks and different building plans, which greatly reduces conflicts. BIM systems also contribute to reducing project time by using pre-fabricated components on a large scale due to the accuracy of the BIM model compared to current work methods.

d. Use of the BIM model during the investment and facilities management phase. And during the maintenance process of the building, by returning to the model, to suppliers, and by overlapping the various building elements. Using a BIM model during the design development phase enables the owner to demonstrate the effects of various modifications on the construction.

3.5.2 Designers

The use of BIM systems by the owner is mainly aimed at reducing errors, unexpected costs and wastage. Whereas design engineers often use BIM for large and complex projects when the use of 2D systems is not feasible (Kaner et al., 2008). Examples of this are projects of petrochemical factories, hospitals, commercial buildings and metal structures that need close coordination that the current regulations do not provide. Training is very important to the design team. And learning the basic functions of the program does not imply the efficient use of BIM systems. Studies have shown that good training increases design productivity. Which indicates that the rate of productivity during the use of BIM is closely related to good training (Kaner et al., 2008).

During a study of a power plant in the state of Wyoming, USA, it was found that by using BIM systems, approximately 20 percentage of the schemes, which require a number of working hours and costs resulting from printing and hard copying, were reduced (Bentley Systems, Inc., 2008). Also, with a study conducted on three projects designed with traditional systems, which were studied by building information modeling systems, it was found that engineering work hours and documentation of plans were reduced by about 58 percentage for two large projects and 21 percentage for the third project, which is the smallest among them.

As for fine electrical and mechanical work, it was found that BIM systems allow precise equipment and pipelines to be clearly and easily visualized and projected onto the drawings, thus reducing the working hours of workers by two and a half if the current systems are used (Bentley Systems, Inc., 2008).

We find that the trend towards adopting BIM systems is increasing in view of the significant productivity gains achieved by BIM, knowing that this adoption may take several years. Thus, the use of BIM systems will enable designers to achieve the following (Eastman et al., 2011):

1. Increase the quality of building plans.
2. Quality control is by verifying that the plans are correct and that there are no conflicts between the various building elements.
3. The ability to analyze and simulate construction is not possible with current methods.
4. The great interaction between the designer and the owner and achieving his needs through the model that illustrates the building and depicts it as it will be implemented in reality and thus will enhance the confidence of customers in the designed companies, as the owner, as mentioned in the previous paragraph, needs to study the different alternatives and their impact on cost and time, and this is what the designer will accomplish and thus BIM systems will open horizons. New and different ways of working for design companies.
5. Optimizing building maintenance in the post-implementation phase.

3.5.3 Contractors

Often contractors are interested in avoiding re-work for any reason, which would weaken productivity and increase the cost of the project.

We find that through smart models, we can increase the ability to carry out prefabricated works and many elements of the origin that can be accomplished outside the site, which increases the overall productivity rates because they are achieved in a more controlled environment, use of materials more precisely, and use more specialized and efficient mechanisms and equipment.

Through coordination and communication between the project parties in the early stages of the project, the contractors engaged in the planning and coordination processes for the construction, architectural and mechanical works, thus exposing the conflicts in the model, for example, (the competition of prizes with the ventilation pipes) and thus the change orders are significantly reduced (Smith and Tardif, 2009). Also, linking the three-dimensional structure to the time to obtain the fourth dimension enables the project to be organized more efficiently by determining the places for the mechanisms to be placed, their movement and the sequence of building elements and avoiding the problems of the work site.

By applying BIM systems to actual projects, the following results were obtained:

1. In Washington National Stadium, only 100 contractor inquiries were counted instead of 1000 inquiries the case for applying the traditional systems that usually result from this type of project. Only 2 percentage of the metal structures that are usually reached by current methods have been changed to 10 percentage for this type of projects of similar size, functions and complexity (Carbasho, 2008).

2. When building the GM plant in Toledo, Ohio, the 3D model was used to detect huge numbers of conflicts by collaborative work between different designers and a saving of 3 percentage -5 percentage of the total cost as a result of avoiding conflicts.

3. The productivity rates of the Camino MOB project in California, USA, have increased by about 15 percentage – 30 percentage, and change orders resulting from conflicts have completely disappeared. Only two of the contractor's inquiries regarding site coordination and organization were counted (Carbasho, 2008).

4. The Dubai Mall project in Dubai, implemented by CCC, was implemented using BIM systems, especially for calculating construction quantities, in preparation for the cost estimation process and monthly statements, which improved work efficiency and extracted 95 percentage of the calculated quantities automatically. And reduce the cost resulting from that process by 65 percentage (Bentley systems, Inc., 2008). Building Information Modeling systems provide implementers with only the required information without downloading additional information that makes the plans difficult to read. Whereas, a lot of data has a negative impact on the extent to which the schemes are understood, as is the case when the schemes lack the necessary information for the implementation process.

5. We find that the use of BIM systems will enable contractors to achieve the following (Eastman et al., 2011):

6. Obtaining detailed information for the building model, and the complete visualization of the building through the 3D model, as the model must contain all the building elements with all their information to enable the contractor to obtain any quantity or information about any element of the building.
7. Get information about temporary items such as templates used or equipment used through Implementation stage.
8. Detect inconsistencies during the early stages of the project and significantly reduce the number of inquiries and change orders.
9. Verify the analysis of the data performed by the structural designer such as structural loads, reactions, load structures, maximum moments, shear forces, and other data performed by the design team.
10. Evaluating the design and construction situation through the ability to compare the set plan with the actual implementation, as it enables the contractor to compare design, implementation and procurement.

3.6 Uses of BIM systems during the implementation phase

The first step in developing a BIM implementation plan is to define the uses of BIM based on the business and project requirements. The biggest challenge is to identify the most appropriate and feasible uses that indicate the usefulness of BIM systems, depending on the characteristics of the project, its objectives and the potential risks. There are many different tasks that can benefit from the use of BIM systems, including 25 uses which are a summary of interviews with experts in the construction industry (Messner et al., 2011) and through analysis of case studies and reference to references. Its importance has been identified and given by the Research Group of Computer Integrated Engineering Design at the University of Pennsylvania in the United States of America, The Pennsylvania State - Computer Integrated Construction Research Group University, illustrated as follows:

The following is a description of the uses of BIM systems during the implementation phase:

3.6.1 Construction site modeling

The process by which the project team proposes a construction model from the terms of the construction site and surrounding facilities. This model can be developed in multiple ways: including laser scanning and traditional scanning techniques, depending on what is required and what is most effective.

Benefits from using BIM in construction site modeling.

1. Availability of metrological investigations for future uses (everything related to general site conditions).
2. Provides an accurate representation of the construction site and its surroundings.
3. An initial concept of the site that is useful during the initial study phase of the project.

3.6.2 Estimating construction costs

Description BIM systems software are used to obtain accurate building component quantities and cost estimates over the project life cycle. This process allows the team to know the impact of their changes on the project cost during all its stages, which can help reduce excessive budget overruns due to project adjustments.

Benefits of using BIM in estimating construction costs

1. Determine the exact resources required.
2. Get quantities quickly to aid decision-making early in the project.
3. Obtaining cost estimates at a faster rate than current methods, especially for the owner, during the design phase and the length of the project's life cycle, including changes during the construction process.
4. Better visual representation of project elements through available high-quality visual technologies.
5. Saving the time responsible for estimating costs by saving time for calculating quantities.
6. Allows the cost estimator to focus more on other activities and tasks such as risk cost analysis, which would lead to high quality cost estimates.
7. Developing the cost estimation process by introducing time as an additional dimension with cost (5D), which helps track the cost path during the implementation phase .

8. An efficient representation of the alternatives, taking into consideration the project budget. Resources required.

3.6.3 Project timeline planning - Phase planning - 4D Modeling

It is the process in which the three-dimensional model is used with the addition of time as a fourth dimension in order to visually verify the sequence of construction stages and the requirements of the general site, and it is a powerful visualization tool that leads to effective communication for the work team, including the owner, which provides a better understanding of the project phases and the construction plan.

The number of tasks on large projects may run into the thousands, as the increase in the number of tasks is inversely proportional to an understanding of the timeline.

Benefits from using BIM in project timeline planning

1. Provide a better understanding of the schedule, especially by the owner and project participants, and represent the critical path for it.
2. Better organization of the project and direct solutions to any conflicts in the movement of mechanisms, workers, places of storage of materials and roads surrounding the project. On site before starting the implementation process.
3. Integration of material, human and equipment resources into the 3D model, better timeline planning and more quality pricing.4.Enticing the customer through the ability to represent the elements with time and roam the electronic building.
4. Better control over purchases.
5. Increase productivity and reduce waste in site work.
6. Communication between the project parties, by photographing all the tasks of the implementation phase.
7. This contributes to the communication of the project parties and the site work team alike. And clarify the mechanism of implementation of complex activities.
8. Avoid errors that may occur in the timeline in terms of the logic of the sequence of tasks or omissions in some of them.

9. Analyze the progress of the work by comparing the basic chart with the actual timeline using-up with dated 4D, the user can determine whether the project is in line with the set plan or not.

3.6.4 Coordination and Conflict Detection 3D

Description BIM systems are characterized by tools that facilitate the detection of conflicts between building elements during the process of coordination between different models from all disciplines to determine the field of conflict, if any. A situation where the shop plans are not updated may result in incorrect construction of certain parts of the building.

It is expensive and may take extra time, especially for critical tasks. Control of collisions large and small is one of the most important features of BIM systems. We mean by large conflicts, that is, when the building elements are placed in the same space (such as the collision of the ventilation tubes with concrete tiles), and small conflicts are when the building elements are closely related to each other, which prevents access And created.

Benefits of using BIM for coordination and collision detection

1. Coordinate the building by integrating 3D models and providing visualization of all building elements.
2. Limiting conflicts that reduce change orders and reducing the lack of information needed for the implementing agency
3. Thus reducing claims.
4. Increased productivity
5. Get more accurate execution charts

There are two main methods of conducting monitoring and conflict control through the BIM model:

1. 1.Control of conflicts through BIM tools: Major software developers often incorporate software collision detection tools to enable them to be controlled during the modeling process. But this method can be cumbersome for the contractor, as he needs to integrate several models from various disciplines.

2. 2.Control of conflicts through separate software: This approach is used when each designer has modeled the elements of the origin separately, and then the user imports and merges those models and conducts the collision detection process. However, it must be noted that any modification made to the merged model is not reflected in the basic model unless it is tied to it. As the modernization process requires accuracy and caution, if the modifications are not properly reflected in the basic model, there will be conflict and lack of coordination with the building plans, and this leads to work delays.

3.6.5 Organization of the work site - site utilization planning

It is the process in which BIM tools are used to visualize both permanent and temporary facilities during the construction process phases. It can also be linked with a schedule to see the sequence of work activities. Additional information may be incorporated including labor resources, materials, delivery methods, and equipment location. Benefits of using BIM in organizing a job site:

1. Proficiency in planning sites for temporary and permanent facilities, collection and delivery areas for materials for all stages of construction.
2. Greater awareness of the sites and areas in the public site and the extent of temporal and spatial conflicts.
3. Careful planning of the construction site for public safety.
4. Reducing time wasted in site planning and planning.

3.6.6 Building construction technology

3D Control and Planning (Digital & Construction System Design Layout) The process in which the BIM model is used to design and analyze methods of implementing complex building parts (methods of installing concrete formwork - methods of installing glass facades - support systems for excavation ...) Benefits from using BIM in building construction technology;

1. Increased portability of complex parts of the building.
2. Increasing construction productivity.
3. Increase public safety awareness on site.
4. Breaking down the linguistic barriers between the parties to the project.

3.6.7 Digital fabrication

The process by which digital information is used to facilitate the digital fabrication of construction parts. Digital fabrication can be used to manufacture metal structures, tubes and other elements.

The benefits of using BIM in the digital manufacturing process

1. Ensure the quality of manufacturing.
2. Reducing the values of tolerances for component parts within the programs of manufactured mechanisms.
3. Increase manufacturing productivity and safety.
4. Reducing the project delivery period. Efficient application of design changes with subsequent stages.
5. Reduce your dependence on 2D diagrams.

3.6.8 Documenting building information - record modeling

Building information and modeling documentation is an accurate description of the conditions surrounding a structure and the elements of origin? Which should contain, as a minimum, information related to the architectural, structural, mechanical, electrical and health elements, which is the culmination of BIM modeling in all project phases, including the operation and maintenance phase of the existing structure (originating from the design process, implementation, coordination and linking with schedules, automated manufactured elements and construction details in general to provide a model An integrated standard for the owner, it also includes information about equipment, space planning and general location in case it is necessary for the owner to use it in the future.

Benefits of using BIM to document building information

1. Helping to improve future designs - Archiving documents for future use.
2. The ability to obtain future data for the purpose of renewing or replacing equipment or building elements.
3. Provide the owner with an accurate model of the building, equipment and spaces within.
4. Ease of linking customers' needs to the building in terms of room areas, location and surrounding environment.

3.6.9 Other uses

At present, there are many software tools used to control the various operations of the project. Including cost control and system monthly purchases and statements etc. These processes depend on the information of the elements in the building, which is often prepared manually. This is considered tedious and prone to human error. Tracking purchases is made easier with BIM by linking the timeline with the 3D model. This facilitates tracking the progress of the project and the supply of the site in a timely manner and avoiding the delays caused by the inaccurate estimation of the times required for the supply.

By dividing the model into phases, we can hide or give the building stages colors according to the period of their completion. This facilitates knowing the required tasks in a specific time and securing the required needs of materials and purchases.

3.7 BIM Systems Software

3.7.1 Design software

1. **Surface design programs:** Surface design programs are not real tools for BIM systems, and they are models with a group of surfaces that give only a three-dimensional model and show the material of the cladding and the final shape of the building. Among those programs is the 3D max program and the Google SketchUP program. When building a wall, these programs do not distinguish more than a six-sided model, which is the same idea for any other model such as doors, ceilings and other elements .. We can even place a window anywhere, even in a vacuum. In short, the program does not distinguish the elements as they are, but rather only distinguishes them by numbers.

2. **Parametric objects smart design programs:** There are many smart programs, including Vico, Tekla, Graphisoft, ArchiCAD, Revit, Bentley, vectorworks, Dprofiler, Innovaya and other programs that support the idea of smart elements based on the fact that the modelled element mimics reality in all its dimensions, characteristics and components, during the construction of the model using smart software, if we try to place a window in a vacuum or in a place that is not suitable to receive the window such as a tile, the program

will prevent us from that. If we put the window in the wall, for example, it will allow that. This matter would severely affect two basic things, namely

a. Clash detection.

b. Quantities Take Off.

3. **The most important parametric design software:**

a. **Revit**: Revit, purchased from Autodesk® in 2002, is one of the most popular and widely used programs (http://usa.autodesk.com/adsk/servlet/pc/index?sitelD=123112&id=84792.63). The reason is due to the ease of dealing with the program's interface, in addition to the great compatibility with many programs, which makes work more integrated between the various disciplines. It includes a package of software, namely, Revit Architecture ™, Revit Structure ™, and Revit MEP TW. All software in this package supports different formats, including DXF, IFC, SAT, SKP, DGN, DWG, DWF AVI, ODBC, gbXML, BMP, JPG, TGA, TIF and others.

b. **Vico**: It features integrated tools belonging to the same company and works in one integrated environment. Which makes great interoperability between different applications. Especially tools scheduling and cost estimation. (http://www.vicosoftware.com/products/Vico_constructor_2008/tabid/84569/Default.aspx). The package includes the following software: Vico Control, Vico Estimator, Vico Constructor, .Vico Change Manager, Vico Cost Explorer, and Vico 5D Presenter.

c. **Bentley**: It is considered one of the leading companies in BIM systems and it produced its software in 2004 (Jiang, X., 2011) and its software package includes the following: Bentley Structural Modeler, Bentley Architecture, Bentley Building Mechanical Systems, Bentley Building Electrical Systems, Bentley Generative Components, Bentley Facilities, and Project Wise Navigator. All of these programs work in common during the life cycle phases of a building. The Bentley software package is compatible with many other software and for various types of projects such as road and infrastructure projects, transportation projects, bridges, treatment plants, water networks, and more. Supports various formats include IGES, STL, IFC, DGN, DWG, DXF, PDF, STEP and others.

d. **Tekla**: The Finnish company Tekla was founded in 1996. One of its most popular programs, formerly called xsteel, is Tekla Structures™ (Jiang, X., 2011). The program is robust in designing and analyzing metal structures. It is widely used for making metal connections and details for structures. The following formats are supported: IFC, DWG, CIS /2, DTSV, SDNF, DGN, and DXF. And it has a large capacity for collaborative work, it is possible to reach the number of users to about 40 users at the same time and synchronize files with the central file. But he needs a lot of training and high skill to take advantage of all the available jobs.

3.7.2 Analytical software

They are the tools that are linked with the design software by direct or indirect links in order to complete the work using 3D models like:

Navisworks: BIM, as it is the Navisworks manage™ program of analytical software within the tools used for several purposes, including

1. Link timelines to the 3D model to obtain on the temporal simulation of the building and seeing the 4D Simulation action sequence.
2. Integrating models from all disciplines and uncovering conflicts between the elements to avoid them before reaching the implementation stage.

The program is distinguished by its capabilities to deal with most of the three-dimensional files. Thus it has the advantage of strong compatibility between software. It is considered one of the tools that contribute most to improving building productivity due to its ability to detect all construction problems during the design stage. (Kymmell, 2010) Therefore, it is considered one of the important tools for the contractor especially. It is noteworthy that there are many software tools that are classified as analytical tools such as Robot™ Structural Analysis for structural analysis of the building, SKYBIM program for cost estimation and others.

There is many important BIM programs in various fields as shown in table (3.1).

Table 3.1: BIM programs in various fields

Architectural programs	“Autodesk Revit Architecture Graphisoft ArchiCAD Nemetschek Allplan Architecture, Gehry Technologies – Digital Project Designer, Nemetschek Vectorworks Architect, Bentley Architecture, 4MSA IDEA Architectural Design (IntelliCAD), CADSoft Envisioneer, Softtech Spirit, and RhinoBIM (BETA)”
Construction programs	“Autodesk Revit Structure, Bentley Structural, Modeler, Bentley RAM, STAAD and ProSteel, Tekla Structures, CypeCAD, Graytec Advance Design, StructureSoft Metal Wood Framer, Nemetschek Scia, 4MSA Strad, and Steel Autodesk Robot Structural Analysis”
Electromechanical, HVAC & sanitary programs	Autodesk Revit MEP Bentley Hevacomp Mechanical Designer, 4MSA FineHVAC + FineLIFT + FineELEC+ FineSANI, Gehry Technologies – Digital Project MEP Systems Routing, and CADMEP (CADduct / CADmech)
Simulation, research and conflict resolution software	Autodesk Navisworks, Solibri Model Checker, Vico Office Suite, Vela Field BIM, Bentley ConstrucSim, Tekla BIM Sight, Glue (by Horizontal Systems), and Synchro Professional, Innovaya
Sustainability programs	Autodesk Ecotect Analysis, Autodesk Green Buillding Studio, Graphisoft EcoDesigner, IES Solutions Virtual Environment VE-Pro, Bentley Tas Simulator, Bentley Hevacomp, and DesignBuilder
Cost calculation software	Cost Estimate Autodesk QTO, Innovaya, Vico, and Timberline or equal
Energy analysis software	Energy Analysis Autodesk Green Buillding Studio, IES, evacomp, TAS, DesignBuilder, eQuest and Sketchup + OpenStudio Plugin
FM (Facility management) software	“Bentley Facilities, FM:Systems FM:Interact, Vintocon ArchiFM (For ArchiCAD), Onuma System,and EcoDomus”
City programs and urban planning	InfraWorks 36 program: From Autodesk, and CityEngine: From esri
Station programs	FlowPlanne: From ProPlanner, and SmartDraw: From Facility Plans

Source: https://www.g2.com/categories/building-design-and-building-information-modeling-bim

3.8 BIM Output

The outputs of a project implemented in the BIM system must be agreed upon along with the delivery dates at the beginning of the project, and after the main members of project have been appointed in order to accommodate their participation, the following models can be expected as important outputs and results from the application of the BIM methodology at work (Ghaffarianhoseini, 2016):

1. Site Model
2. Massing Model.

3. An architectural, structural and electromechanical mode:
    a. For regulatory submissions.
    b. For coordination and / or clash detection analysis.
    c. For visualization.
    d. For cost estimation.
4. Project scheduling and phasing and fabrication construction models.
5. Program phasing & Schedule Construction & Fabrication Models.
6. Detailed drawings (Shop drawings).
7. As-built Model.
8. Data for Management Facility
9. Any form or other Informa-tion in the form of stereoscopic or non-3D features.

Through these outputs, we can achieve the following:

1. Create a simulation of the environment.
2. Validate the estimate for energy requirements.
3. Light design validation.
4. Add a time dimension.
5. Construction cost estimate.
6. Resolve conflicts between different departments.
7. Documentation with a laser scanner.
8. Create a schedule for facility management.

3.9 Roles And Responsibilities Of The BIM Team

The definition of the roles and responsibilities that must be clarified at the outset is one of the initial steps for implementing BIM on a specific project or at the level of the engineering entity and identifying the persons responsible for applying these responsibilities and roles in an appropriate manner to arrive the maximum benefit and achieve the highest possible quality.

3.9.1 BIM and the team

BIM has a significant impact on a team. Architects use this technology to work on their blueprints more systematically (no sketching anymore) to create documents needed from them. Designers use BIM to quickly generate a virtual perspective view and VR (virtual reality) to better introduce the project to the client or authorities. Engineers use the BIM process to model mechanical, electrical and HVAC designs to assess a building’s performance. Sustainability experts, engineers, and architects are able to estimate day lightning, sun orientation, and the life cycle of materials used as well as pollution caused during construction works. (Hardin, 2009).

3.10 The application of BIM through project management

Employee opposition to reform is one of an obstacles to introducing BIM. The emphasis would be on the experiences of the BIM from the viewpoint of a project manager. PMs have a major impact on whether or not a project uses BIM. The customer, PMs, and/or facilities manager were the main actors who must make crucial BIM deployment decisions (Gu and London, 2010).

The project manager is in charge of several facets of a project, including time, safety, cost, risk management, quality, and safety. In addition, the PM stays in communication with the stockholders on a daily basis. When overseeing building ventures, (Rokooei, 2015) stresses the value of providing a working knowledge of the modern management. Technology advancements, as well as modern procedures and approaches for managing organisations and programs, are critical.

The project manager is in charge of decision making and project communication. As a consequence, Rokooei advises that the PM start utilizing BIM as a modren management method. Surprisingly, project managers is one of the least studied BIM partners (Sawhney, Khanzode, Tiwari, 2017). There is also little literature on the experience of project managers on BIM (Bryde, Broquetas, Volm, 2013; Xiao & Noble; 2014). Because of their critical position in programs, project managers must be able to collaborate with BIM to ensure smooth execution. As a consequence, one of the goals of this analysis is to decide which perspectives on BIM exist among PMs.

3.11 BIM Applications Through The Project Phases

BIM applications can be integrated into the AEC industry via the during the, construction, and post-construction processes of an AEC project. (Latiffi et al., 2013).

3.11.1 The prior to construction phase

In the pre-construction process, BIM is used for three purposes: evaluation, site coordination, and buildability research. Additionally, wıth BIM's applications in pre-construction modelling, preparation, architecture, and scheduling. BIM provides visibility into the project timeline by the usage of 4D imaging, resulting in the early identification of sequencing problems. Stakeholders in the project, such as project managers (PMs), are encouraged to monitor development and optimize logistics. Perhaps one of the most significant advantages of BIM during the pre-construction process is the model's visual feature. Building prior to the start of actual work enables all stakeholders to have a clearer understanding of the undertaking. Virtualization provides benefits such as better connectivity and conflict prediction. As a result, this would result in more rapid decision-making and early identification of problems throughout the design phase.

3.11.2 The buıldıng phase

Highlight the following three BIM technologies during the build phase: progress reporting, coordination sessions, order detail insertion (RFI), change orders, and punch lists, plus other BIM implementations during the build phase, such as the ability to explain the build method through 4D visualizations.

3.11.3 After buıldıng phase

The basic post-construction implementation of BIM stems from the asset's BIM model, which preferably includes a comprehensive data set and this knowledge is used for facility management in the future and will aid project processes and management phases to become more effective. And for scheduled maintenance, it will be better with BIM software that often has the ability to retrieve maintenance records. However, compared to the pre-construction period, the post-build phase uses BIM to a lesser extent.

3.12 BIM Features

There are many advantages of implementing BIM for construction infrastructure in terms of project life cycle management and sustainability, including:

1. **Reduced Waste:** By recording all of the specifics of the construction architecture, BIM functionality can be used to evaluate any of the structural elements, products, and assemblies. The research will assist in determining the best levels or amounts to use, as well as the associated prices, such that wastes such as erroneous orders and forecasts can be eliminated (Dave, et al., 2018).
2. **Coordinated Informa-tion exchange:** BIM serves as a knowledge repository that allows various Buillding structures to communicate with one another. This archive will be used to make early cost and quality analyses of schedules, as well as to recommend designs based on them. BIM will also aid in the early identification of potential clashes and constructability inefficiencies (Ustinovičius, et al., 2018).
3. **Better performance:** Buillding Informa-tion modelling (BIM) allows for the estimation of Buillding output in terms of accessibility, amenities, capacity, and properties. As a result, any efficiency gaps may be identified and addressed in advance to increase Buillding resilience (Bazjanac, 2004).
4. **Project Management:** BIM employs a standard database that allows for the development of plans, resource preparation, risk identification, budgeting, and other tasks. Both of these project management processes are made easier with the help of BIM features. The central repository allows for detailed documentation on various stages of the project, which aids in decision-making (Sebastian, 2011).
5. **Savings**: A seamless flow of knowledge across the supply chain will reduce the complexity of function and logistical activity, lowering costs. A lot of money could be avoided if systems were quicker and there were no gaps (Studio4 Consultants Pvt. Ltd, 2013).

3.13 BIM for Buillding Life Cycle Management

BIM is also often used for Buillding life cycle management. The objective of Buillding life cycle and management is to ensure that a comprehensive Informa-tion base is available which describes the Buillding in every way which is possible with parametric presentations of BIM technology (An-Naggar, et al., 2017). This Informa-tion added to the 3D model gives much comprehensive Informa-tion which helps in making critical decisions. Managers can assess Buillding performance to identify the needs for improvements (Shaikh, et al., 2017).

Throughout the project, BIM holds a constant eye on all events. Data on the actual state of Buillding is compiled on a regular basis, allowing for evaluation. (Reeves and friends, 2015).

BIM often offers economic guidance by comparing various features and resource uses with in project to see if they affect the Buillding or management costs. Mathematical analysis for conditions is feasible, and will assist in resource optimization by achieving a stage where expense, time, and efficiency constraints that constrain the project could be balance (Ginzburg, 2016).

Site research, engineering analysis, concept authoring, and environmental analysis are only some of the applications for BIM technology. Site analysis is the process of evaluating Buillding properties in order to determine the best site, make important decisions, and measure energy efficiency. Technology research is carried out in order to find successful engineering approaches, increase design efficiency, and develop improved facility designs (Azhar and Brown, 2009). Design authoring entails creating 3D models from data in a database that includes expense, processes, material quantities, and schedules (Liu et al., 2018).

3.14 BIM Project Stages

A BIM project has four key project life cycle stages, including planning, designing, construction, and operations.

1. **Planning:** A regulatory system must be established during the planning period of a construction project to govern the creation of the structure, which includes considerations of site, relationships, connectivity, heights, and masses. The features must be durable and flexible, according to the law. (Thabet & Wetzel, 2015).
2. **Initial Designing:** The stage of design of a construction project entails identifying Buillding features and materials, as well as their provisions, focused on the performance requirements for stability and reliability. At this stage, the decision-making phase is often iterative and prescriptive, since it suggests different possibilities. The choices are made depending on the

planned design's potential to satisfy performance requirements, as well as Buillding regulations, sustainability, and accessibility (Bragança et al., 2014).

The knowledge repository created in BIM will aid in simple design adjustments at this level, as well as at later stages of incorporation, so that any improvements made during the design process can automatically cause change requests at subsequent stages. The designs and forecasts that come from this use of BIM is more precise and simpler to be build (Kensek and Noble, 2019).

The designing stage begins with the development of a primary design that defines the building's shape, size, and major spaces (Pilehchian and colleagues, 2015).

3. **Detailed Design:** After delving into basic elements of preliminary design, detailed design developed. Fixtures, floors, ventilation, electrical equipment, and interiors will also be included in the comprehensive plan. At this stage, design choices are assessed in terms of their effect on construction costs and architecture. Details in this template are usually provided as segment cuts which call outs, and are received from suppliers (Hegazy. et al., 2001).

4. **Analysis of Sustainable Design:** it is a critical field of sustainable construction in this period, since it can be utilized to identify sustainable solutions in the early stages of the project life cycle. Energy use, water use, structures, Buillding specifications, greenhouse pollution, and waste production are some of the characteristics that can be examined. (El-Alfy, 2010).

   Krygeil and Nies suggested a chronological approach to Buillding sustainability architecture. Sustainable design research includes the macro-level conceptualization of large logical structures and the measurement of quantities for various design alternatives in order to evaluate them and assess the appropriate solution in terms of sustainability (Zhang', et al., 2014).

5. **Construction:** BIM is used to track and measure the productivity of operations at the construction stage. And they are compared to the expected parameters to see if there are any anomalies from the standard that need to be addressed. When deviations are discovered, they are compared to the

estimates produced at the preparation period, and disciplinary steps may be taken if necessary (Suermann & Issa, 2008). In terms of organizational procedures the scheme can be changed, labor efficiency, and material timeliness with each corrective action. This is because, through BIM, a closed loop will be established between the building's organizational operations and change management, allowing for a better understanding of how resources are exchanged (Zhang et al., 2015).

6. **Operation:** If BIM is utilized during the operating phase of a Buillding project, it is the maximum degree of acceptance. To be able to achieve sustainable income, the output of one method should become the contribution to another in an interconnected system. It is critical that the output be greater than the inputs for the least resource utilisation. (Yu, et al., 2016).

3.15 Benefits and advantages of BIM in construction

Studies by the (Stanford University Center) for amalgamated Facility Engineering-Stanford University have been conducted on 32 main ventures and find that:

1. Up into 40 percentage removal of unbudgeted changes.
2. Cost assessment precision below 3 percentage.
3. A loss of up into 80 percentage of the time required to produce the cost estimate.
4. Gains of up into 10 percentage, of a contract sum by the identification of clashes.
5. Up to a 7 percentage decrease in project duration.(Eroğlu, 2019).

The benefits of 5D BIM for Quantitative Survey can be summarized as:

1. Increase visualization.
2. Improving collaboration on projects where people need to work together to make the models effective.
3. Improve project quality and BIM data.
4. Ease of visualizing the project.
5. Greater ability to analyze.
6. Better efficiency in take-off operations during the budget estimation period.
7. Better efficiency in cost planning while developing a detailed costing plan.
8. Providing early stages of identifying risks by improving them.

9. Save time through greater ability to resolve requests for information (RFIs).
10. Better Choices for Projects and Recognition (Stanley and Thornell, 2014).

3.15.1 Benefits of BIM during design, construction, facilities and operations, and maintenance of a building project

BIM is an innovative pre-construction method in terms of design, construction, and the post construction act of the project compared to the traditional method of drawing wherein BIM surpassed the traditional two-dimensional CAD approach during the various construction phases (pro-construction, designing, manufacturing, building, and post construction such as maintenance and operation) and we can summarize the benefits of BIM as follows (Eastman et al., 2008; 2011):

1. For the owner (pre- construction)
    a. Concept, design and feasibility benefits.
    b. Increase the quality and performance of buildings.
    c. Improve collaboration using integrated project delivery.
2. For the design
    a. More accurate and early design visualizations.
    b. Corrections to design changes are automatic and low-level.
    c. At different design stages, consistent and high-resolution 2D drawings can be made.
    d. Collaboration between different design disciplines is early.
    e. Consistency with design purpose is easy to verify.
    f. Cost estimates can be obtained at the steps of design.
    g. Increase energy sustainability and efficiency.
3. For manufacturing & construction
    a. The design pattern is used as the basis for the manufactured components.
    b. The speed of reaction to design changes.
    c. Discover design errors and omissions before construction.
    d. Concurrent design and construction planning.
    e. Better application of lean construction techniques.
    f. Procurement conforms to construction and design.
4. For post-construction
    a. Better delivery and operation of facility information.
    b. Improve the operation and management of facilities.

c. Integration with the facility's operating systems and management.

With complete simulation and linking the design to the virtual model, BIM is often used to deal with existing facilities. BIM holds the promise of providing benefits to stakeholders and project management organizations by allowing the knowledge obtained through the BIM stage and processing it into a BIM-compliant database for use in a range of facility management activities. BIM in FM is gaining immense popularity as a method of dealing with reliable, orderly, and computable building information during the life cycle of a building, from planning and development to operations and maintenance (Becerik-Gerber et al., 2011).

3.16 Building Information Modelling BIM Challenges

BIM has led a paradigm shift in the construction industry by allowing a structured, well-coordinated process of managing project information, with assigned responsibili-ties and manageable framework (Ghaffarianhoseini et al., 2016). (Ilhan and Yaman , 2013) interviewed industry practitioners and found that BIM is not used thoroughly for sustainable purposes and assessment processes due to the lack of qualified staff, beside the shortage of the allocated project budgets, and the limitation of the current BIM standards. While BIM has no single clear definition, it can be described as a data-rich, intelligent and object-oriented parametric building modelling technology (Gao, Koch and Wu, 2019), in addition to a set of interacting processes and standards to man-age the building data in digital format (Succar, 2009).

BIM comprises two main aspects; process and technical, where process refers to items as workflow, decision timing and responsibilities, while technical refers to software and IT solutions. However, the ma-jority of literature was remarkably concerned with the technological side of BIM, while the other aspect involving methods, standards and procedures received less attention from researchers when trying to integrate sustainability principles. It is believed that the current Green BIM practices are heavily technology-driven instead of process-driven (Lu et al., 2017).

Multiple BIM standards documents have been issued over the last years, aiming to provide guidelines for BIM practitioners to adopt BIM efficiently, however. Nevertheless, they lacked any acknowledgment to sustainability. For exam-ple, ISO

19650 “Information management using BIM”, a recent international standard key document, issued by BSI in 2018, to set out the concepts and principles managing building information when using BIM.

Over 13 chapters, discussing different BIM top-ics, and as the case with other preceding BIM documents, ISO 19650 failed to address any sustainability matters, nor even include any mention to the words: sustainability or green. Similarly, the 2011 RIBA Plan of work, a key document for architects and de-signers, suffers from deficiencies within the theoretical framework suggested by RIBA to integrate GBA credits into the design and construction stages (Ayman et al., 2017). Multiple studies concluded that existing BIM protocols paid very little attention to GBA criteria and provided guidance on how to enhance it.

For example, (Choo et al., 2012) outlined the need for the development of 'Green BIM Guidelines' for energy perfor-mance evaluation, and (Chong, et al., 2017) uncovered the need for an innovative pro-curement system.

The Technological part of BIM on the other hand still acts as a major hurdle to an extensive BIM-GBA integration. Current BIM software and Exchange data formats are unable to provide an integrated analytical solution for a robust GBA. Existing technol-ogies do not have the capacity to simultaneously analyse all green aspects of buildings at a time (Lu et al., 2017). Previous research shows no evidence for a true fully auto-mated real-time integration between GBA process and BIM-based tools that could pro-vide an immediate reflection on credits when changes are made to BIM models. Soft-ware diversity, information exchange format deficiency and lack of interoperability among both users and tools, are all barriers that make GBA a challenging task.

Interoperability can be defined as the ability to communicate electronic project data between different collaborating teams or different software (Bynum, et al., 2013). Many of the tools used to measure the impact of sustainable design strategies are not directly accessible from within the BIM model. Accordingly, data needs to be exported to other applications or imported from different data sources. Energy analysis applications, lighting simulation tools and Geographic Maps services are all among the employed applications (Jalaei et al., 2020).

(Azhar et al., 2009) used three building performance analysis software namely Ecotect™, Green Building Studio™ (GBS) and Virtual Environment™ beside the BIM authoring software (i.e. Revit or ArchiCAD). All the aforementioned proposed models lacked comprehension, where multiple software were needed to provide a variety of analysis for different sustainabil-ity categories. The results of these analyses are then used to generate the needed docu-mentation, which are then employed to award the proper rating. No clear solution has been presented to afford automated, interoperable, instant and comprehensive green rating, without the need to transfer information between different platforms (Azhar et al., 2011). (Lu et al., 2017) acknowledged the implications when they confirmed that dependence of BIM-based GBA on external databases can generate potential risks for sustainability analysis processes, because imprecise data input might get in, with high errors probability, which would lead to deviations in GBA calculations and inaccurate final green ratings.

Finally, lack of sufficient design information needed to satisfy GBA schemes re-quirements, especially at early project stages is a serious challenge confronting design teams. BIM models have to be complete and adequately developed, in order to be ef-fective in GBA purposes (Azhar et al., 2011).

4. SUSTAINABLE BUILDING

4.1 Preface

Meeting the needs of future generations while continuing to nurture the well-being of current generations is one of the fundamental principles of sustainability in the urban and industrial sectors. The idea of sustainability revolves around balancing the use of natural resources with those that can be accessed, in order to reduce environmental pollution caused by human activities while not compromising the use of these resources for future generations (Glass, 2003).

There are cries in the world today calls for the reduction of environmental interactions and reduce energy and water consumption and the use of environmentally friendly materials and lack of resource depletion and increase the energy efficiency of the design and implementation, the incorporation of environmental standards has become a global aim to mitigate the negative impact of buildings on the environment, which puts this sector is in front of highlighting its role and ability in producing designs that are designed in a manner that respects the environment and takes into account the conditions and standards of sustainability, which is what led to the emergence of many concepts and methods that came as a deterrent to the concern for environmental conservation. Urbanism, such as sustainable design, green architecture, and sustainable buildings, in addition to a set of standards and requirements, including systems of assessing and designing sustainability for buildings as (LEED, BREEAM, Green Star, GBA, and HQE etc.), whether buildings is existing or newly constructed (Lu et al., 2017).

4.2 The concept of sustainable

The concept of sustainability emerged in a large way within the various developmental trends during the second half of the twentieth century, and it began to impose itself with force and new formulas in the twenty-first century, when managing modern renewable economic resources and adding to the modern approach.

The main idea of sustainability is based on maintaining balance and restoring balance, as it is an approach that aims to balance the economic, social and environmental impacts, as well as search for rational strategies that try to normalize society with the natural order (Tainter, 2006). This is achieved in many applications, one of which is construction projects (Glass, 2003).

that sustainability is based on three fundamental foundations, and that the issue cannot be resolved without considering their variables, which are the environment, economy,

and community (Purvis et al., 2019). Sustainability may be visualized as a triangle, with the joints representing sustainability priorities and the ribs representing sustainability foundations, with the ecosystem serving as the foundation of the triangle, as solid sustainability is based on the environment.

4.3 Sustainable Buildings

With the rise in global warming in addition to the increase in desertification and their effect on the ozone layer, as well as the entrance into force of raw materials, minerals, and oils in the planet, and the increase in the world's population and thus the increased demand for energy and water consumption, all these reasons have prompted most countries of the world to adopt the idea of sustainability in construction (Ilhan and Yaman, 2016). Sustainable buildings are those that improve human existence and take environmental values into consideration at any point of planning, design, installation, service, and maintenance, minimizing the building's negative environmental effect on the community and the world in general. James Steele’s definition of sustainable architecture comes as “the architecture that aims to fulfill the requirements and needs of society at the present time in a way that provides future generations with the capabilities to achieve their needs” (Steele, 1997). The figuer (4.1) shows an idea of the green building.

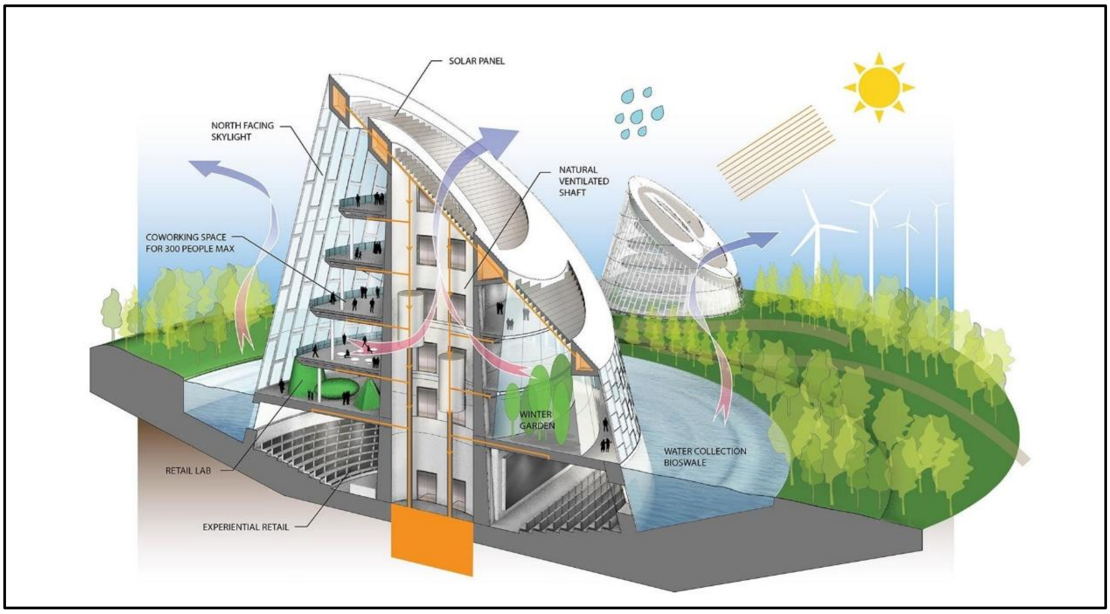

Figure 4.1: Diagram of the Green Building Idea

Source: https://www.constructiontuts.com/sustainable-construction/

4.3.1 The main benefits of sustainable buildings

The essence of the importance of green buildings is that they help to reduce (Hussin et al., 2013):

1. 35 percentage of carbon dioxide emissions.
2. 40 percentage of water consumption.
3. 50 percentage of energy consumption.
4. 70 percentage of what is known as solid waste.

There are other benefits of green buildings according to the basic principles of sustainability, as shown in table (4.1) (Ghaffarianhoseini et al., 2017).

Table 4.1: Benefits of Green Buildings According to the Basic Principles of Sustainability

Health benefits	Functional benefits	Economic benefits	Environmental benefits
The improvement of the air, thermal and acoustic nvironment.	Green buildings are high-performing	Reduce your bills for electricity and water	Reducing the negative impacts of the environment
Ensure the comfort and health of employees and residents	Improve aesthetics	Reducing operating and maintenance costs	Promote and protect environmental systems and biodiversity.
Contribute to improving the quality of life	Improvement of the functional aspects of the buildings	Enhancing asset value and profits	Improving air and water quality

Table 4.1: Continue

Health benefits	Functional benefits	Economic benefits	Environmental benefits
Create a healthy environment	Saving energy consumption	Improving employee productivity	Reduction of solid waste
Reducing disease rate	Enhancing energy efficiency	Improve the economic performance of the building life cycle	Conservation of natural resources
Contribute to hygiene	Securing energy alternatives	Improving the economic cycle in society	Preventing further depression The thermal
Reducing the pressure on the infrastructure	Use of renewable energy	Contributing to increasing investments	Preserving the ozone layer

Source: Ghaffarianhoseini et al., (2017)

4.3.2 Sustainable building challenges and barriers

Environmental factors are generally seen to be important in the construction industry, and research on this issue has been conducted extensively. (Akadiri et al., 2012) stressed the importance of considering environmental issues in contract terms as well as specifications associated with the implementation of ecological paraphernalia like the ecological effect systems or systems of ecological management. (Meryman and Silman, 2004) claimed that one of the major challenges to implementing sustainable construction is the economic factor. (Kubba, 2012) indicated that the main obstacle to implementing sustainable construction is the economic barrier. It is also important to identify the many limitations associated with sustainable construction, and they may be viewed as an opportunity or a challenge. The regulations under which these restrictions are imposed are due to the requirements to align sustainability with the ecological problems for all building-related success Constituents. (Baloi, 2003) said, it is imperative that all stakeholders have a basic understanding that to meet the requirements of sustainable construction, it is necessary for different players to adapt, request changes in the policies, laws, the designs, implement and operate projects of construction. Since it is a case of reconstruction, the construction industry must find a better way to implement every step of the construction process, in terms of reuse of building materials, energy conservation, and utilization of naturalistic resources.

Whereas (Issa, 2015), (Akadiri et al., 2012), (Asif, 2016) agreed to define the most well-known issues in the sustainable construction industry such as economic, capacity, professional, societal, and technological challenges, disagree on whether or not this assessment is correct.

With regard to investors and developers, there are several factors that control their decisions, the most important of which is the financial profits of construction projects. In order to appropriately account for sustainable building practices, decision-makers must pay critical attention to implementing these practices. We agree with (Zuo and Zhao, 2014). The lack of positive long-term benefits impedes the application of sustainable building techniques, leading to the misconception that these methods are financially costly, without meaningful results (Ambec et al., 2013). However, according to many studies, the majority of those looking to implement sustainable construction find an increase in the price range from 0 to 18 persentage (Kats, 2013). Continuous construction delays constantly change the total project cost, because sustainable building requires the integration of mechanisms and tools of sustainability with the other mechanisms of construction. Therefore, it is imperative to put in place measures to assess and maintain the status of all project phases in order to deal with delays (Maguina, 2011).

It is imperative that the community is aware of environmental problems in order to ensure the successful completion of sustainable construction. (Biygautane and Al-Yahya., 2011) claim that most customers are aware of pollution problems of environmental, yet they often rely on government duties related to environmental protection. This reduces our view of what we should be responsible for and what we do not know about sustainable building practices. The construction industry is made up of many different parties, each with their own ideas on how to change building practices to become more sustainable.

4.4 Sustainable Building Project Management

Incorporating environmental and sustainability strategies from the start is part of the project management methodology known as sustainable project management. One of the most important goals of sustainable project management is to take into account environmental issues when making choices and not to ignore those (Silvius, 2013) (Al-Tekreeti, 2015). Project managers overseeing project development must ensure that the project pays off while weighing the constraints on expenditures, time, and efficiency (Kerzner, 2013). Despite these problems, simply satisfying these traditional project management standards is not sufficient at present. There are many other features that can be included in the so-called iron triangle of management:

features such as safety, sustainability and a mechanism for gathering knowledge and support from stakeholders and the organization itself (Ahlemann et al., 2013). While it is likely to be well addressed in the academic literature, incorporating sustainability issues into project management procedures may employ improvement, according to (Økland, 2015). However, the study of this topic is still in its early stages, as the number of publications is very small; He also said that knowing what will positively impact sustainability is a challenge. According to (Hornstein, 2015) and (Gmelin and Seuring, 2014), those who make decisions and those on project teams should have enough experience, but a major mental shift is also needed. Finding out where to locate the project team, project owner, and stakeholder mental models on sustainability is likely to be an important start. If project management mental models are introduced, they can help identify the control points necessary for long-term success to be incorporated into project management.

4.5 Sustainable Building Environmental Assessment Systems

4.5.1 Historical background of environmental assessment systems of sustainable building

Because buildings have a wide impact on the environment through the consumption of energy, water, and raw materials and produce waste and cause harmful emissions to the environment, it was necessary to develop special standards for sustainable buildings in order to reduce their impact on the natural environment through sustainable green design.

Thinking about this increased in the year 1990 when the Building Research and Establishment Environmental Assessment Methods (BREEAM) Institute established the first building classification system in the United Kingdom, and in 1998 the American Green Building Council appeared, which made an improvement in the systems and standards for evaluating sustainable buildings through its new system, Leadership in Energy and Environmental Design (LEED), and then the development of this system continued and took the lead with increasing global interest in green architecture evaluation systems, including the Green Building Initiative in Canada (GBI), which was established in support of the National Green Building Association. After that, many different evaluation systems in the world followed, which mainly relied on these primary systems, while updating and developing them in line with local priorities and national requirements for access to concepts of sustainability and a wider range of resources. With it, the number and types of standards and certificates related to green products have increased, which help in directing, demonstrating, and documenting efforts to reach sustainable high-performance buildings.

4.5.2 Sustainable (green) building classification systems

There are many global systems for evaluating the sustainability of green buildings in the world that are appropriate to the conditions of each country. We will mention some of these systems and we will choose the most famous and international system to shed light on some of the details of its work in a way that serves this research and as shown below: The most famous systems in the world are:

1. Sustainable Buildıngs Ratıng System of USA, Leadership in Energy and Environmental Design (LEED), was established by the American Green Building Council (USGBC) in 1998.
2. Sustainable Buildıng Ratıng System - British Kıngdom - the Buildıng Research Establishment Environmental Assessment Method (BREEAM), was established by the British Building Research Foundation (BRE) in 1990.
3. French green building standard - High-Quality Environmental Standard (HQE).
4. Malaysian green Buildıng Standard - Green Buildıng Index (GBI).
5. Qatar Green Building Standard - The Global Sustainability Assessment (GSAS).
6. Abu Dhabi City Sustainability System (Estidama Rating System) was established by the Abu Dhabi Urban Planning Council in 2008.
7. Sustainable Buildıngs Ratıng System - Australia - The Green Star was established by the Green Building Council of Australia (GBCA) in 2003.
8. Sustainable Buildıngs Ratıng System - Japan - Comprehensive Assessment System for Built Environment Efficiency (CASBEE) was established by the Japanese Green Building Council (JGBC) 2001.

4.6 The LEED (Leadership in Energy and Environmental Design) system and its objectives

LEED (Leadership in Energy and Environmental Design) is a system that divides and classifies green buildings according to their degree of sustainability into several levels and classes. It was issued by the US Green Building Council in the year 2000, so that whereas, we may not encounter an environmentally friendly project or building unless it has obtained or is seeking LEED certification for sustainable building. The LEED System is an educational system that is not binding on all buildings, but rather provides verification of the design, construction, and operations of green buildings from a third party. Where there is a need for more integration and linkage between the contracting and design teams, it includes a number of sustainable project tools that analyse the building. In order to initiate an environmentally friendly process, the contractor needs to learn about the green topic, as well as a system that classifies the study as LEED (Hardin, 2009, p 231).

The (LEED) system is characterized by distinctive flexibility, which made him the leading first globally in meeting the requirements and solutions are not for buildings only, but for all types of projects so that it can be applied to all types of commercial buildings and residential buildings, including new projects, restoration projects, buildings existing interiors in commercial buildings, internal development and external, schools and homes, where the system assesses the life of the building cycle in terms of design, construction, operations, maintenance, and equipping the building of the population and operations update task system (LEED) takes into account the impact of the building on the space is located.

LEED certification is awarded to buildings according to the regulations to ensure that the building, home, or urban assembly is designed and built according to the systems of building the basic goal of achieving the highest performance efficiency in energy, environment, and humanitarian directions, through the development site a sustainable building, and the preservation of raw materials and water, do not waste resources, As well as energy efficiency, design efficiency, and the internal environment (Wu et al., 2017), the LEED standards aim in their entirety to:

1. Acknowledgment of environmental leadership in the construction sector.
2. Evaluate the buildıng’s performance throughout its entire life cycle.

3. Economy in construction through the availability of maintenance costs.
4. Raisıng consumer awareness of the benefits of green buildıngs.

4.6.1 Appropriateness of evaluation systems

The Federal Office for High Performance Green Buildings commissioned the General Services Administration (GSA) to conduct a study to define standards for green building certification tools in compliance with the Energy Independence and Security Act (Energy Independence and Security Act of 2007- EISA) (U.S. Congress, 2007)

EISA - Independence and Security Act of); Articles 433 (a) and 436 (h) of EISA stipulate that the director of the office should define a system for issuing green building certificates, "provided that a comprehensive and environmentally sound approach to green building certification is adopted."

The US federal government has set minimum sustainability requirements for its private buildings for the importance of assessing the mechanism by which the various systems assist in helping the government achieve green building goals. This review of certification systems is designed to demonstrate how current certification systems are aligned with principles of sustainable design and high-performance operational needs. The analysis framework is a set of standards derived from EISA and Federal Building Performance requirements. The criteria mentioned by EISA in reviewing certification systems include the following:

1. The durability of the technical components of the certification system to meet the requirements of high-performance federal design and operational requirements of federal facilities.
2. The independence of auditors or evaluators.
3. Availability of technically qualified auditors or evaluators
4. Availability of a documented valuation method.
5. Transparency of evaluation systems approach in collecting and processing data.
6. A consensus-based standard for documenting the development and review process.
7. System maturity.
8. The ease of use of the system.

9. System recognition in the local construction industry.

Despite the differences and diversity in green building assessment schemes, they rely on the same priorities and axes, and the goals of green buildings can be outlined as follows:

1. Efficient utilization of the all materials, such as energy generation, water, and materials, and waste minimization (the principle of reducing, re-using and then recycling).
2. Nature, which is the basis of all energy, must be preserved.
3. Make the world healthier for future generations.
4. Creating high-efficiency buildings by managing disease, the climate, and money, as well as concentrating on the long-term cost of ownership rather than the original cost of development.

Within the framework of these objectives, a number of axes branched out, which facilitate the process of monitoring and evaluating the design, construction and operation specifications, and the LEED system relies mainly on the method of earning points, as construction projects collect points to meet the LEED standards for green buildings, and within each of the major LEED ratings, must These projects must meet the following requirement (Acampa, G. et al. 2020):

1. Sustainable sites: choosing environmentally friendly sites and design strategies.
2. Water efficiency: rational use and conservation of water.
3. Energy and the atmosphere: improving the energy efficiency of the entire building.
4. Materials and Resources: Promote waste management and responsible material selection.
5. Indoor air quality: reducing pollutants and improving the indoor environment by controlling the intensity of lighting and utilization of sunlight.
6. Innovation in design, giving priority to the areas concerned: creativity in design and the creation of new ideas in environmental design, which take into account the local geography.
7. Social and economy: use of traditional local materials and techniques, design compatible with cultural values, the cost of use and commercial viability.

8. Service Quality: efficiency in the use of the spaces, the capacity of local control of the different systems, and the efficiency of an adequate management and maintenance plan.
9. Circular economy: use of resources and reuse of building materials, systems and subsystems.
10. Climate changes: ability of buildings to adapt to climate change and its consequences without incurring damage.

4.6.2 LEED goals

LEED is a building appraisal system that has impact classes within which it operates (USGBC, 2021):

1. Climate change.
2. Promote public health.
3. Preserving water sources.
4. Preserving biodiversity.
5. Building a green economy.
6. Preserving raw materials and their life cycle.

4.6.3 Classifications of LEED certificates for green buildings

The LEED system gives ratings (certificates) for green buildings by collecting points in the main classifications described previously and each classification includes a set of required credits achieved to obtain the LEED certification and these certificates are divided into four ranks as applied to the required standards, as shown in the table (4-2), Which is: the platinum, gold, silver, and documented mattress (USGBC, 2021., Wu and Low, 2010).

Table 4.2: The Type of Green Certificate

Number of points required to obtain The building on it	**The form of the certificate**	**The name of a certificate**
80 + points		LEED Platinum Certificate
From 60 to 79 points		LEED Gold Certificate
From 50 to 59 points		LEED Sılver Certificate
From 40 to 49 points		LEED Accredited Certification

Source: USGBC, (2021), Wu and Low, (2010).

4.6.4 Classifications of LEED projects according to building type

The rating system works on all buildings in all stages, from the newly constructed buildings to the existing buildings. It also evaluates all types of buildings from residential houses to hospitals to companies.

There are five classifications of the types of LEED system according to the type of building table (4.3).

Table 4.3: Types of LEED System According to the Type of Building

System shortcut	**The name of the system**	**The goal of the system**
LEED BD + C	LEED Building Design & Construction	For building design and construction method. It is applicable to the newly built buildings.
LEED ID + C	LEED Design & Construction	For interior design and its construction method, and it applies to buildings that have been finished and are in the process of implementing interior decorations
LEED O + M	LEED Operational and Maintenance	The method of building operation and maintenance applies to buildings that have completed all the works and have maintenance and improvement works
LEED ND	LEED Neighborhood Development	District development applies to new land development projects or development projects that contain residential and non-residential uses, or are a combination of projects
LEED HOMES	LEED HOMES	One of the stages of the development or planning process, and it applies to family or individual homes, whether they are low in height from 1 to 3 floors, or medium in height from 4 to 6 floors.

Source: USGBC, (2021), Wu and Low, (2010).

4.6.5 The basic requirements for the classification of a green building

The LEED system is mainly based on the point-earning method, as construction projects collect points to achieve the green building standards specified by the LEED evaluation system, and within each of the LEED basic classifications, projects must meet prerequisites and obtain points.

It consists of several prerequisites and credits, as for the requirements, they are basic and must be met in any project applying to obtain the LEED certificate, as for additional points, they are optional as in figure (4.2).

Figure 4.2: LEED Rating System's Points

Score: https://www.archdaily.com/227934

By obtaining them, the project gets a higher degree as we mentioned earlier that the evaluation of LEED system is chosen and adopted by the building type, for example, buildings that will newly arise, it should follow this system contains several requirements which fall under seven assessments and classification through the rating system BD + C LEED in ratings Basic (USGBC, 2021) :

1. (Sustainable Site): You can collect 26 points.
2. (Energy Efficiency): Addition of 35 points.
3. (Water Efficieny): Able to add 10 points.
4. (Materials Selection): You can add 14 points.
5. (Indoor Air Quality): can add 15 points.

6. (Innovation in Design): You can collect 6 points.
7. (Regional Priority): can collect 4 points.

4.7 Sustainability Analysis Based on BIM

As previously said, BIM will operate on multidisciplinary data inside a single paradigm. Given the complex architecture and delivery of sustainability interventions, this function allows them to be performed (Azhar et al., 2009). As a result, BIM has been a significant element of sustainability research and modeling, and it helps to reduce environmental damage and industrial waste (Wong and Fan, 2013). As a result, demand for BIM based research in the area of sustainability is skyrocketing.

BIM technology, as well as its general applications, can help with sustainable development at different stages of a project, from early decision-making to the demolition to improve efficiency and output (Azhar and Brown, 2009). In terms of sustainability, its BIM's contribution to the construction phase can be related to the three major sustainability dimensions: economic, social, and environmental.

4.7.1 Economic aspects

BIM's direct role in the economic dimension through the process of cost estimation and risk management is one of its important contributions to sustainable construction in addition to its general uses (Hartmann et al., 2012). Estimating the project's costs and necessary capital may be broken down into phases in order to forecast and quantify the cost of each process (Halpin and Woodhead, 1998). Furthermore, in comparison to the 3D versions of BIM models, project managers should integrate time into their research as 4D models to more accurately and reliably predict project risks (Zhang and Hu, 2011). Even if this method will help a project be more progressive and cost-effective, it cannot be deemed a sustainable solution because it considers environmental benefits and the idea of improving life quality in its calculations, and prioritizes human well-being as well as principles of social principles (Sassi, 2006). Furthermore, applying BIM to other areas of a project may have a significant impact on its economic performance. Predicting upcoming events and improving public company collaboration and coordination, for example, result in less waste, more resources saved, better building maintenance, and lower project costs (Eastman et al., 2011; Hartmann et al., 2012)

4.7.2 Environmental aspect

Many of the data needed for measuring performance is collected automatically as the design of the project progresses. By using the construction knowledge model, planners will analyse how a building can work through premature stages of construction and rapidly evaluate potential designs in order to make a more informed decision to iteration on environmentally friendly design (Azhar et al., 2011). The majority of BIM instruments have numerous features for analysing material and energy use, as well as the mechanical and electrical systems of the construction, in order to generate explicit knowledge about reducing resource and energy waste (Wong and Fan, 2013). Several BIM software packages, like Revit and Autodesk Ecotect, provide methods for processing data in order to analyze the project's environmental characteristics. Additionally, this allows architects and designers to control electricity use and resource use more effectively. Through analysing the solar direction, the orientation of the building, the shading configuration, and the determination of heating and cooling requirements, such software will combine data to create a more environmentally friendly design (Wong and Fan, 2013; Azhar et al, 2009)

4.7.3 Social aspects

In general, the social advantages for sustainability are seen in conjunction with other facets of sustainability that result in increased human well-being, convenience, and fitness (Sassi, 2006; WDBG, 2001). In terms of sustainability, the societal concept encompasses a broad range of principles and values that can be classified into two categories based on their relationship to BIM: contingent and autonomous functions. Dependent characteristics of societal sustainability are measurable in nature and can be quantified explicitly by other measures that BIM can provide for different facets of environmental condition, such as electricity efficiency and illumination Figure (4.3). According to Sassi, enhancing those environmental characteristics by sustainable design promotes health and success, while adverse conditions may exacerbate health problems such as fatigue, pain, and absenteeism. As a result, these considerations favor the whole population and culture. In the other side, the majority of meanings and terms associated with socially sustainable architecture are unrelated to other factors, the majority of which are qualitative.

(Sassi, 2006) classifies a portion of these traits as community-related characteristics of resilience and classifies the remaining facets of safety and wellbeing as opportunities for social contact, an individual's sense of self-worth, and a sense of place belonging. Additionally, urban architecture will increase the life quality at the societal level by information transfer, increased air quality, neighbourhood preservation, and decreased health threats associated with emissions associated to the energy use in building (WDBG, 2001).

Sustainability Dimensions		Sustainability Factors	BIM Implementation	BIM Examples
Environmental		Site and Land Use Materials Energy Water Air	Orientation Shadow Light Path Heating and Cooling Load Analysis	Ecotect Revit Energy Plus Green Building Studio™ (GBS) Virtual Environment
Economic		Long-term Resources Productivity Low running Costs Operating Cost Maintenance Cost Revenue	Cost Estimation Quantity Surveying	Cost X Total Project Logistics Resi-Cost Chief Estimator Quantity Take off
Social	Dependent	Health Well-being Comfort	Orientation Shadow Light Path Heating and Cooling Load Analysis	Ecotect Revit Energy Plus Green Building Studio™ (GBS) Virtual Environment
	Independent	Social and Cultural Values Human Design Community		

Figure 4.3: Sustainability Analysis Based on BIM

Source: Soltani, (2016)

4.8 BIM in the Area of Sustainability: Evaluating the Utilization of BIM Software

There are many sustainability analyzes based on building information modeling, and each of them uses a specific program for the purpose of knowing the cost and time of that analysis, such as energy analysis, daylight analysis, building orientation, location, mass and other analyzes. Among these programs:

1. Autodesk Green Building Studio (GBS)™
2. Integrated Environmental Solution (IES), Virtual Environmental (VE)™
3. Autodesk Ecotect™

4. Hevacomp ™
5. Energy Plus™
6. Delight™
7. Rediance™
8. HEED ™
9. Virtual DOE™
10. Homer™
11. Bentley HEVACOMP™
12. Bentley TAS™
13. Climate consultant™

The most common users of these analyzes are architects and civil engineers in addition to contractors as they use it in the design and planning stages. The most common types of sustainability analysis are site analysis, solar analysis (i.e. daylight), energy analysis, mass analysis and building orientation analysis.

When comparing BIM-based sustainability analyzes with traditional analysis methods, users of BIM-based analytics realize the high cost and time savings in implementing projects (Azhar and Brown, 2009).

5. RESEARCH METHODOLOGY

5.1 Research Methodology and Tools

The researcher relied on the quantitative approach with its steps and procedures, which is represented in data collection, analysis, results presentation and discussion, due to its relevance to the nature of the research and its objectives, by revealing the link between BIM with sustainable construction and project management, in addition to focusing on the field application aspect through the use of the questionnaire as a tool for data collection

5.2 The Study Population and Its Sample

The research sample consisted of engineers of all disciplines and with different academic certificates, and it consisted of participants in construction projects (investor, contractor, designer.

5.3 Search Tool

To achieve the objectives of the research and collect data from the target sample, a questionnaire was prepared by making use of theoretical literature, previous studies, research papers and scientific articles related to the topic of the research and based on that the questionnaire was designed.

5.4 Questionnaire

The researcher conducted a survey to validate the research hypothesis and as a supportive step for the search for factual information on the impact of using BIM systems in managing sustainable construction projects, the survey provided feedback from workers in the construction industry. It was distributed by e-mail and the web without personal interviews due to the Corona pandemic, and the questionnaire contained a brief definition of the BIM application and a request for the participants' cooperation and information for the purpose of research.

The main objective of sending the questionnaire was to correlate research data with theoretical studies on the impact of the use of BIM systems on the determinants of sustainable construction project management.

The questionnaire contained simple and understandable questions about the use of the BIM application and its impact on the determinants of sustainable project management in terms of saving cost and time, improving economic standards (revenues and profits), and improving management processes.

5.5 Questionnaire Design

The questionnaire is designed to include 3 main parts:

The first part is information and personal data, including engineering specialization, years of experience, engineering occupation, and education level.

The second part includes the benefits of applying BIM in the project construction process from start to finish to after use in terms of management, time, cost, quality, environment, and society.

The third part includes the challenges facing the use of the BIM application in construction projects.

In parts 2 and 3 of the questionnaire respondents used a Likert scale to estimate the extent of the impact as (1 - Strongly agree, 2 - Agree, 3- Neutral, 4- Disagree, 5- Strongly disagree).

5.6 Authenticity Search Tool

To verify the apparent validity of the research tool, which included the questions of the questionnaire, it was presented to a group of specialists in the field of project management, sustainability and BIM, and they were asked to express their views on the questions of the questionnaire in terms of clarity of phrases and their belonging to each field, in addition to expressing their observations about them and proposing appropriate modifications to achieve the objectives of the research

5.7 Data Collection

The questionnaire was released via the internet by sending the electronic questionnaire to the selected sample, and that the period of gathering the necessary information took place within approximately two weeks. A total of 135 participants were asked, the number of respondents reached 100 At a rate of (74 percentage), everyone who answered was using BIM technology.

5.8 Data Analysis

Statistical analysis of the data collected via the Internet was carried out using the SPSS statistical analysis program. Through this program, Cronbach's alpha was analyzed, as well as the analysis of the relative importance index (RII), and the results of the statistical analysis were interpreted for the purpose of providing valuable information to evaluate factors according to their importance.

The respondents followed the instructions in the questionnaire form in appendix A and the respondents varied in terms of their engineering specialties as follows: 74 participants with a specialization in civil engineering, which is the highest percentage among the rest of the engineering disciplines, 1 participant in an architectural engineering specialty, 9 participants in a mechanical engineering specialization, and 10 electrical engineering majors and 6 participants in other engineering majors.

(Fig. 5.1) showing the details of the distribution of the research sample according to engineering disciplines.

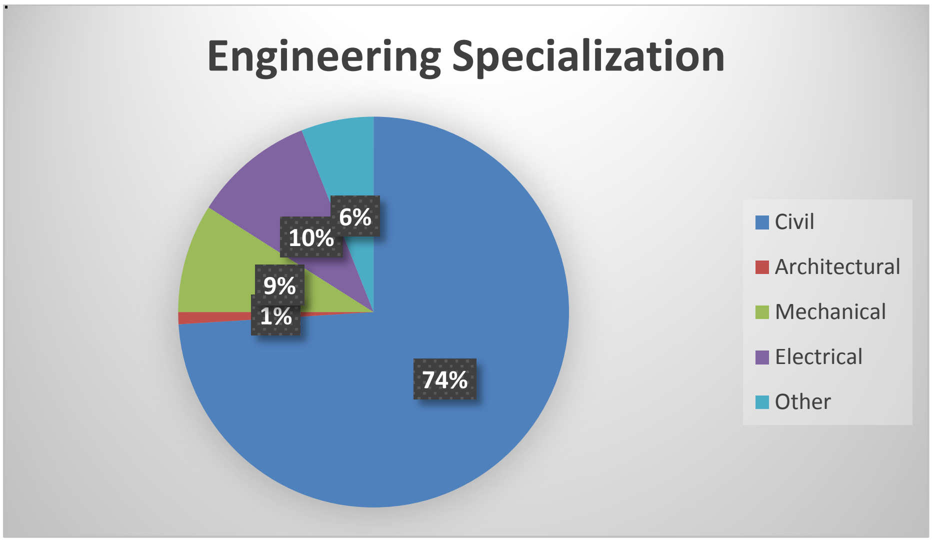

Figure 5.1: Distribution of Engineering Disciplines

The engineering experiences of the participants varied as follows: 10 participants of 1 to 5 years of work experience, 12 participants from 6 to 10 years of work experience, and 9 participants from 11 to 15 years of experience in the field of work and 22 participants from 16 to 20 years of experience in the field of work and 47 participants with more than 20 years of experience in the field of work and as shown in the figure (5.2).

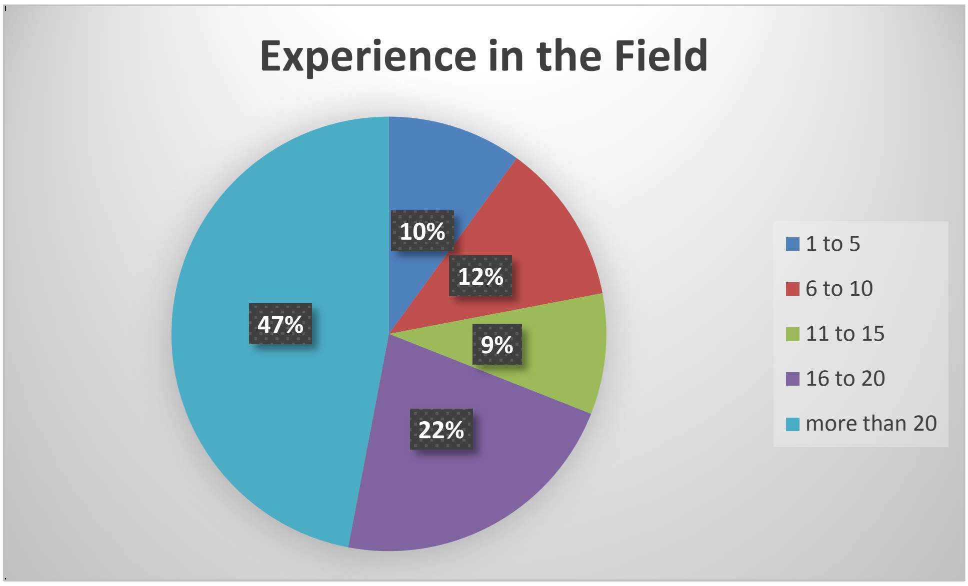

Figure 5.2: Experience in the Field

5.9 Search Tool Stability

5.9.1 Cronbach's Alpha

One of the most important technical advantages in educational research (whether quantitative or qualitative) is reliability, and the most appropriate measure of reliability is Cronbach's alpha, especially when using Likert scales.

To verify the stability of the research tool represented by the questionnaire questions, the internal consistency was calculated using the Alpha Cronbach method for the 2 and 3 parts of the tool separately, through the following equation (5.1):

$$\alpha = \frac{n}{(n-1)}\left[1 - \frac{\sum_{i=1}^{n}\sigma_{yi}^{2}}{\sigma_{x}^{2}}\right] \quad \text{--} \quad (5.1)$$

Where:

α = Alpha Cronbach.

n = refer to the number of scale items.

σ_x^2 = refer to the variance associated with the item i.

σ_{yi}^2 = refer to the variance associated with observed total scores.

In order for the measures to be reliable for this analysis, the best value of Cronbach's alpha must be greater than or equal to (0.7) as shown in the table (5.1).

Table 5.1: Cronbach's Alpha Values

Components	No. of Items	Cronbach's Alpha	Reliability
BIM Benefits	24	0.908	excellent
BIM Challenges	10	0.778	v.good

It is clear from the table that the stability of the questionnaire axes according to Cronbach's alpha coefficient amounted to (0.908) for the second part and (0.778) for the third part, which indicates the availability of a high degree of internal stability and consistency in the answers of the participants in the questionnaire and enables us to rely on these answers in analysing the results.

5.9.2 Relative importance index (RII)

The relative importance indicator is used in statistical analysis for the purpose of presenting and discussing the results to be of relative importance so that deleting them or displaying them incorrectly can affect the decisions taken from those data and through the application of the equation (5.2) (Akadiri, 2011).

It is possible to obtain a value for the relative index, as the higher the value of the index, the higher the importance, and vice versa table (5.2).

$$\text{RII} = \frac{\sum w}{A*N} \quad \text{---} \quad (5.2)$$

Where:

W = is the weighting as assigned by each respondent on a scale of 1 to 5 with the 1 for the least and 5 for the highest.

A = is the highest weight (i.e 5 in our case)

N = is the total number of the sample

Table 5.2: The Relative Importance Index Values Importance Level

RII values	Importance level	
0.8 ≤ RII ≤ 1.0	High	H
0.6 < RII < 0.8	High-medium	H-M
0.4 < RII < 0.6	Medium	M
0.2 < RII < 0.4	Medium-low	M-L
0.0 < RII < 0.2	Low	L

Table 5.3: Comparing the Importance Ratio Index for the Benefits of BIM.

BIM Benefits in Management (Time) Field	**RII**	**Mean**	**Rank**		**Previous Statistics Values**		
			In Field	**Over all**	**RII**	**Mean**	**Rank**
BIM application leads to improve the monitoring and assessment of the construction projects of sustainable buildings.	0.864	4.32	2	2	0.775	3.87	8
BIM gives better communication of different professions during the project design and execution, so that will reduce time and cost	0.852	4.26	3	4	0.746	3.73	22
Improve risk identification (risk management) to be available in the earlier stage before construction. That will Improve safety, comfort for users, and emergency analysis.	0.838	4.19	4	6	0.812	4.06	1
BIM provides information related to quantity, cost, schedule, and material inventory, so that will support decision-makers in taking prompt informed decisions regarding the life cycle performance of a building.	0.872	4.36	1	1	0.70 0	3.85	9
Increase the ability to resolve requests for information (RFIs) from the partners in real-time, so that will reduce the time	0.822	4.11	5	8	0.768	3.84	10
BIM Improves simulations and visualization of construction details, so that will Save design time and costs.	0.838	4.19	4	6	0.760	3.80	12
BIM Benefits in Environment Field							
BIM application encourages energy conservation through organizational energy reduction, energy monitoring, and the use of energy-efficient and equipment.	0.808	4.04	1	12	0.757	3.79	13
BIM application enhances environmental building evaluation and contributing to material waste management.	0.798	3.99	2	16			

Table 5.3: Continue

BIM Benefits in Management (Time) Field	RII	Mean	Rank		Previous Statistics Values		
			In Field	Over all	RII	Mean	Rank
BIM application promote the use of environmentally friendly building materials, including efficient and recycled materials.	0.796	3.98	3	17			
BIM applications encourage the construction of environmentally friendly buildings in a low-pollution manner.	0.798	3.99	2	16			
BIM Benefits in Cost Field							
BIM application enables cost management in areas of sustainable development that are perceived to have high construction costs.	0.814	4.07	3	10	0.733	3.66	23
BIM application has many positive advantages of economic activities of buildings, all of which contribute to prompt the industry's sustainability.	0.800	4.00	5	15			
BIM promotes practices that improve the sustainability efficiency of the design, construction, service, and maintenance of buildings.	0.806	4.03	4	13	0.770	3. 85	
BIM application encourages experimenting with new technology.	0.858	4.29	1	3			
The BIM improves identifying mistakes before work commences on-site by detecting and reduce clashes, so it reduces the cost.	0.840	4.20	2	5	0.789	3.95	4
BIM Benefits in Quality Field							
BIM improves the quality of milestones and productivity of companies and organizations of construction projects.	0.820	4.10	3	9	0.802	4.01	3
The BIM contributes to quality control of materials take-offs, minimizing conflict and errors in schedules, and streamlines the management of construction projects results.	0.810	4.05	4	11	0.746	3.73	21
BIM applications prompt the provision of outdoor and indoor quality requirements for the installation and equipment that is necessary.	0.802	4.01	5	14			
BIM application prompts to adjust for different uses of sustainable construction projects.	0.760	3.80	6	19			
BIM improves design quality and verifies consistency to the design intent easily, which prevents expensive delays	0.830	4.15	1	7			

Table 5.3: Continue

BIM Benefits in Management (Time) Field	RII	Mean	Rank		Previous Statistics Values		
			In Field	Over all	RII	Mean	Rank
Improve project quality and BIM digital data quality	0.822	4.11	2	8	0.755	3.78	15
BIM Benefits in Social Field							
BIM application promotes ethical behaviour in terms of meeting building project requirements.	0.744	3.72	3	21			
BIM application contributes to preserving local heritage and culture which the social and leads to satisfaction for users sustainable projects.	0.756	3.78	2	20			
BIM encourages companies to embrace this technology in order to maintain the works market, which acts as a driving force.	0.788	3.94	1	18	0.725	3.63	24

Through the results of RII presented in Table (5.3), we see that the highest value of the RII scale for all component was in providing of BIM for information related to quantity, cost, schedule and stock of materials, so that it supports decision makers in making quick informed decisions regarding the performance of the building life cycle. While the lowest value of the RII scale for all component was in promoting the application of BIM for ethical behavior in terms of meeting the requirements of the construction project.

While the value of the RII in each component was as follows:

1. **BIM benefits in management field**

The relative index values for this field as shown in table (5.3) were as follows:

a. BIM provides information related to quantity, cost, schedule, and stock of materials so that it supports decision-makers in making quick informed decisions regarding the performance of the building life cycle
b. BIM application leads to improve the monitoring and assessment of the construction projects of sustainable buildings
c. BIM gives better communication of different professions during the project design and execution, so that will reduce time and cost.

d. Improve risk identification (risk management) to be available in the earlier stage before construction. That will improve safety, comfort for users, and emergency analysis.
e. And as the same degree of importance, BIM improves simulations and visualization of construction details, so which will save design time and costs.
f. Increase the ability to resolve requests for information (RFIs) from the partners in real-time, so will reduce the time.

2. BIM benefits in environment field

The relative index values for this field as shown in table (5.3) were as follows:

a. BIM application encourages energy conservation through organizational energy reduction, energy monitoring, and the use of energy-efficient and equipment.
b. BIM application enhances environmental building evaluation and contributing to material waste management, and as the same degree of importance, BIM applications encourage the construction of environmentally friendly buildings in a low-pollution manner.
c. BIM application promote the use of environmentally friendly building materials, including efficient and recycled materials.

3. BIM benefits in cost field

The relative index values for this field as shown in table (5.3) were as follows:

a. BIM application encourages experimenting with new technology.
b. BIM improves identifying mistakes before work commences on-site by detecting and reduce clashes, so it reduces the cost.
c. BIM application enables cost management in areas of sustainable development that are perceived to have high construction costs.
d. BIM promotes practices that improve the sustainability efficiency of the design, construction, service, and maintenance of buildings.
e. BIM application has many positive advantages of economic activities of buildings, all of which contribute to prompt the industry's sustainability.

4. BIM benefits in quality field

The relative index values for this field as shown in table (5.3) were as follows:

a. BIM improves design quality and verifies consistency to the design intent easily, which prevents expensive delays.
b. BIM improve project quality and digital data quality
c. BIM improves the quality of milestones and productivity of companies and organizations of construction projects.
d. BIM contributes to quality control of materials take-offs, minimizing conflict and errors in schedules, and streamlines the management of construction projects results.
e. BIM applications prompt the provision of outdoor and indoor quality requirements for the installation and equipment that is necessary.
f. BIM application prompts to adjust for different uses of sustainable construction projects.

5. **BIM benefits in social field**

The relative index values for this field as shown in table (5.3) were as follows:

a. BIM encourages companies to embrace this technology in order to maintain the works market, which acts as a driving force.
b. BIM application contributes to preserving local heritage and culture which the social and leads to satisfaction for users sustainable projects.
c. BIM application promotes ethical behaviour in terms of meeting building project requirements.

After obtaining the values of the materiality index and displaying them in Table (5.3), the researcher found that all components of the electronic questionnaire have a degree of importance, and this means that the application of BIM plays an important role in sustainable CPM in terms of cost, time, quality, environment, and society in addition to risks. This conclusion is identical to what Saber and Wali (Saber and Wali, 2020) found about the benefits of implementing BIM, as shown in Table (5.3).

5.9.3 One-way ANOVA analysis

The results of the questionnaire were statistically analysed by spss version 22 at a significance level of 5 percentage. In addition, for each part of the questionnaire, a one-way ANOVA analysis was performed to assess the difference of opinion regarding the components of the questionnaire through the experience of the participants, as well as to determine the degree of importance of applying BIM to the administrative, economic and social components of sustainable construction. The same zero theory is adopted, meaning that = 0 H0: σi, which means that all means of the samples are equal to the total mean, the results are shown in the table (5.4)

So if the p-value is > 0.05, it means that the null hypothesis cannot be rejected and there is not much difference in the opinion of engineers with different experiences.

Table 5.4: ANOVA Analysis For The Benefits of BIM

Items		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
BIM application leads to improve the monitoring and assessment of the construction projects of sustainable buildings.	Between Groups	1.144	4	0.286	1.021	0.401
	Within Groups	26.616	95	0.280		
	Total	27.760	99			
BIM gives better communication of different professions during the project design and execution, so that will reduce time and cost	Between Groups	2.170	4	0.542	1.558	0.192
	Within Groups	33.070	95	0.348		
	Total	35.240	99			
Improve risk identification (risk management) to be available in the earlier stage before construction. That will Improve safety, comfort for users, and emergency analysis.	Between Groups	1.387	4	0.347	1.030	0.396
	Within Groups	32.003	95	0.337		
	Total	33.390	99			
BIM provides information related to quantity, cost, schedule, and material inventory, so that will support decision-makers in taking prompt informed decisions regarding the life cycle performance of a building.	Between Groups	2.493	4	0.623	1.536	0.198
	Within Groups	38.547	95	0.406		
	Total	41.040	99			
Increase the ability to resolve requests for information (RFIs) from the partners in real-time, so that will reduce the time	Between Groups	1.975	4	0.494	0.872	0.484
	Within Groups	53.815	95	0.566		
	Total	55.790	99			
BIM Improves simulations and visualization of construction details, so that will Save design time and costs.	Between Groups	1.962	4	0.491	0.759	0.555
	Within Groups	61.428	95	0.647		
	Total	63.390	99			

Table 5.4: Continue

Items		Sum of Squares	df	Mean Square	F	Sig.
BIM application encourages energy conservation through organizational energy reduction, energy monitoring, and the use of energy-efficient and equipment.	Between Groups	1.633	4	0.408	0.919	0.456
	Within Groups	42.207	95	0.444		
	Total	43.840	99			
BIM application enhances environmental building evaluation and contributing to material waste management.	Between Groups	1.518	4	0.380	0.701	0.593
	Within Groups	51.472	95	0.542		
	Total	52.990	99			
BIM application promote the use of environmentally friendly building materials, including efficient and recycled materials.	Between Groups	1.882	4	0.470	0.697	0.596
	Within Groups	64.078	95	0.675		
	Total	65.960	99			
BIM applications encourage the construction of environmentally friendly buildings in a low-pollution manner.	Between Groups	4.051	4	1.013	1.889	0.119
	Within Groups	50.939	95	0.536		
	Total	54.990	99			
BIM application enables cost management in areas of sustainable development that are perceived to have high construction costs.	Between Groups	0.661	4	0.165	0.292	0.883
	Within Groups	53.849	95	0.567		
	Total	54.510	99			
BIM application has many postive advantages of economic activities of buildings, all of which contribute to prompt the industry's sustainability.	Between Groups	1.220	4	0.305	0.647	0.630
	Within Groups	44.780	95	0.471		
	Total	46.000	99			
BIM promotes practices that improve the sustainability efficiency of the design, construction, service, and maintenance of buildings.	Between Groups	.675	4	0.169	0.362	0.835
	Within Groups	44.235	95	0.466		
	Total	44.910	99			
BIM application encourages experimenting with new technology.	Between Groups	.496	4	0.124	0.267	0.898
	Within Groups	44.094	95	0.464		
	Total	44.590	99			

Table 5.4: Continue

Items		Sum of Squares	df	Mean Square	F	Sig.
The BIM improves identifying mistakes before work commences on-site by detecting and reduce clashes, so it reduces the cost.	Between Groups	2.089	4	0.522	0.801	0.527
	Within Groups	61.911	95	0.652		
	Total	64.000	99			
BIM improves the quality of milestones and productivity of companies and organizations of construction projects.	Between Groups	.906	4	0.226	0.565	0.689
	Within Groups	38.094	95	0.401		
	Total	39.000	99			
The BIM contributes to quality control of materials take-offs, minimizing conflict and errors in schedules, and streamlines the management of construction projects results.	Between Groups	2.310	4	0.578	1.046	0.388
	Within Groups	52.440	95	0.552		
	Total	54.750	99			
BIM applications prompt the provision of outdoor and indoor quality requirements for the installation and equipment that is necessary.	Between Groups	0.785	4	0.196	0.442	0.778
	Within Groups	42.205	95	.444		
	Total	42.990	99			
BIM application prompts to adjust for different uses of sustainable construction projects.	Between Groups	5.945	4	1.486	2.821	0.029
	Within Groups	50.055	95	0.527		
	Total	56.000	99			
BIM improves design quality and verifies consistency to the design intent easily, which prevents expensive delays	Between Groups	1.608	4	0.402	0.747	0.562
	Within Groups	51.142	95	0.538		
	Total	52.750	99			
Improve project quality and BIM digital data quality	Between Groups	3.058	4	0.764	1.158	0.335
	Within Groups	62.732	95	0.660		
	Total	65.790	99			
BIM application promotes ethical behavior in terms of meeting building project requirements.	Between Groups	1.685	4	0.421	0.510	0.728
	Within Groups	78.475	95	0.826		
	Total	80.160	99			

Table 5.4: Continue

Items		Sum of Squares	df	Mean Square	F	Sig.
BIM application contributes to preserving local heritage and culture which the social and leads to satisfaction for users sustainable projects.	Between Groups	1.430	4	0.358	0.396	0.811
	Within Groups	85.730	95	0.902		
	Total	87.160	99			
BIM encourages companies to embrace this technology in order to maintain the works market, which acts as a driving force.	Between Groups	5.175	4	1.294	2.177	0.077
	Within Groups	56.465	95	0.594		
	Total	61.640	99			

After conducting a test for the purpose of detecting whether there is a difference in opinion of the survey participants from engineers with varying experiences regarding the benefits of BIM application in the management of sustainable construction, it was noted that there is stability in opinion for all components except for one component, which is "BIM application prompts to adjust for different uses of sustainable construction projects." different sustainable building projects" where the value of the ANOVA test was 2.9 percentage, while all components had a test value greater than 5 percentage as shown in the table (5.4).

5.10 The Challenges to Achieve BIM Application Analysis

The results of the challenges of achieving BIM implementation obtained from the electronic questionnaire were discussed, through which the RII value for each component was found for the purpose of evaluating the respondents' information using equation (5.2) and the RII values that showed the importance of each component were as in Table (5.5). Where the most important components were as follows, which are 3 components:

1. Lack of government awareness, the industry of construction and decision-makers of BIM benefits.
2. Lack of competence and skill to work on BIM
3. A culture of reluctance of workers (designers - contractors - owners in building and construction) to change and adopt new technologies.

While the last component in terms of importance was the component 'There is no sufficient execution of the program's design goals'.

Knowing that all components achieved the best values of RII as shown in Table (5.5).

Table 5.5: The Challenges to Achieve BIM Application's Relative Importance Index Values

Items	RII	Rank	Importance level
A culture of reluctance of workers (designers - contractors - owners in building and construction) to change and adopt new technologies.	0.804	3	H
The height cost of technological advancements.	0.78	9	H-M
Lack of client's demand on BIM.	0.79	5	H-M
There is no sufficient execution of the program's design goals.	0.764	10	H-M
Lack of competence and skill to work on BIM	0.842	2	H
Lack of government awareness, the industry of constructıon and decision-makers of BIM benefits.	0.886	1	H
Adoption of BIM requires patience as it is a lengthy operation.	0.776	8	H-M
Due to the intense pressure on top management to complete the project on time, do not expect them to waste time experimenting with new technology.	0.788	6	H-M
Lack monitoring and assessment can negatively impact and even halt the BIM transformation phase.	0.782	7	H-M
Incomplete visibility of the benefit of using BIM in project management in the investment phase.	0.798	4	H-M

5.11 Chapter Summary

By discussing the results obtained from the electronic questionnaire and by conducting the required tests to determine the extent of the stability and stability of these results, such as the Cronbach's alpha test, and knowing the importance and effectiveness of the results obtained through the (RII) test, as well as knowing the extent of the difference in the opinions of the participants by conducting an ANOVA analysis test Unidirectional. It was found that the results obtained from the electronic questionnaire are all real and have a strong impact on the components mentioned in the questionnaire, and therefore it can be relied upon to achieve the objectives of the research.

6. CONCLUSION AND RECOMMENDATION

This chapter summarizes the results of the research, which examines the importance of using BIM systems in achieving the desired benefit from managing sustainable construction projects.

The remarkable developments in BIM systems hold a lot of promise for addressing the challenges of the construction industry by allowing the project team to test the electronic model of the building prior to its implementation. As the projects that have been successfully implemented using BIM systems have brought many benefits, including design quality, improved construction site productivity, forecasting, optimal cost control, reduced conflicts, increased change management efficiency, reduced rework caused by changes, safety factors, community welfare, and improved sustainable construction and building life cycle from design to use.

Even after the building is occupied, and in general, these changes lead to a reduction in the cost and time of the project, improvement of its quality, the environment, the welfare and security of the community.

The major interest in BIM research has focused on the relationship of BIM systems to sustainable building and project management. Therefore, the aim of this research is to study the impact of the use of BIM systems on both, ie the management of sustainable construction projects through the possibilities available for BIM applications in both sides.

The work was done by searching for the extent of the relationship of the use of BIM systems with the components of sustainable CPM and extrapolating that by sharing the opinion of all workers in the construction industry, including academics and engineers, whether they are implementers or contractors.

This study proposes the use of BIM systems to improve the management of sustainable construction projects. And it allows the design team to invest the time available for innovation and creativity by reducing the time for coordinating plans in one specialty and between different disciplines, which is inefficient with the current systems in place.

In addition to providing a virtual environment for the owner to roam in the building and preview its elements and color schemes. It makes the possibility of providing different alternatives available and is directly related to its impact on the cost.

6.1 The Impact of the Application of BIM Systems on the Management of Sustainable Construction Projects

The researcher studied the possibility of using BIM systems in managing sustainable construction projects. The researcher used several tools and concepts to develop the research. Represented by the scientific review of books and research related to the research, as well as conducting an electronic questionnaire, and the response rate was 100 respondents.

The statistical analysis of the collected data was done using the SPSS statistical analysis program. The results revealed the importance of applying BIM in affecting cost, time, quality, environment and society, in addition to community safety.

The researcher found that the current traditional techniques do not meet the required needs as effective tools for the sustainable CPM process. This is due to the principle of the work of these tools based on independent entities and the creation of multiple representations of one design. As the process of managing changes must take place in a participatory and interactive environment. Therefore, the approach based on a central database with all project information provides a means to improve efficiency for all project phases through optimal management of project information. Managing the workflow during the design and implementation stages, the method of exchanging information and the technology used, in addition to managing the obstacles facing this is the secret of the project's success. By ignoring proper management, this will lead to concessions from the parties to the project and the failure to obtain satisfactory results. The researcher concluded that building information modeling systems ensure the best management of sustainable construction, so one of the objectives of this study was to measure the impact of the use of BIM systems on cost, time, quality, environment, society and safety, and this effect was measured as through an electronic questionnaire.

The researcher concluded that one of the most important things that BIM provides is to provide information related to quantity, cost, schedule and stock of materials, which supports decision makers in making quick informed decisions regarding the performance of the building life cycle, as 93 percentage of the participants agreed on that. Also, one of the most important reasons for wanting to adopt BIM systems was to improve the monitoring and evaluation of sustainable building construction projects by 97 percentage. BIM encourages 90 percentage new technology experience.

BIM also provides better communication for different professions during project design and implementation, reducing time and cost by 94 percentage. BIM improves fault identification before site work begins by detecting and minimizing clashes, thus reducing cost by 86 percentage.

In addition to improving the identification of risks (risk management) to be available in the previous stage before construction. This will improve safety and convenience for users, contingency analysis, increase the ability to resolve requests for information (RFI) from partners in real time, improve simulations and visualize construction details. BIM encourages energy conservation through regulatory energy reduction, energy monitoring, and energy-efficient equipment use.

BIM app evaluates environmental buildings and contributes to managing waste of materials BIM also promotes the use of environmentally friendly building materials, including efficient and recycled materials. BIM promotes practices that improve sustainability efficiency in the design, construction, service, and maintenance of buildings. BIM improves landmark quality and productivity for companies and organizations on construction projects.

BIM contributes to quality control of material take-offs, reduces inconsistencies and errors in schedules, and simplifies the management of construction project results. BIM improves design quality and easily checks consistency with design goal, preventing costly delays, improving project quality and BIM digital data quality, and contributing to preserving local heritage and culture, satisfying users with sustainable projects and encouraging companies to adopt this technology In order to maintain the business market, which acts as a driving force.

There was a clear apprehension about the implementation of BIM due to the lack of awareness of the government, construction industry and decision makers of the benefits of BIM. As well as the need for training and technical expertise due to the lack of competence and skill to work on BIM, as well as the reluctance of workers (designers - contractors - owners in building and construction) to change and rely on new technologies, in addition to the lack of customer demand for BIM.

The researcher found that the costs resulting from the application of BIM systems are considered one of the main obstacles, including the costs of equipment and equipment and costs resulting from training in addition to the lost productivity during the first period of training, in addition to the incomplete vision of the benefit of using BIM in project management in the investment stage.

6.2 Recommendations

6.2.1 Recommendations for Those Involved In Sustainable Construction Project Management

The researcher proposes a set of recommendations, including:

1. Interest in using the application of BIM more broadly in the process of managing construction projects in general and sustainable construction projects in particular by paying attention to training and qualifying workers in this field on this technology, in addition to including it within the training courses of institutes, engineering colleges and specialized academic institutions, providing courses and qualified trainers, and cooperating with qualified companies to provide the necessary support for the application, as well as to focus on specialized and accredited training courses in this field.
2. Keeping pace with the technological development in this field through software and software applications that facilitate this, including the application of BIM, with the need to be patient because technological development continues with the continuity of life.
3. There must be a real effort to overcome all the difficulties and obstacles that stand in the way of integrating BIM application technology with the sustainable construction process, and this falls on the shoulders of the private

sectors represented by the parties to the sustainable and public construction process represented by governments.

4. Providing government support for the implementation of BIM by issuing binding laws to use this technology in major projects of a special nature to obtain licenses and approvals from the municipalities and relevant government agencies and to start a gradual transition to generalization to the rest of the projects and to prepare specifications, codes and contracts regulating the use of this technology in the construction sector in its traditional and sustainable types.

6.2.2 Future Recommendations

The researcher proposes a set of recommendations, including:

1. Intensifying scientific research in the field of sustainable CPM due to the lack of such research in the scientific arena.
2. Research on the efficiency of using BIM systems in managing sustainable construction projects by comparing the costs, times and quality of projects using current and smart methods, in addition to the costs resulting from the application of modern technologies and their impact on return and investment.
3. Activating the role of the unions of engineers and civil institutions specialized in raising awareness and spreading BIM application technology by holding workshops and training courses.
4. Researching the impact of the types of engineering contracts and the methods of delivering projects that are most compatible with BIM systems.
5. Study the impact of the use of BIM systems on the investment and maintenance phase of the building, facilities management and the benefits for the owner through the six-dimensional model (6D model).
6. Researching the correct methods in modeling to obtain the correct quantities and researching other components of the building to enhance the understanding of software requirements for calculating the quantities of building elements.

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APPENDİX

APPENDİX A

REALIZING THE DESIRED BENEFIT OF SUSTAINABLE CONSTRUCTION PROJECT MANAGEMENT BY WORKING ON THE APPLICATION OF BIM

Building Information Modeling (BIM) is the process of generating, managing, and modeling all building information to make it accessible to all project participants during its life cycle and this process is done by dynamic real-time 3D modeling programs to increase productivity in the field of design, construction, and as well as demolition.

With my regard

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Section 1: Respondent's Demographic Data

Engineering Specialization	Civil	
	Architectural	
	Mechanical	
	Electrical	
	Others	

Years of Experience	1 to 5	
	6 to 10	
	11 to 15	
	16 to 20	
	more than 21	

Engineering Occupation	Site Manager	
	Site Engineer	
	Planning Engineer	
	Supervisor	
	Other	

Education Level	BSC	
	MSC	
	PHD	
	Other	

Section 2: Realizing of BIM Benefits to Sustainable Buildings

No.	Items	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	BIM application leads to improve the monitoring and assessment of the construction projects of sustainable buildings.					
2	BIM gives better communication of different professions during the project design and execution, so that will reduce time and cost					
3	Improve risk identification (risk management) to be available in the earlier stage before construction. That will Improve safety, comfort for users, and emergency analysis.					
4	BIM provides information related to quantity, cost, schedule, and material inventory, so that will support decision-makers in taking prompt informed decisions regarding the life cycle performance of a building.					
5	Increase the ability to resolve requests for information (RFIs) from the partners in real-time, so that will reduce the time					
6	BIM Improves simulations and visualization of construction details, so that will Save design time and costs.					
7	BIM application encourages energy conservation through organizational energy reduction, energy monitoring, and the use of energy-efficient and equipment.					
8	BIM application enhances environmental building evaluation and contributing to material waste					

	management.					
9	BIM application promote the use of environmentally friendly building materials, including efficient and recycled materials.					
10	BIM applications encourage the construction of environmentally friendly buildings in a low-pollution manner.					
11	BIM application enables cost management in areas of sustainable development that are perceived to have high construction costs.					
12	BIM application has many postive advantages of economic activities of buildings, all of which contribute to prompt the industry's sustainability.					
13	BIM promotes practices that improve the sustainability efficiency of the design, construction, service, and maintenance of buildings.					
14	BIM application encourages experimenting with new technology.					
15	The BIM improves identifying mistakes before work commences on-site by detecting and reduce clashes, so it reduces the cost.					
16	BIM improves the quality of milestones and productivity of companies and organizations of construction projects.					
17	The BIM contributes to quality control of materials takeoffs, minimizing conflict and errors in schedules, and streamlines the management of construction projects results.					
18	BIM applications prompt the provision of outdoor and indoor quality requirements for the installation and equipment that is necessary.					
19	BIM application prompts to adjust for different uses of sustainable construction projects.					

20	BIM improves design quality and verifies consistency to the design intent easily, which prevents expensive delays					
21	Improve project quality and BIM digital data quality					
22	BIM application promotes ethical behavior in terms of meeting building project requirements.					
23	BIM application contributes to preserving local heritage and culture which the social and leads to satisfaction for users sustainable projects.					
24	BIM encourages companies to embrace this technology in order to maintain the works market, which acts as a driving force.					

Section 3: The Challenges to Achieve BIM Application

No.	Items	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	A culture of reluctance of workers (designers - contractors - owners in building and construction) to change and adopt new technologies.					
2	The height cost of technological advancements.					
3	Lack of client's demand on BIM.					
4	There is no sufficient execution of the program's design goals.					
5	Lack of competence and skill to work on BIM					
6	Lack of government awareness, the industry of construction and decision-makers of BIM benefits.					
7	Adoption of BIM requires patience as it is a lengthy operation.					
8	Due to the intense pressure on top management to complete the project on time, do not expect them to waste time experimenting with new technology.					
9	Lack monitoring and assessment can negatively impact and even halt the BIM transformation phase.					
10	Incomplete visibility of the benefit of using BIM in project management in the investment phase.					

APPENDİX B

Frequencies

Statistics					
		Engineering Specialization	Years of Experience	Engineering Occupation	Education Level
N	Valid	100	100	100	100
	Missing	0	0	0	0
	Mean	1.73	3.84	3.77	2.14

Frequency Table

Engineering Specialization					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Civil	74	74.0	74.0	74.0
	Architectural	1	1.0	1.0	75.0
	Mechanical	9	9.0	9.0	84.0
	Electrical	10	10.0	10.0	94.0
	Other	6	6.0	6.0	100.0
	Total	100	100.0	100.0	

Years of Experience					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-5	10	10.0	10.0	10.0
	6-10	12	12.0	12.0	22.0
	11-15	9	9.0	9.0	31.0
	16-20	22	22.0	22.0	53.0
	more than 21	47	47.0	47.0	100.0
	Total	100	100.0	100.0	

Engineering Occupation					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Site Manager	8	8.0	8.0	8.0
	Site Engineer	14	14.0	14.0	22.0
	Planning Engineer	8	8.0	8.0	30.0
	Supervisor	33	33.0	33.0	63.0
	Other	37	37.0	37.0	100.0
	Total	100	100.0	100.0	

Education Level					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BSC	26	26.0	26.0	26.0
	MSC	42	42.0	42.0	68.0
	PHD	28	28.0	28.0	96.0
	Other	4	4.0	4.0	100.0
	Total	100	100.0	100.0	

Statistics				
	BIM application leads to improve the monitoring and assessment of the construction projects of sustainable buildings.	BIM gives better communicatio n of different professions during the project design and execution, so that will reduce time and cost	Improve risk identification (risk management) to be available in the earlier stage before construction. That will Improve safety, comfort for users, and emergency analysis.	BIM provides information related to quantity, cost, schedule, and material inventory, so that will support decision-makers in taking prompt informed decisions regarding the life cycle performance of a building.

N	Valid	100	100	100	100
	Missing	0	0	0	0
Mean		4.32	4.26	4.19	4.36
Std. Error of Mean		.053	.060	.058	.064
Median		4.00	4.00	4.00	4.00
Mode		4	4	4	4
Std. Deviation		.530	.597	.581	.644
Variance		.280	.356	.337	.415
Skewness		.144	-.449	-.038	-.733
Std. Error of Skewness		.241	.241	.241	.241
Kurtosis		-.740	1.046	-.245	.638
Std. Error of Kurtosis		.478	.478	.478	.478
Range		2	3	2	3
Minimum		3	2	3	2
Maximum		5	5	5	5
Sum		432	426	419	436

Statistics

		Increase the ability to resolve requests for information (RFIs) from the partners in real-time, so that will reduce the time	BIM Improves simulations and visualization of construction details, so that will Save design time and costs.	BIM application encourages energy conservation through organizational energy reduction, energy monitoring, and the use of energy-efficient and equipment.	BIM application enhances environmental building evaluation and contributing to material waste management.
N	Valid	100	100	100	100
	Missing	0	0	0	0
Mean		4.11	4.19	4.04	3.99
Std. Error of Mean		.075	.080	.067	.073
Median		4.00	4.00	4.00	4.00
Mode		4	4	4	4
Std. Deviation		.751	.800	.665	.732
Variance		.564	.640	.443	.535
Skewness		-.622	-1.083	-.044	-.142
Std. Error of Skewness		.241	.241	.241	.241

Kurtosis	.292	1.882	-.697	-.667
Std. Error of Kurtosis	.478	.478	.478	.478
Range	3	4	2	3
Minimum	2	1	3	2
Maximum	5	5	5	5
Sum	411	419	404	399

		BIM application promote the use of environmentally friendly building materials, including efficient and recycled materials.	BIM applications encourage the construction of environmentally friendly buildings in a low-pollution manner.	BIM application enables cost management in areas of sustainable development that are perceived to have high construction costs.	BIM application has many postive advantages of economic activities of buildings, all of which contribute to prompt the industry's sustainability.
N	Valid	100	100	100	100
	Missing	0	0	0	0
Mean		3.98	3.99	4.07	4.00
Std. Error of Mean		.082	.075	.074	.068
Median		4.00	4.00	4.00	4.00
Mode		4	4	4	4
Std. Deviation		.816	.745	.742	.682
Variance		.666	.555	.551	.465
Skewness		-.190	-.432	-.567	-.195
Std. Error of Skewness		.241	.241	.241	.241
Kurtosis		-.940	.047	.294	-.210
Std. Error of Kurtosis		.478	.478	.478	.478
Range		3	3	3	3
Minimum		2	2	2	2
Maximum		5	5	5	5
Sum		398	399	407	400

RESUME

2010–now

Working in Baghdad College of Economic Sciences as Lab Supervisor engineer to this present day.

2011–2013

Working in Korek Telecom as a NMS engineer in Core operation

EDUCATION:

- Gedik University, Engineering Management, MSc. 2019-2020
- University of Technology, Telecommunication Engineering department, B.Sc. in Laser Engineering and Optical electronics. 2007-2008.
- AL-kindy Secondary school,2002-2003

APPLICATION PROGRAMS:

1. Software Skills (MS Office , MS Adobe Photoshop. ,MatLab, SQL server, Python, C++)
2. Maintenance of computers and networks
3. GSM Network

ACADEMIC ACTIVITIES:

- Member of Iraqi engineering union.
- Giving advance course for network & computer connection in Baghdad College of Economic Sciences
- Certificate in (Information Security based on ISO 27001:2013) from Innovators Training Company
- Mm Certificate in (Documentation of quality manual and procedures based on ISO 9001 & 10013) from Innovators Training Company
- Certificate in (QMS ISO 9001:2015) from Innovators Training Company
- Certificate in (Good Laboratory practice GLP according to Criteria of OECD on testing and calibration) from Innovators Training Company

PUBLICATIONS/PRESENTATIONS ON THE THESIS:

- “Laser Application And Artificial Intelligence Utilization In Production Quality Management: Piping Fabrication” International Journal of Soft Computing and Artificial Intelligence (IJSCAI), Vol.2. No.3.