T.C.
ISTANBUL GEDİK NIVERSITY
INSTITUTE OF GRADUATE STUDIES

APPLICATION OF BUILDING INFORMATION MODELING TO CONSTRUCTION PROJECTS STAGE

MASTER's THESIS

Arwa Emad Shakir AL-KHAFAJI

Engineering Management Department

Engineering Management Master in English Program

AUGUST 2023

T.C.
ISTANBUL GEDİK NIVERSITY
INSTITUTE OF GRADUATE STUDIES

APPLICATION OF BUILDING INFORMATION MODELING TO CONSTRUCTION PROJECTS STAGE

MASTER's THESIS

Arwa Emad Shakir AL-KHAFAJI
(211281009)

Engineering Management Department

Engineering Management Master in English Program

Thesis Advisor: Assoc. Prof. Dr. Redvan GHASEMLOUNIA

AUGUST 2023

T.C.
İSTANBUL GEDİK ÜNİVERSİTESİ
LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ MÜDÜRLÜĞÜ

Yüksek Lisans Tez Onay Belgesi

Enstitümüz, Engineering Management Department İngilizce Tezli Yüksek Lisans Programı (211281009) numaralı öğrencisi Arwa Emad Shakir AL-KHAFAJI'nin "Application of Building Information Modeling to Construction Projects Stage" adlı tez çalışması Enstitümüz Yönetim Kurulunun 03/08/2023 tarihinde oluşturulan jüri tarafından *Oy Birliği* ile Yüksek Lisans tezi olarak *Kabul* edilmiştir.

<u>Öğretim Üyesi Adı Soyadı</u>

Tez SavunmaTarihi: 03/08/2023

1) Tez Danışmanı: Doç. Dr. Redvan GHASEMLOUNIA

2) Jüri Üyesi: Dr. Öğr. Üyesi Tuğbay Burçin GÜMÜŞ

3) Jüri Üyesi: Dr. Öğr. Üyesi Mert TOLON

DECLARATION

I, Arwa Emad Shakir Al-Khafaji, declare that this thesis titled “Application of Building Information Modeling to Construction Projects Stages” is original work done by me for the award of the master’s 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. (03/08/2023)

Arwa Emad Shakir AL-KHAFAJI

DEDICATION

As well as everything that I do, I would be honored to dedicate this study to my parents. The two people gave me the tools and values necessary to be where I am standing today. My parents support me at every step I make, and decision I take; but is necessary to understand that they let me take my decisions alone in order for me to learn from my personal mistake and as my father says to "learn and grow from each seatback". I will never finish thanking my father and mother for all the opportunities they have offered and given me.

Also, I dedicate this study to my brother Ayad, who passed away a few months ago, leaving me in grieve and sadness, he encouraged me to continue with my master's study, and was so happy for me, Ayad, may Allah have peace and mercy on your sweet soul, you will always be in my heart forever.

I dedicate this study to my siblings who are my backbone and always trusted me, I'd like to tell them that they are my pillars in this world.

I dedicate this study to my soulmate, who was and still with me every step of the way, you brought happiness and joy to my life since the moment you came.

I dedicate this study to my best friend, the one who was with me in the bad times before the best, it's true that we are distant in places but close in hearts.

I dedicate this study to my supervisor, Dr. Redvan, a great teacher. Your support all the time kept me energic to complete my thesis.

Finally, I dedicate my study to my all family and friends, who showed me support, love and were happy for me.

PREFACE

Foremost thanks to Allah, the most beneficent and merciful, who helped me to complete this study and to submit it in such a way.

I would like to express my thanks, appreciation, and gratitude to my supervisor, Assist. Prof. Dr. Redvan Ghasemlounia for his concern, guidance, and advice.

Special thanks to my family who supported me in my study. Especially to my beloved mother who is always ready to support me.

Special thanks to my soulmate, you are the greatest person I’ve ever known.

August 2023 Arwa Emad Shakir AL-KHAFAJI

TABLE OF CONTENT

Page

ABBREVIATIONS

2D	: Two Dimension
3D	: Three Dimension
AEC	: Architecture Engineering and Construction
BDS	: Building Description System
BREEAM	: Building Research Establishment Environmental Assessment Method
CAD	: Computer-Aided Design
CAFM	: Computer-Aided Facility Management
CED	: Cumulative Energy Demand
CO_2	: Carbon dioxide
EC	: European Commission
FM	: Facility Management
FMA	: International Facility Management Association
GDL	: Geometric Desecration Language
HVAC	: Heating, Ventilation, Air Conditioning
IEA	: International Energy Agency
IES	: Integrated environmental Solution
IFC	: Industry Foundation Classes
ISO	: International Organization for Standardization
IT	: Information Technology
LCA	: Life Cycle Assessment
LEED	: Leadership in Energy and Environmental Design
MEP	: Mechanical, Electrical, and Plumbing
ROI	: Return on Investment
SC	: Sustainable Construction
SD	: Sustainable Development
USGBC U.S.	: Green Building Council
WCED	: World Commission on Environment and Development

LIST OF TABLES

LIST OF FIGURES

APPLICATION OF BUILDING INFORMATION MODELING TO CONSTRUCTION PROJECTS STAGE

ABSTRACT

This study will focus on the Implementation of BIM in the field of sustainable design and its advantages for Management, which integrates Building Information Modelling (BIM) with the principles underlying the Sustainable Design methodology in order to maximize the advantages for proprietors.

In point of fact, BIM and sustainable Planning are a new type of production that starts with a concept, then moves on to feasibility, software development, initial study, making strategies, initial study layout, manufacturing, offering over, functioning, and finally ends with the deconstruction or repair of the construction. Nevertheless, in terms of the whole procedure, the initial inquiry is the most important component. This is due to the fact that various essential parts are developed based on the results of the search.

In most cases, the research process is carried out with the end goal in mind of acquiring the necessary documentation for the reasons that will ultimately be served. However, in order to have sustainable planning, there are a few aspects that ought to be taken into consideration during the design stages. These aspects include things like how efficiently electricity is used, environmental concerns, and so on.

BIM is a popular technology that is used for the reconnaissance of a project's characteristics prior to the manufacturing stage. The utilization of BIM makes it possible for proprietors, engineers, designers, and builders to create a unified platform on which they can investigate all of the components and test the features and overall efficiency for the purpose of alteration and correction when the building is built.

The criteria that specialists and owners have for BIM, as well as the expectations that they have of it, are investigated in this thesis. We identify the criteria that owners will use to determine whether or not they will utilize BIM, as well as the decisions that result from those factors. After gaining knowledge of the fundamental issues that owners have regarding the cost, duration, and quality of the project as a whole, interviews with industry professionals that specialize in the planning and construction stages were carried out.

The questionnaire focused on the advantages of BIM for owners, and the responses were examined using academic resources and supplemented with the author's thoughts, and also the researcher spotlighted the obstacles that impede owners from implementing BIM in their projects and how these obstacles may be overcome.

The final stage is a discussion of the identified elements, which are derived from the interviews and the context in which they were conducted. This thesis will eventually be beneficial for the operation of making choices for owners. It will enable the examination of the essential aspects discovered in this research, which will determine whether or not BIM will be used in a particular project.

Keywords: *Sustainable Building, Building Information Modelling, Implementing Building Information Modelling*

YAPI BİLGİ MODELLEMESİNİN İNŞAAT PROJELERİ AŞAMASINA UYGULANMASI

ÖZET

Bu çalışma, mülk sahipleri için avantajları en üst düzeye çıkarmak amacıyla Bina Bilgi Modellemesini (BIM) Sürdürülebilir Tasarım metodolojisinin altında yatan ilkelerle bütünleştiren sürdürülebilir tasarım alanında BIM'in Uygulanmasına ve Yönetim için avantajlarına odaklanacaktır.

Aslında, BIM ve sürdürülebilir Planlama, bir konseptle başlayan, ardından fizibilite, yazılım geliştirme, ilk etüt, strateji oluşturma, ilk etüt düzeni, üretim, teklif verme, işleme ve nihayet sona eren yeni bir üretim türüdür. yapının yıkımı veya onarımı ile. yine de tüm prosedür açısından ilk sorgulama en önemli bileşendir. Bunun nedeni, arama sonuçlarına göre çeşitli temel parçaların geliştirilmiş olmasıdır.

Çoğu durumda, araştırma süreci, sonuçta hizmet edilecek nedenlerle gerekli belgeleri elde etme nihai hedefi ile gerçekleştirilir. Ancak sürdürülebilir bir planlama için tasarım aşamalarında dikkate alınması gereken birkaç husus vardır. Bu yönler, elektriğin ne kadar verimli kullanıldığı, çevresel kaygılar vb. gibi şeyleri içerir.

BIM, bir projenin özelliklerinin üretim aşamasından önce keşfedilmesi için kullanılan popüler bir teknolojidir. BIM'in kullanılması, mal sahiplerinin, mühendislerin, tasarımcıların ve inşaatçıların, bina inşa edildiğinde değişiklik ve düzeltme amacıyla tüm bileşenleri inceleyebilecekleri, özellikleri ve genel verimliliği test edebilecekleri birleşik bir platform oluşturmalarını mümkün kılar.

Bu tezde uzmanların ve mal sahiplerinin BIM için sahip oldukları kriterler ve BIM'den beklentileri araştırılmıştır. Sahiplerin BIM'i kullanıp kullanmayacaklarını belirlemek için kullanacakları kriterleri ve bu faktörlerden kaynaklanan kararları belirliyoruz. Proje sahiplerinin projenin maliyeti, süresi ve kalitesi ile ilgili temel sorunları hakkında bilgi sahibi olunduktan sonra, planlama ve inşaat aşamalarında uzmanlaşmış sektör profesyonelleri ile görüşmeler gerçekleştirildi.

BIM'in mal sahipleri için avantajlarına odaklanan ankette, yanıtlar akademik kaynaklar kullanılarak incelendi ve yazarın düşünceleri ile desteklendi ve ayrıca araştırmacı, mal sahiplerinin projelerinde BIM'i uygulamalarının önündeki engellere ve bu engellerin nasıl aşılabileceğine ışık tuttu. .

Son aşama, görüşmelerden ve yürütüldükleri bağlamdan elde edilen tanımlanmış unsurların tartışılmasıdır. Bu tez, sonunda sahipler için seçim yapma işlemi için faydalı olacaktır. BIM'in belirli bir projede kullanılıp kullanılmayacağını belirleyecek olan bu araştırmada keşfedilen en önemli yönlerin incelenmesini sağlayacaktır.

Anahtar Sözcükler: *Sürdürülebilir Bina, Bina Bilgi Modellemesi, Bina Bilgi Modellemesini Uygulama.*

1. INTRODUCTION

1.1 General Introduction

It is a truth that cannot be refuted that human operations have a significant effect on the environment, like the melting of glaciers, the rise in sea level, the change in meteorological conditions, the lack of available water, and the destruction of tropical forests, which causes the greenhouse impacts and emissions of greenhouse gases (Samimpay and Saghatforoush, 2020).

In addition, since the construction sector develops at a rapid pace, the number of structures is expected to more than double by the year 2030, resulting in an increased demand for energy. Furthermore, the "International Energy Agency (IEA)" predicts that the rise in "energy demand" will rise by 30% by the year "2030", which will result in a rise in the rates of energy consumption, particularly in emerging nations (Samimpay and Saghatforoush, 2020).

The construction sector is an important one that makes a contribution to the expansion of the socioeconomic system, particularly in nations that are still growing. Furthermore, the building industry is the primary sector responsible for the global trend away from sustainable development. For example, the industry uses up forty per cent of the world's entire energy production, forty per cent of all of the raw materials, and twenty-five per cent of all of the lumber that is produced.

According to Khoshfetrat et al. (2011), the building sector is responsible for producing 35% of all CO_2 emissions as well as 16% of the overall water use.

It is essential to have efficient management, communication, and collaboration in order to complete the requirements of a project in the building industry, which is a broad, vast, and demanding environment. Understanding Building Information Modeling, more commonly referred to as BIM, is one of the foremost cutting-edge methodologies for attaining sustainability and unified design. BIM is used in the fields of architecture, engineering planning, and building design.

BIM offers actual time management of changes, which makes it feasible to employ an integrated digital database framework for construction and an elevated level of document preprocessing; all of these combine to stimulate a higher quality of work, improved efficiency, and reduced expenses (Silva et al., 2016).

Principles regarding Building Information Modeling (BIM) have been developed by a number of different businesses, the majority of whom are owners creating and managing several sites. The majority of nations throughout the world have implemented BIM after realizing the advantages that can be gained by their respective building businesses from using this technology. According to Zakari et al., (2014), one of these benefits is an increase in the amount of coordination and cooperation between the various sectors.

The capability of the application to include virtualized design principles and clash identification applications is one of the primary reasons why building information modelling (BIM) is gaining widespread recognition around the world; nevertheless, its use is restricted in the middle east. This is one of the primary reasons why BIM has become so popular. Choose the appropriate project elements that have led to the adoption of BIM to boost the efficiency of the construction sector before construction applications, offer reports on schemes and assistance, and choose suitable project elements. In addition to this, Building Information Modeling (BIM) is going to become of the construction business; organizations that do not adopt it will be phased out (Gerges et al., 2017).

The BIM technique is more suited to large-scale endeavours than it is to relatively modest undertakings, and it requires additional development and testing time before it can be made available to entrepreneurs.

Sustainable structures are plans that take into account ecological contexts and make use of energy efficiency in man-made environments to create ones that are both more pleasant to spend time in and less harmful to the planet. They are designed to be as adaptable as possible to their circumstances and to the environment as a whole. When properly applied, Building Information Modeling (BIM) is an emerging innovative in the construction sector that can help provide adequate project effectiveness, precise timing and quantity departure schedules, and reduced project costs. For example, this instrument can lead to less wasteful and energy-hungry design processes that encourage passive design strategies.

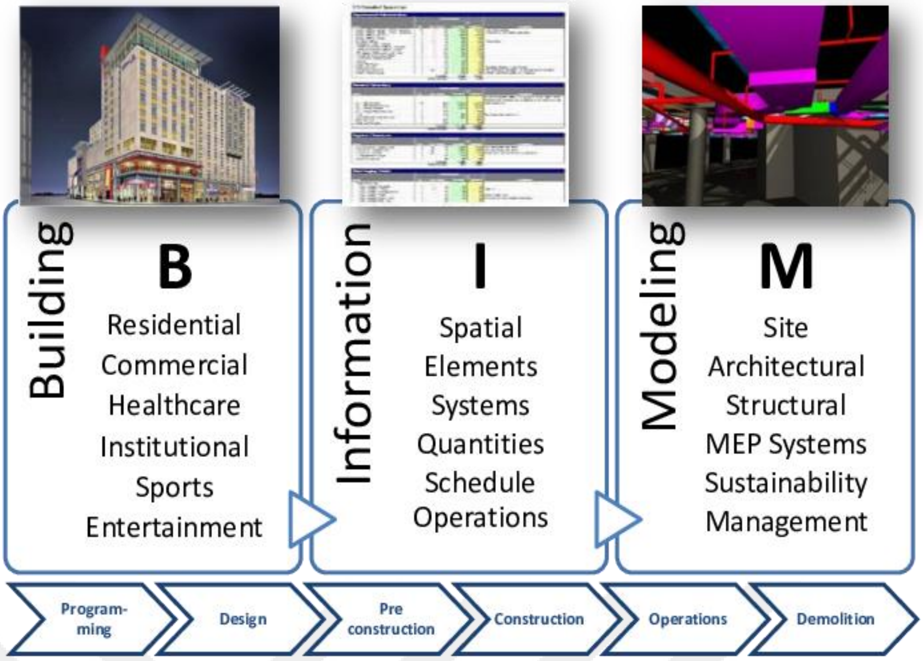

Figure 1.1: A Visualization of the BIM Principle

Source: Guerriero et al., (2017)

In order to build environmentally friendly and long-lasting constructions, one must keep the following concerns in mind at all times:

- Make satisfied use of the most fundamental aspect of human nature.
- An effective influence on the planning process.
- The aspect of reducing waste should be taken into consideration during design as much as is practically possible.
- Efforts should be made to cut down on the amount spent on building maintenance as much as possible.
- It is recommended that during the design process, a high value be placed on nature in order to encourage further development.

1.2 Statement of Problem

This research investigates the factors that influence the decision of enterprises working in the sector of building construction to embrace Building Information Modeling (BIM), as well as the obstacles and benefits that those organizations may encounter as a result of doing so. The combination of building information modelling (BIM) and environmentally responsible architecture is the focus of this study. The current owners and organizations are attempting to make an understanding of the most effective link between BIM and rational design in the hopes that it will be of benefit to them and has many benefits both for the earth and entrepreneurs.

Today, management is a worldwide trend because it is one of the basic solutions for ecological change; the world is engaged in a competition to lessen gas outflows and any other activities that have a negative impact and have the potential to seriously impact the earth. It is, to tell the truth, an approaching time bomb, and there will be a period when the acknowledgement that it is past the moment of no return will arrive unless the move is done at this point in time. The only way to avoid this is to make the move immediately.

The manufacturing sector of manufactured conditions and advancements has its fair share of effects and has had a considerable negative impact up to this point. Building new structures has a significant impact on the environment; it is a required consumer of land and raw resources and generates an unnecessary quantity of garbage. Recently, sustainable development has been recognized as one of the most important responses for reducing the emissions of ozone-depleting substances by buildings and increasing the use of power generated by plants.

1.3 Purposes and Targets

The purpose of this research is to look into not only the benefits of utilizing a BIM application in the design and construction sector but also the drawbacks and difficulties associated with doing so. It is possible to forecast the benefits of how Building Information Modeling (BIM) will boost efficiency in the building sector with an understanding of the program and how it operates. Their viewpoints will also be gathered regarding the implementation of BIM on projects, including the merits and disadvantages of this methodology in terms of efficiency.

The demand for the usage of complex advancements within a limited span of time and budget has increased the necessity for a more unexpected and advanced strategy for advancement rather than the conventional approach.

This requirement has increased the necessity for a more propulsive strategy for advancement. At the end of the working day, in order to keep from exceeding the confinements, we need to think about a more planned and technology-involved strategy for design initiative and, in addition, the assembly advance in the improvement process. This is something that we need to do so that we don't wind up exceeding the limitations.

Because of this, the role of the planner will need to be expanded to that of a general venture arranger of the geometric approach, which will call for adjustments to both the way the activity is performed and the way it is understood. Utilizing a BIM-based strategy, some academics believe, may deprive the brain of a draftsman of its capacity for clean and adaptable innovation as well as the creative energy it contains. On the other hand, numerous specialists are working to improve society's acquaintance with BIM, its compositional benefits, and other benefits.

There is still a significant number of industry professionals that believe BIM to be an instrument for documenting; thus, they employ it in the phases that follow after they have completed planning in their own individual strategy. It is important to identify building information modelling (BIM) as remarkable among other methodologies available to date for the design that produces the most output.

An isolated framework is offered as part of a BIM-based approach. In this structure, the undertaking benefits from both BIM and sustainability being coordinated together into one innovative and extensively productive blend. As a result, automation of the planning and assembly process has the potential to be viewed as an effective solution for addressing several destinations' viewing concerns, such as erection faults, waste of materials, and, consequently, bad quality in implementations.

1.4 Research Questions

- What are the advantages that employing BIM brings to organizations?
- What obstacles impede owners from implementing BIM in their projects, and how may these obstacles be overcome?
- To what extent does the implementation of BIM play a role in the development of environmentally responsible design procedures?
- What types of instruments and platforms are there, and do any of them have the capacity to monitor the various ways that different methods of BIM and sustainable characteristics use in projects?

- Is it possible for owners to make a profit from employing BIM in environmentally responsible design while also providing benefits to society and the environment?
- How valuable is Building Information Modeling (BIM) to shareholders, and how can this value be transformed into sustainability?

1.5 Significance of Research

The primary purpose of the study is to identify the challenges that are faced by or inhibit the deployment of BIM technology in construction management and to put up a solution to embrace BIM as quickly as possible.

To clarify the desired return from the application of BIM technology at the level of the construction industry and to raise it to a higher level through the introduction of programs covered by the BIM and to lay the foundations for a curriculum at the university that adopts this technology, adopting its teaching, training students, and benefiting from the experiences of neighbouring countries in this field.

It is crucial to have a working knowledge of the practical principles and initiatives utilized in the modern construction business in order to have a complete understanding of how the building sector operates and, more importantly, how BIM may impact the building sector.

The implementation of BIM in the building sector is bringing to light challenges that need to be solved. Due to a lack of recordkeeping, there are several constraints to contend with, including the fact that historical data is not easily accessible. This software is still in its early stages, and although the vast majority of industry professionals believe that building information modelling (BIM) is the way of the future for the construction sector, architects and engineers are making the transition very slowly. The Building Information Model (BIM) is becoming increasingly popular in the construction industry as a result of the many ways in which it integrates with the planning and estimation software that is presently in operation.

1.6 Overview of Thesis

The thesis contributes to the rapidly expanding field of research known as BIM by examining and analyzing the BIM implementation process from various perspectives, including the academic sector. The thesis's overall framework is five further chapters after this introductory chapter.

- The first part, the introduction (Chapter 1)
- A review of the existing literature (Chapter 2)
- BIM and sustainable construction (Chapter 3)
- Create survey questionnaires, upload them to the platform, and distribute them via email to academic institutions, businesses, and industry professionals, and analysis of the results using the SPSS program (Chapter 4)
- Conclusion and Recommendations (Chapter5)

2. SUSTAINABLE CONSTRUCTION

2.1 General Review

One of the most important challenges in our world is sustainable development (SD). These have developed from limited environmental conservation concerns to larger social or economic growth issues. The claim on the sustainable building also has developed. This claim is sufficient to imitate the increase of natural resource exhaustion, increasing energy expenses, and greenhouse emissions pollution and a greater understanding of the condition of indoor air. This chapter reviews a summary of SD and its background; the chapter discusses the first purpose of this research study with the theoretical background, focused on the principle of sustainable construction. The first aim of this research study with the theoretical history of the sustainable building definition is covered in this Chapter.

In the recent thirty years, SD has played a significant role in the main field of social issues. Where is a continuous mission to assess and how to make development, the main challenge is to evaluate achievements in sustainable development, where no more action decisions could be made in addition to assigning a clear vision of the present situation, there is indeed a general awareness that sustainable development is beneficial, refers to inter-temporal justice, and also serves multiple elements to achieve useful life after several cycles of lives (Kardos, 2012).

Malthus (1766–1834) and William Stanley Jevons (1835–82), and other theorists from the 18th and 19th centuries who were interested in the lack of resources, especially in growing numbers of population upwards (Malthus) and energy shortages are among the key concerns concerning SD (Jevons). Between Fairfield Osborn (1953) and Samuel Ordway, the issue was posed in the 1950s (1953).

It wasn't before the sixties, so the seventies, but there was some discomfort in a large segment regarding community feeling. The intensity of worries in relation to the environment, especially the wellness hazards due to practical pollution, has marked such decades. This led to traditional production economic development's environmental views in effect (Baker, 2006). As an outcome of these growing worries, over the past 40 years, the UN, an international organization shaped by the USA, has been helping to improve international peace and safety. Sustainable Development Strategy, the European Commission (EC) started by publishing the main evaluation on the development achieved since 2001 in February 2005, and established action guidelines for future years on environmental issues, threats to public health, lack and social inclusion, the absence, and exclusion of citizens. On this basis, a statement on sustainable development recommendations, including a revised Lisbon Agenda on Growth and Jobs, was adopted in 2005 (Hategan and Ivan, 2014).

They are also seeking to find some kind of consensus at the UN on being interested in the UN Convention on Environmental Change (UNFCCC). In 1992, the Rio Convention was adopted in international society and executed in Japan in 1994, after which the Kyoto Protocol was introduced in international society (UN, 1998).

This was primarily made according to practice in developed countries as it has the ideals to reduce GHG pollution. Until 2005, the necessary industrialized countries had agreed to sign its implementation, but the Kyoto Protocol was not implemented. Consequently, the first effort and commitment period for GHG emissions were in 2008 and 2012. The World SD conference on the sustainable development platform, kept in Aichi-Nagoya, Japan, in 2014, is also organized in certain programs, teaching the public about the existence of SD.

The convention was defined and implemented in the later years of the United Nations Development Instruction, and until 2005–2014, the Convention dedicated intensive efforts to eradicate poverty and hunger. The convention saved earthly sources and provided an extra environment for the livelihood of human beings, as announced at the UN sustainable development summit in New York in 2015.

These varied initiatives, as described above, contributed to activities to reach SD and also helped decrease GHG emission levels at the series of UN meetings in Copenhagen and Denmark. In the event that we look at the gist of it all, the enhancements that we are achieving are a consequence of the numerous changes in the present government that have agreed to strengthen the social and economic climate. The implementation of SD is rendered significantly advantageous in different sectors, including agriculture, mining, manufacturing, construction, and other industries. Sustainability is often misunderstood, considering the long history of SD. The implementation of SD is rendered significantly advantageous in different sectors, including agriculture, mining, manufacturing, construction, and other industries. Sustainability is often misunderstood, considering the long history of SD.

2.2 Definition of Sustainable Development

The notion of sustainability serves as the overarching compass for the many components of the growth strategy for the countries. During the course of the past two decades, the international community has started to operate as a unified system with common goals for global growth. These aims strive to hasten human growth, particularly in the poorest countries of the world, while simultaneously eradicating the profound injustices that are a byproduct of development and safeguarding the natural ecosystems of the earth (WCED, 1987).

According to the WCED report, " Humanity has the ability to make advancement sustainable so that it meets the demands of the present without compromising upcoming generations' ability to meet their own demands." This is the definition of sustainable development, where this report demonstrated that the biosphere's capacity to tolerate the negative consequences of human activity has its limits.

In addition, the report concluded that poverty is not inevitable and that technological and social parties can be controlled to pave the path for a new economic boom (WCED, 1987). The SDGs are designed to ensure that our economic, social, and environmental structures remain stable throughout time.

All of these structures are interconnected with one another and with people's requirements for the goods and services provided by ecosystems for their material well-being and safety.

Services provided by ecosystems to humans include the provision of groundwater, air, food, and energy, amongst many others. Humans have the ability to change the conditions of ecosystems, which can either make them more or less appealing to people. It is common knowledge that human wellbeing, precarity, and safety are negatively impacted when ecosystems are unable to provide the services that humans require, despite the fact that these consequences are frequently the direct result of human activities (Reyers et al., 2021).

The “World Commission on Environment and Development “(WCED) has given its stamp of approval to an overarching conceptual framework for sustainable development. The outcomes of the conference indicate that the state of the world's three pillars of sustainability has reached a "critical moment."

The ability of the globe to produce food is in jeopardy as a result of damage to the global soil base, which is being caused by growing populations as well as the clearing of forests and other natural areas, which results in a loss of biodiversity (WCED, 1987).

The concept of sustainable development was initially conceived as a way of thinking about how to protect the natural environment; however, it has since evolved into a more comprehensive framework for guiding mankind into the future. Today's concept of sustainable development takes into account all three pillars, often known as sets of goals: the economic, the social, and the environmental (Reyers et al., 2021).

Figure (2-1) is a Venn diagram depicting the interdependency of the three tenets of sustainable development.

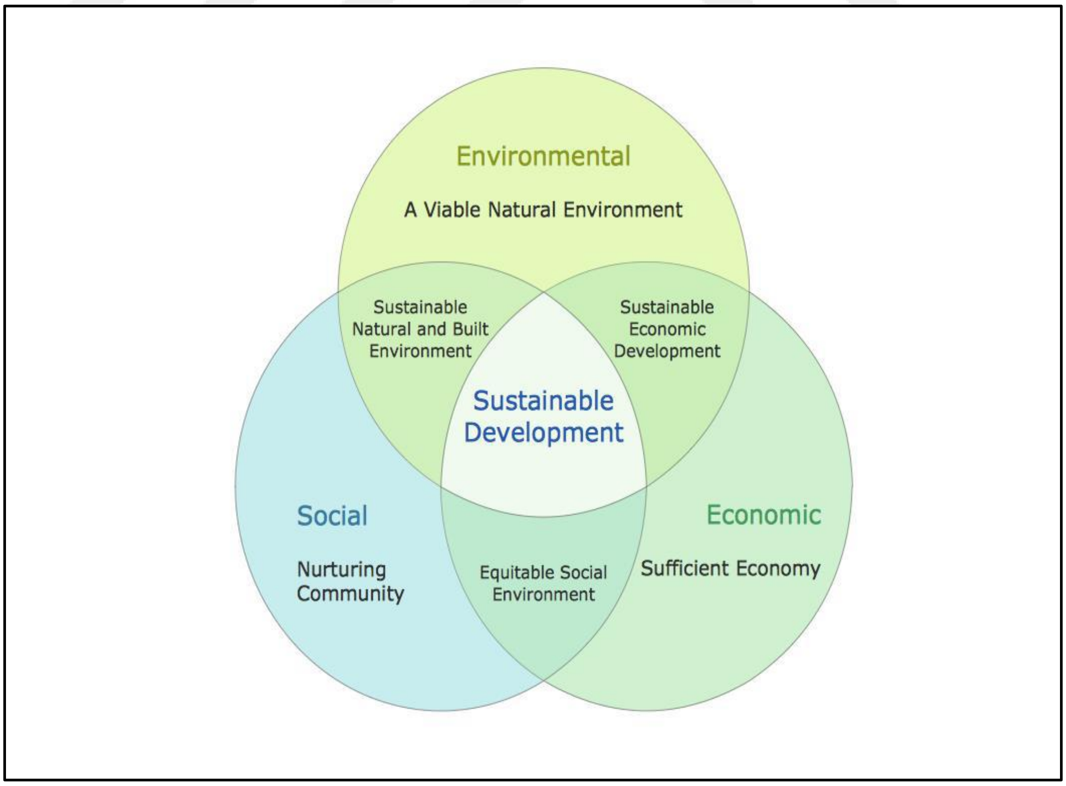

Figure 2.1: Visual Sustainable Development Goals Venn Diagram Template

Source: Josephsen (2017)

- Economic Element: Growth in the economy, which is essential to national power and societal prosperity, is bolstered by sustainable development. There are two aspects of economic growth that sustainability advocates are concerned with, in addition to stressing technological advancements, resource conservation, waste mitigation, and efficiency increases (Xu et al., 2020).
- Environmental Element: Coordination between social and economic progress and the capacity of Earth's natural systems is central to the concept of sustainable development, which holds that failing to do so will inevitably lead to resource depletion and slow progress (Xu et al., 2020).
- Social Element: Sustainable development is a strategy for promoting both environmental safety and social justice. Different regions of the world have unique development methods to further their own unique agendas. However, these development plans should aim to better people's lives and foster a social climate that prioritizes issues of fairness, freedom, and knowledge. The plan for sustainable development has economic sustainability as its foundation, environmental sustainability as a necessary condition, and social sustainability as its ultimate goal (Xu et al., 2020).

2.3 SD in the Industry of Construction

2.3.1 Sustainable in industry

Sustainable construction is a strategy commonly applied to the construction industry in order to improve sustainable growth. When looking at the construction industry, it is defined as a whole community of individuals who create, establish, manage, design, construct, change, or save the current environment and consists of providing the materials and producers for those clients or users.

The sustainability framework can be got as a subcategory of sustainable growth, covering things such as the design of things, the purchase of things, the planning of the locations, the choice of things it is being recycled, and the minimum waste requirements (Khalfan et al., 2022).

Du Plessis (2002) defines another SC as the holistic method through the principles of sustainable growth, from the extraction and use of raw materials to the preparation, design, and construction of buildings and infrastructures to the potential final demolition and the management of events waste.

The more recent definition of SC is a way of looking at construction company operations that incorporates environmental, social, and economic concerns in their values. This proposal places sustainable development concepts in all the buildings and facilities that we create, from natural resources to the management, configuration, and implementation of facilities and the management of waste (Tan et al., 2011).

The construction industry refers in particular to the workplaces that can cause a lot of people to suffer from bad weather conditions and subsequent illnesses, as it affects entire social activities of people in our life and, because of that, can have a great effect on our health and well-being, which plays a significant part in our social life. In order to determine where the industry requires to modify and improve its processes, it is first important to consider which industry has the largest impact.

2.3.2 Effect on the construction industry of sustainable development

Buildings' sustainable performance is of paramount importance to construction professionals for several reasons, including the growing recognition of the significance of a sustainable construction sector. Among these are a variety of national and regional motivations and aims, as well as a growing knowledge about how construction contributes to environmental deterioration, which has, in turn, prompted a variety of initiatives, including building regulation and evaluation (Tokbolat et al., 2020).

It is essential to the success of the project to have all of the project's stakeholders involved and working together from the early stages of design. It is also essential to raise awareness about the positive effects that sustainable construction techniques have on the environment.

According to (Du Plessis, 2002), sustainable building is "an all-encompassing process that seeks to restore and maintain the balance between the natural and built ecosystems while also producing settlements that recognize human dignity and promote economic fairness."

Figure (2-2) depicts the overarching structure that sustainably-minded building practices rest upon.

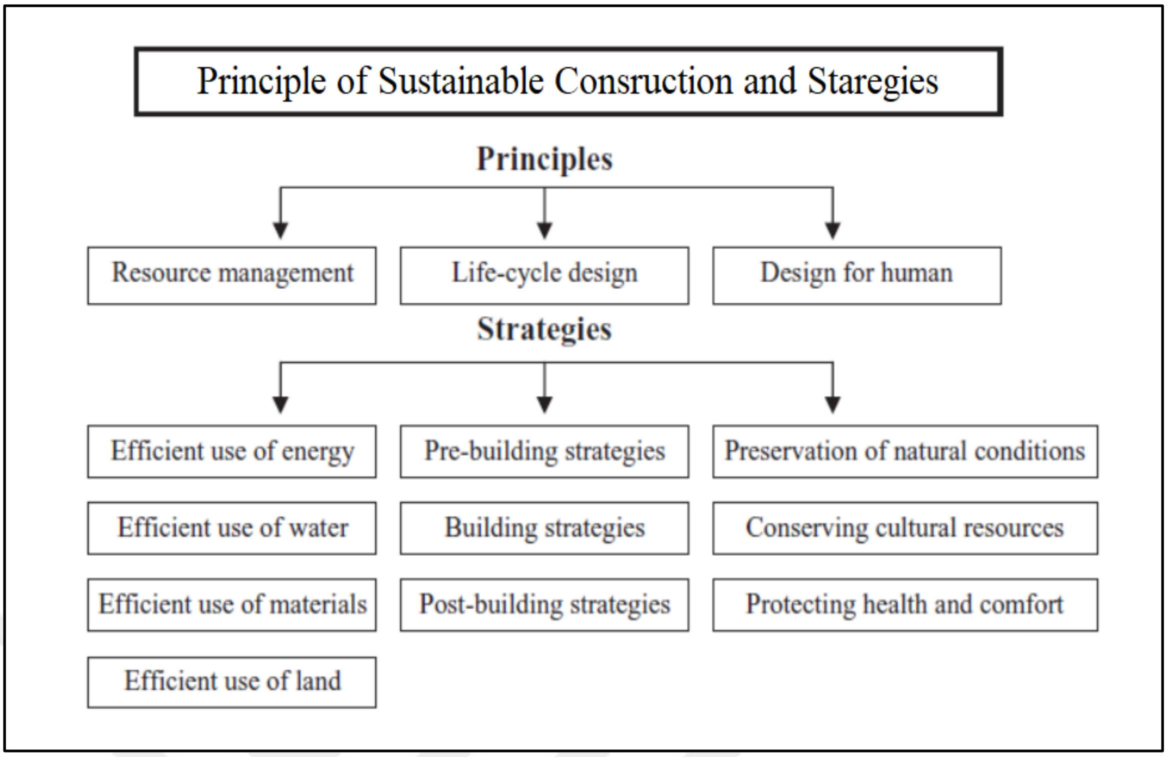

Figure 2.2: Effect on the Construction Industry of Sustainable Development

Source: Sev, (2009)

The main pollution is due to industry, and it responds to carbon dioxide due to the energy used for manufacturing, transport, construction, and operation of raw materials, repair, demolition, and generation of waste (Lei et al., 2020).

Because the environmental damage produced by the construction industry is cumulative in nature, sustainable practices should be included into every stage of the lifecycle of a project, beginning with the initial design and continuing all the way through to the final deconstruction.

Reducing resource consumption, reusing resources, using recyclable materials, protecting the environment, removing toxic substances, applying lifecycle expenses, and placing emphasis on quality are all principles of sustainable construction that instruct decision-makers across all of a building's entire lifecycle. The goal of the sustainable building industry is to uphold the ideals of sustainable development while fostering the expansion of the market (Al-Yami, and Sanni-Anibire, 2021).

Calculating the influence that sustainable development will have on the construction sector may be done by analyzing the benefits that SD brings to the table when it comes to combining the fundamental needs of societies, corporations, and governments in terms of housing and social infrastructure. The intention of the entire industry as a whole and its high economic worth have resulted in substantial negative effects on the environment and on society, including increased levels of air pollution and negative health effects (Hategan and Ivan-Ungureanu, 2014).

However, for any country's economic development, innovation in the built environment remains important. The BSI (2008) has shown this: this is a critical region in the economies of the country; a key factor for helping poor people to create, function, and sustain to reduce poverty; it is the main provider of employment; it is a large volumetric resource that is absorbed; it is a significant pollutant in the environment; and it contributes to the growth of (Al-Yami, and Sanni-Anibire, 2021).

2.3.3 Planning and preparation for construction project

The overall environmental performance of a building needs to be tested before it is completed; where more methods have been created over the years to measure the general sustainable efficiency of a building in helping SD in the current environment, where these evaluation tools play a necessary role in increasing consciousness and developing the construction industry into increasingly sustainable building procedures across the world.

The individuals participating in a construction project in order to meet the client's specifications, where the construction procedure can be classified into three primary stages: pre-construction, construction, and post-construction (Shipman and Siemiatycki, 2022). Figure (2-3) displays the "per-construction stage" of the building project lifecycle.

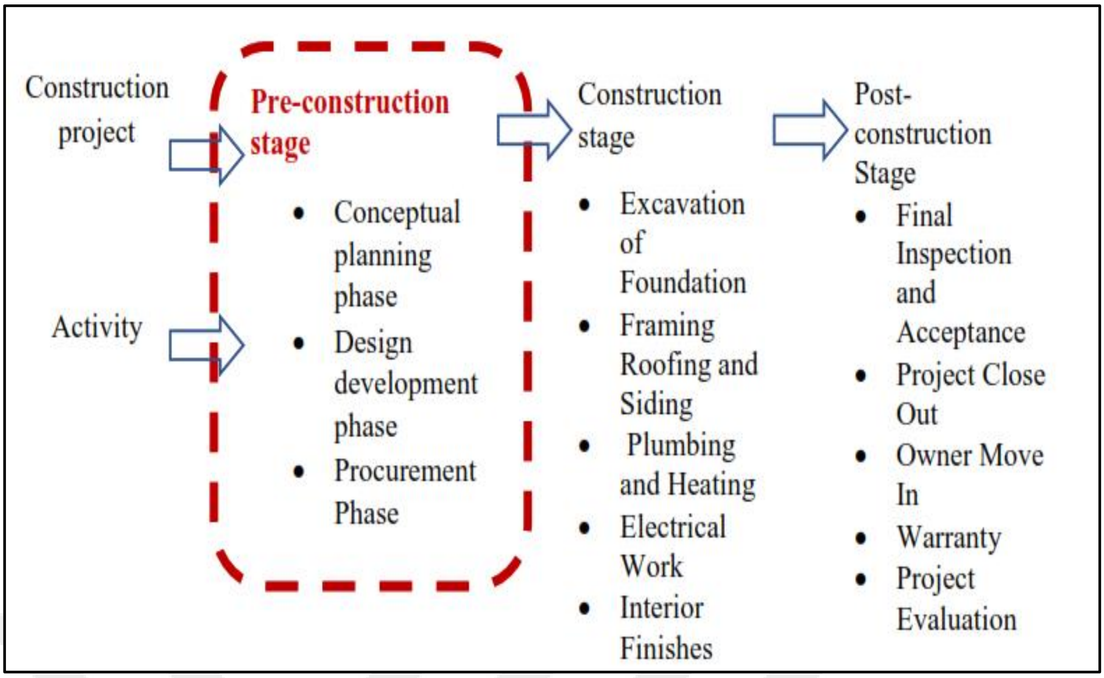

Figure 2.3: Construction Project Stages

Source: Shipman and Siemiatycki, (2022)

During the pre-construction step of a project, decisions concerning the project's objectives and performance are made. The designing process consists of four phases: pre-design and economic analyses, conception design, design improvement, final design, and contracting.

The collaboration between the various parties involved is necessary in order to prevent design issues such as design adjustments, design scuffles, poor design manufacturability, and poor 2D drawings. These design issues are the primary contributors to a variety of construction issues, including project delay, cost overrun, conflicts, and low efficiency (Kikwasi, 2012).

- Conceptual planning phase: the stage in a project when designers give the owner crucial information for making judgments about the project's viability. At this stage, the consulting group creates a rough budget, schedule, and outline for the project.
- Design development phase: the stage in which the design team uses their preliminary sketches to explore and compare potential design directions, components, and systems. The comprehensive design then got ready to assess, choose, and finalize the project's primary systems and parts. The consulting group

then creates the necessary technical documentation, specifications, fundamental conditions, timetables, and budget.

- Procurement phase: preparations for contracting out the work and completing the project within its set budget and timeframe. After the design phase is complete, the next step is to begin preparing the site for the building.

The impact that pre-construction issues had on the subsequent stages of construction is illustrated in figure (2.4).

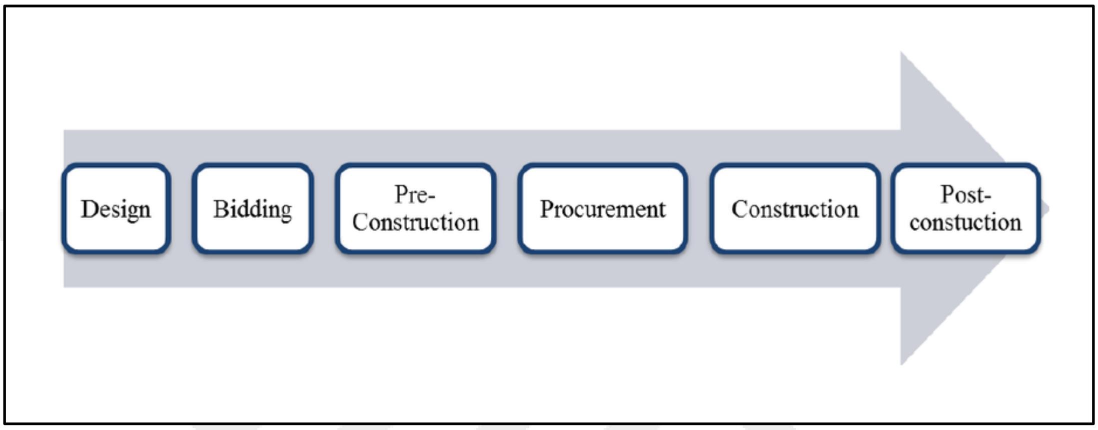

Figure 2.4: Impact of Pre-Construction Issues on the Subsequent Stages of Construction

Source: Shipman and Siemiatycki, (2022)

2.4 Process for Delivering Sustainable Buildings

The process of designing a building consists of a series of distinct steps, each of which is carried out in strict adherence to predetermined guidelines. If the client's needs are not met by the first design concept, the designers will revise and improve the plan. Iteratively refining the design until it delivers the promised results is a time-consuming and error-prone process (Shipman and Siemiatycki, 2022).

Sustainable design centres on improving people's daily lives. It aspires to enhance people's social, economic, and environmental circumstances by providing them with a healthy place to live. To be considered sustainable, a building must adhere to standards such as low energy use, reduced greenhouse gas emissions, increased indoor air quality, decreased noise levels, and minimal disruption to the surrounding ecosystem. In addition, with just minimal upkeep and recycling after demolition, a building should last until the end of its useful life cycle.

Recently, stakeholders in the construction industry have started to take significant action in an effort to offset the detrimental impacts that the practices of their profession have on the surrounding environment. The design team may be able to mitigate the unfavourable effects that the construction project will have on the natural environment if they plan the project with sustainability aims in mind. There is empirical evidence that supports this assertion (Akadiri et al., 2012).

2.5 Sustainability Evaluation Tools in Construction

The overall environmental performance of a building needs to be tested before it is completed, where more methods have been created over the years to measure the general sustainable efficiency of a building in helping SD in the current environment.

According to Carmody et al. (2009), these evaluation tools play a necessary role in increasing consciousness and developing the construction industry into increasingly sustainable building procedures across the world. This leads to sustainable building achievement and is an instrument that motivates the design, service, maintenance, and deconstruction of sustainable buildings. They lead to greater convergence between environment, social, economic, and other parameters for choice (Braganca et al., 2010).

In order to inspire designers and builders to enhance the efficiency of the building, they have objectively been designed to calculate the effect of a project on sustainable qualities. These assessment instruments have been developed 15 years ago to determine the viability of a building through a variety of parameters (AlWaer and Kirk, 2012).

Where building evaluation methods perform significant importance in the evaluation of sustainability and in evaluating different levels of sustainable development (Reed et al., 2011).

The collected of 3 categories: Systems for “Cumulative Energy Demand (CED)” focusing on energy use, Life Cycle Analysis focused on the environmental aspect, and “System Total Quality Assessment (TQAS)” (Gordon et al.,2011).

2.5.1 Systems for cumulative energy demand

Systems Cumulative Energy Demand (CED) has popularly been recognized for evaluating building energy use.

However, Tronchin and Fabbri (2008) clarified the partial measures such as energy and emergency do not apply where energy is the most beneficial assignment, which takes a system into a thermal balance, and solar energy is not used directly in a transformation director but is directly available.

These units of measurement, as per Marszal et al., (2011), are related to thermodynamic concepts of the useful utilization of resources and whilst may also be more suitable for determining the use of heat in buildings than for electricity.

CED technologies monitor and analyze the energy usage of buildings, such as heating, ventilation, air conditioning, heating and electricity, and communications (Berardi, 2012).

2.5.2 Net zero energy

The net-zero-energy buildings (ZEB) are domestic or industrial building that needs substantially fewer energy thanks to efficiency features that allow renewable energy balancing. Despite the fascination with the term "zero energy," we need a joint description of what it means or a common understanding (Torcellini et al., 2006).

In terms of energy usage and the climate, buildings have a major impact. Industrial and residential buildings in the United States use about (40%) of critical energy and about (70%) of power (EIA, 2005).

The energy used by the building partition continues to rise, mostly because of the fact that new buildings are designed faster than old ones. Between 1980 and 2000, the use of electricity in commercial buildings is doubled, and by 2025, another (50) per cent is projected to rise (EIA, 2005).

Energy consumption will rise in the commercial construction sector before buildings can generate sufficient energy to offset the building's increasing energy demand. In order to do this, the US Department of Energy (DOE) has a strategy for creating a low-budget zero energy commercial building (ZEB) base with technical know-how and capacity by 2025.

Depending on the constraint and metric, the ZEB may be defined in different methods. Depending on project wishes and the principles of the design community and building owner, different meanings can also be preserved. Building owners, for example, are serious about the cost of electricity. Organizations like DOE have broad country numbers and are typically interested in mainstream or source energy. A building designer may also be involved in using energy for energy codes.

Finally, those interested in polluting power plants and fossil fuel combustion should also engage in pollution reduction. Four major concepts: net-zero energy, net-zero energy sources, net-zero energy costs, and net-zero energy pollution. There are four common definitions (Petersburg et al., 2006).

- Net Zero Energy Pollution: A net-zero pollution building produces at minimum as much pollutions-free renewable energy as it uses from pollution-producing energy sources.
- Net-Zero Energy: A Site ZEB creates at least the same amount of energy used on the site in a year.
- Net-Zero Energy Source: A source ZEB creates at least as much energy in a year, when taken into account at the source. Energy source refers to the primary energy that is used to create and supply the site with energy. The related site-to-source conversion multipliers are used to measure the total energy source for a building. Imported and exported energy.
- Net-Zero Energy Costs: The money that the service provider spends on the cost of ZEB, the power supplier of buildings, is equal to the amount of electricity the owner pays for the energy supplies and the energy used during the year, at least to the amount the building exports to the grid.

2.5.3 Life-cycle analysis

The Life Cycle Analysis (LCA) centres on the SD environmental element and provides construction materials and products with environmental impact evaluation. These assessment methods include environmental assessment systems such as Environmental Risk Assessment (ERA), Material Flow Accounting (MFA), Input-Output Analysis (IOA), and Life Cycle Assessment (LCA), where LCA is the system more widely used (Hauschild et al., 2018).

The LCA separates the construction of basic operations and raw materials and measures the environmental effects of the building from the cradle to the grave over the life cycle. Where the capacity to extract or process raw materials, to generate, transport and distribute raw materials, to use, reuse, maintain, recycle and finish disposal (Hauschild et al., 2018).

In addition, by defining and quantifying resources, materials, and wastes produced by the environment, LCA also assesses the environmental burden associated with a product, process, or operation. It also measures the environmental impacts of goods and recognizes and evaluates ways to change the environment (SETAC, 1993).

LCA is also an international instrument for assessing the effect of products and structures on the environment during their lives. LCA allows engineering experts to analyze various building designs on the basis of the environmental effects and to implement educated decisions about the relevant materials. The LCA enables the assessment of the environmental effect of various building structures in a single area and different building types in different geographical areas (Zabalza et al., 2013).

The LCA includes four interconnected steps, due to Weißenbergera: description of aim and scope; analysis of life cycle inventory, evaluation of the effect of the life cycle; and analysis of the outcome. The objective and the scoping stage constitute the definition of the aim and scope in accordance with standards.

The second phase, the life-cycle inventory review, involves the quantification of the whole substance and energy flow input and output in a generally thorough lifestyle inventory assessment. At this point, the information obtained in the life cycle inventory analysis (substances and flow analysis) is analyzed in accordance with its possible environmental impacts. The third phase is the life cycle effect assessment. And at the end, the fourth phase includes the review of life cycle inventory outcomes and the evaluation of the life cycle effect cycle to extract environmental effects and to offer submission of decision-makers (Weißenbergera, 2014).

This is not only because of the functionality of the buildings but because the life length of the buildings makes it more difficult to use LCA over the entire life cycle; because of the improvements in the life cycle of the building, because of the simplicity of the making such modifications and the minimal environmental effect of these modifications. For almost all phases of the building life cycle, therefore, new alternatives must be created (Hauschild et al., 2018).

The application of LCA in the field of construction is a particular practice in contrast with other sectors and is currently the main important sector of LCA application. There is a constraint on LCA technology, in which tests the environmental concept of SD without acknowledging social and economic impacts (Hauschild et al., 2018).

Berardi (2012) recommends a mixture of LCA and Life Cycle Cost (LCC) analyses in order to comply with this restriction. The utilization of LCC is the capacity to measure the expenses related to the construction method for the whole facility. LCC is the means by which costs of the whole construction phase are recorded, and these costs are usually reduced to their present value.

Reducing entire installation costs makes it possible to compare alternative building systems and compares a selection of alternative systems' current value (Hodges, 2005).

Restricted application, limited versatility, and limited accessibility are the majority of open methods used for LCC and LCA execution in the building industry. They demand that the enhanced design and efficiency of the SD lead to effective tools for LCAs. The normal practice of implementing fixed criteria for the life-cycle analysis and for life-cycle evaluation stages is restricted to LCA, where the operating stage of the longest period building can have significant effects on the environment, resulting in variations that are often greater in this phase than the total effects of materials, design, or life-time end (Chatti et al., 2012).

2.5.4 Total quality assessment system

The total quality assessment system (TQAS) aims at three elements: the environmental and energy pollution factors, investment economic factors and equity, and social needs such as the accessibility and quality of the areas. The system aims to achieve a total system for the sustainable development of buildings. Moreover, Multi-Criterion systems are called TQAS (Cai and Zhu, 2015).

Multi-criterion systems include the Building Research Establishment Environmental Assessment Method (BREEAM) developed in the UK, the Leadership in Energy and Environmental Design (LEED) developed in the US, Comprehensive Assessment

System for Built Environment Efficiency (CASBEE) developed in Japan, Sustainable Building Tool (SBTOOl), Green Building Index (GBI) developed in Malaysia, Hong Kong the Building Environmental Assessment Method developed in Hong Kong, the Australian Building Greenhouse Rating (ABGR), the Green Home Evaluation Manual (GHEM), the Chinese Three Star, the US Assessment and the Rating System (STARS), and the South African Sustainable Building Assessment Tool (SBAT) (Alyamia and Rezgui, 2012; (Shi et al., 2012;).

While frameworks assist in identifying sustainable construction requirements, where these multi-criterion frameworks are composed of several specifications that quantify the sustainability of a building (Carmody et al., 2009).

Each method weights a guaranteed number of points available over the total evaluation. TQA, with respect to sustainability, is the compilation of results from the evaluated parameters and states that the system's summing process is important because it assigns rankings to elements that have been positively assessed. It is generally understandable and can be implemented in steps for each criterion, allowing a building to be assessed at different stages from design to design and, moreover, over the entire construction as correctly as possible (Berardi, 2012).

The three main types of Multi-criteria recommended by Srinivasan et al. (2014), which are: evaluation frameworks, evaluation of research tools, and metrics. The evaluation frameworks are interconnected and standardized evaluation models that provide tools for a comparison of a variety of project alternatives. The evaluation of research tools helps to analyze and provide potential solutions for specific problems during the construction of a house, and these instruments are divided into tools for reduction and non-reduction (Srinivasan et al., 2014).

A cost-benefit analysis was used to assess output by minimizing the challenging structure according to fewer variables and combining its properties; these simplistic methods involving non-reductionist instruments involve a multi-criteria analysis that involves partly subjective analytical equivalents (Henrichson and Rinaldi, 2014).

Performance indicators, as per Srinivasan et al. (2014), to evaluate the sustainability of the building includes the Ecological Level (like the Environmental Impact), the Building Level (like Zero Energy), and the Building Environmental Level (like LEED, BREEAM, and GREEN GLOBES, Stool, GBI, SBAT, and so on).

2.5.4.1 BREEAM

The BREEAM, which means a Building Research Establishment Environmental Assessment Method, was created by the BRE and is a template used for the design of sustainability evaluation instruments worldwide, such as the Green Star in Australia and the HK-BEAM in Hong Kong (Ding, 2008).

With more than (425,000) facilities with BREEAM evaluation tools accredited and about two million authorized for evaluation in greater than fifty countries as of 1990, BREEAM is the world's widest environmental evaluation and inspection framework for structures (Yuhui, 2013).

BREEAM has an extensive building measurement and definition system (BREEAM, 2012) in which guidelines are set for best practices in the building industry; BREEAM has a broad structure.

In the following places, BREEAM tests the efficiency of buildings:

- Management: Regulation for general management, site management overseeing, and procedural matters.
- Energy: issues of pollution and running energy
- Pollution: consideration of air and water pollution
- Health and well-being: health and well-being considerations indoors and outdoors
- Transport: carbon due to transportation
- Land usage: places of the green and brown region
- Ecology: protection of the ecological benefit and site improvement
- Materials: impacts of environmental-related to construction materials
- Water: water quality and consumption
- Innovation

The BREEAM application requires an examination of the above categories in terms of practice and results, which allows for the award of credits in the ten grades (Pitt et al., 2009), a method to measure the BREEAM values of Great Britain as demonstrated in (Figure 2.4). Each category has different requirements, where the contributions may be attributed or produced on the basis of such parameters. The weightings were developed during the national advisory process in the UK (Sev, 2011).

These attributes are accumulated in order to generate a level cumulative ranking on a level of strong, very strong, or excellent.

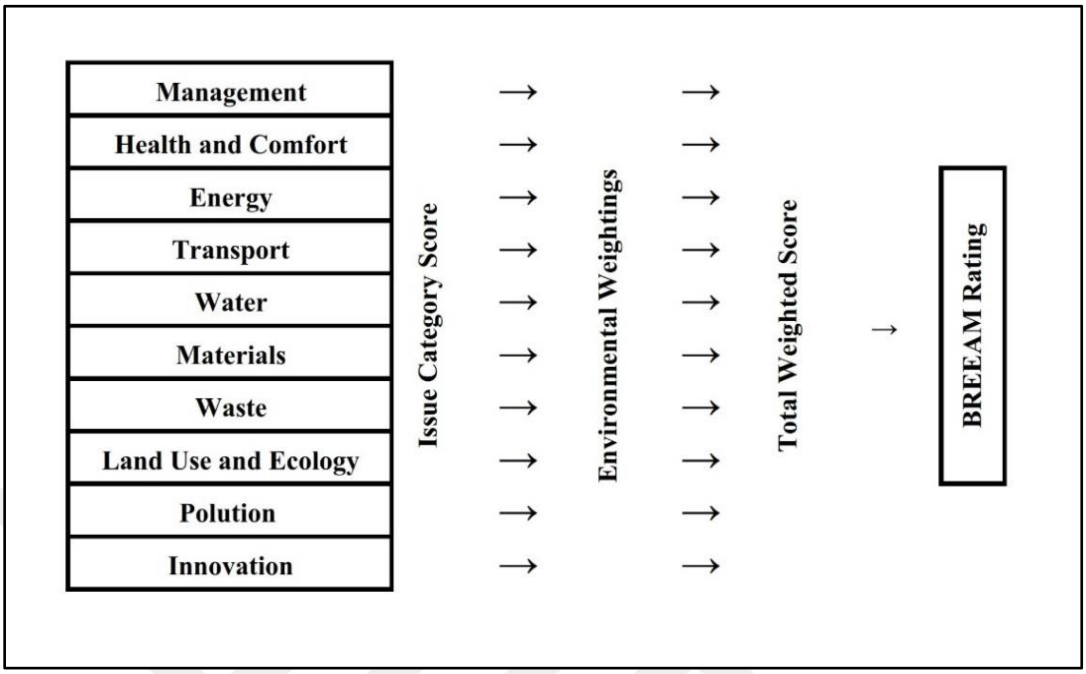

Figure 2.5: BREEAM Scoring Estimate of UK

Source: Pitt et al, (2009)

2.5.4.2 LEED

This was founded in 1998, by the United States Green Building Council (USGBC), with several parties involved, to turn to a demand for green buildings (Zimmerman and Kibert 2007).

Regarding USGBC, LEED is the second most commonly used sustainability assessment tool in the world, with (20,000) projects that were approved and registered, where LEED that accounts for energy and environmental design leadership. Members of the design team will control the progress of their project toward a LEED rating without the need for specialization of consultants during the project itself. It is well-founded in science and is linked to its demand.

LEED evaluation consists of three phases:

- Pre-requirements: the specifications to be achieved once the proposal can be evaluated.
- Core attributes: credits provided to meet or exceed the criteria of the 5 first criteria.
- Innovation credits: performance credits offered; key credits issued in the past.

Alyamia and Rezgui (2012) describe in order to provide a systematic, simple framework to evaluate overall building performance and to achieve sustainable development goals, the LEED evaluation was created through a consistency process involving some key actors, the different sustainability classes are evenly the weighted and different points are taken into account, and the credits allocated to each form are joined together. Table (2.4) shows the evaluation attributes.

Table 2.1: Division of LEED Points

Criteria	Attributes
Sustainable Location	26
Quality of Water	10
Environmental and Energy	35
Products and Materials	14
Interior Quality of Climate	15
Innovation	6
Regional Priority	4

Source: LEED, (2011)

These evaluation methods helped develop SD skills and understanding in the construction industry. However, Gifford (2008) indicates that the BREEAM evaluation range is broader and that its standards are more complex to follow with the LEED criteria, which means that BREEAM compared with LEED, is a much more complete technique.

2.5.4.3 SBTOOL

The concept of SBTOOL has a framework for building efficiency assessment which is utilized by the third side to create evaluation systems for a number of different regional criteria and facility types, and the rating system toolbox may also be considered.

The SBTOOl is concentrated on the concept of adapting a rating system to local requirements before its findings can make sense. The system, therefore, has a typical structure to identify local context conditions and establish excellent weights and benchmarks in local non-commercial organizations (Larsoon and Macias, 2012).

Through the global effort for a sustainable construction environment, SBTOOl was developed by the collaboration of over 20 governments as a sustainable building method. The tool has been developed so that countries can create their own local rating systems to fix local climatic conditions and languages (Larsson, 2014).

It helps users in various regions and countries participating in this assessment process to represent the different goals, technology, building tradition and cultural values.

This is why national groups can boost their benchmarks and weightings using different methods, such as the analytical hierarchy system, as shown in table (2.5) (Knollenberg et al, 2014).

Table 2.2: SBTOOL Environmental Credits

Criteria	Weightings (%)
Location Choosing, and Project Managing	7.6
Energy and Products Utilization	21
Environmental Factors	25.2
Interior Quality of Climate	21
Quality of Services	15.1
Elements of Socioeconomic	5
Elements of Cultural and behavioural	5

Source: Knollenberg, et al., (2018)

2.5.4.4 CASBEE

The CASBEE is Japan's green construction management system, and it represents the "Comprehensive Assessment System for Built Environment Efficiency", where the rating instrument uses a weighting system that allows for the positioning of environmental concerns in the sense of a conditional environment.

CASBEE is an assessment tool introduced by Japan's state, established under the Building, Infrastructure, and Transportation Ministry, to evaluate the overall environmental performance of a facility (CASBEE, 2011).

The four main elements of CASBEE consist of the 80 sub-criteria for energy conservation, resource efficiency, the local environment, and the indoor environment.

In addition, these groups are re-classified into two main groups: Q (quality) and L (loading) (Horvat and Fazio, 2005).

Rather than simply applying attributes points combined, the CASBEE integrates the concept of building environmental efficiency, as seen in Equation (2.1) (BEE). Excluding the weighting factors for the classification of different kinds of buildings, the execution of its particular plan to achieve the final results is differentiated from the other evaluations, where those are focused primarily on the results of a survey of response stakeholders like designers occupants of buildings, and customers. The answers are then evaluated by analytical hierarchy.

$$\boldsymbol{BEE} = \frac{\boldsymbol{Efficiency\ of\ Environmental\ construction}}{\boldsymbol{Processing\ of\ Environmental\ \ Construction}} \tag{2.1}$$

2.5.5 Developing the evaluation tools for the building sustainable

More than 600 sustainability evaluation systems are available worldwide, but neither of such systems will prosper effectively if they have been utilized in nations where they were not initially intended to operate (Morrison-Saunders and Retief, 2014).

Because of who it is being built, each tool must be customized according to take into account the local climate. To attain sustainability, Comparisons of actual personal projects evaluated by each strategy often need to be communicated. Such direct assessment of the rating categories within each system isn't really easy and, at the same time, expensive (Morrison-Saunders and Retief, 2014).

Frameworks of sustainability evaluations vary from overall energy efficiency assessment towards multi-dimensional performance evaluation. Therefore, the viability of the building should be evaluated for any sub-element, like the services, the system structure, and the construction as a whole; therefore, the need for different evaluation and ranking tools must be evaluated, following the implementation of the Sustainable Building Alliance, these variations between systems have led to the establishment of common assessment categories and the improvement of comparability between systems (Berardi, 2012).

Although the resources for sustainable building evaluation tools have increased, Seles involving researchers such as Rumsey, McLellan (2005), Schindler, and Udall have been criticized for engaging in their evaluation process (2005). The US National Institute of Standards and Technology (NIST) analyzed the LEED system in the light of LCA; they put an end to its confined scientific marker system, that is not a credible sustainability evaluation regulation (Suzer, 2019).

LEED is increasingly being enhanced to develop the building's sustainability efficiency.

LEED-NC is currently in operation for the design of housing and the construction of new buildings for schools, residences, hospitals, data centres, warehouses, etc. LEEDs for external plans, LEEDs for current buildings, and LEEDs for new property improvement projects are also available (USGBC, 2016).

Over the years BREEAM have developed, where the (BREEAM-NC), a guide with more than 400 pages that may be utilized for urban, private, residential, and industrial structures,

Including construction modifications, it was originally published on a BREEAM 20 pages long and deals with a variety of issues (Soulti and Leonard, 2016).

The BREEAM is available for current non-residential facilities, and the BREEAM communities are planned for the sustainable design of new communities' master plans or redevelopment projects. BREEAM is also eligible for the rehabilitation of existing buildings with international renovation and fit-out technical requirements (BREEAM, 2016). However, it promotes the adaptation of these instruments in countries that have not yet built their own resources, with attention to sustainable buildings.

2.6 SB and the Constructability Methodology

The demand for sustainable buildings is increasing in AEC industry, where sustainable design has demonstrated its capacity to reduce energy and water consumption, mitigate the environmental effects of construction projects, and promote the use of environmentally friendly materials. When a sustainable building's design is managed using a traditional project management approach, it can lead to a less effective design and construction phase. Methods are needed to capture the knowledge of sustainable buildings in order to speed up the abilities of construction experts in creating green structures. With its potential to enhance construction via the design process, constructability addresses sustainability from the earliest stage of design. This is achieved by decreasing waste materials, increasing site safety, decreasing field labour costs, and streamlining construction. Both constructability and sustainable design aim to improve building industry processes and lessen the negative effects of construction projects on the natural environment, although the latter adds a greater focus on environmental considerations. As reported by (Horman et al., 2006).

It is advantageous for owners, developers, designers, and other stakeholders to make a decision about a sustainable building during the pre-construction phase in order to estimate the costs associated with the construction process. For instance, designers prefer to study and analyze various design factors at the conceptual stage of projects (e.g., materials, technologies, and locations) that have a direct impact on the concepts, measurements, and cost of Sustainable Universal Design (SUD) (Bryde et al., 2013).

There is a need for a cutting-edge method of evaluating sustainability and constructability in design, which is currently lacking in the construction sector as a whole. Funds, the scope of work, effective project scheduling, avoiding changes, disagreements, and delays, and materials procurement are just a few of the overlapping activities that must be managed in order to successfully complete a construction project. In the realm of building, information is crucial and often convoluted. The human element has always been the controller of information coordination, with numerous meetings, reports, work schedules, and blue papers utilized to coordinate the job progress. By supplying managers with accurate, visual, and up-to-date model data, IT advancements would be helpful in organizing this information and allowing them to keep tabs on the design and building process.

Computerizing a project allows for faster and more accurate results. In addition, today's IT solutions are utilized for cross-discipline coordination in construction role description and documentation. The most cutting-edge piece of information technology now being used in buildings is called Building Information Modeling (BIM).

Building information modelling (BIM) is a technique whereby an accurate digital representation of an architecture’s physical and functional attributes is constructed, studied, documented, and evaluated virtually before being altered to produce the best possible building design. Building Information Modeling (BIM) is a database that includes essential information packages for project practices like estimating, scheduling, change orders, etc., in addition to a 3D project model. Before the actual building begins, BIM allows for a realistic simulation of the project to be created (Yalcinkaya and Arditi, 2013).

BIM is also understood as a novel method that gives architects and engineers command over project costs from the outset. Before a building even exists, the architect or engineer can use it to see how the finished product will look and how different materials and technology will interact (Bryde et al., 2013).

The chapter then goes on to talk about the SDGs and the role the building industry plays in achieving them. Sustainable design and constructability, two key ideas in sustainable construction, are used throughout this chapter to define sustainable construction theories and practices. In conclusion, the chapter emphasized the importance of using innovative technologies, such as BIM, to manage the entangled and complex construction operations.

3. BIM AND SUSTAINABLE CONSTRUCTION

3.1 General Review

In the recent few decades, there has been a tremendous uptick in the usage of IT solutions to enhance the quality of construction papers and streamline the workflow across the various disciplines involved in a building project. These days, technology tools in a variety of formats are used to construct every project.

Project engineers make most decisions pertaining to the project's constructability, as shown in figure (3.1), and these decisions are presented to the team via the construction documentation (2D and 3D drawings, schedules in several formats, numerous diagrams, graphs, tables, and etc.).

To work together, engineers must exchange data in order to make necessary adjustments to the project's approach, detailed design, cost, and timetable.

Figure 3.1: Construction Feasibility Analysis of Multiple Diagrams for a Project

Source: Fischer and Kunz (2004)

In isolation from one another's thoughts, engineers each present their own vision of the present and future based on their readings of the relevant texts. IT helps with the multidisciplinary management and coordination of construction projects because so many discussions and decisions need to include all of the engineers from multiple disciplines. Integrating and coordinating information across disciplines and across the many stages of a project is one of the primary goals of computerizing the design approach (Fischer and Kunz, 2004).

In the 1990s, people started talking about the concept of an integrated strategy for construction management, where project information is described as a collection of information technology (IT) methodologies, tools, and standards for creating programs that manage, exchange, and share product details.

Figure (3.2) illustrates the divergence between the two models of information exchange. All parties involved in a project only need to enter their information once into the shared building product, and they may all make changes and additions at the same period (Elhendawi, 2018).

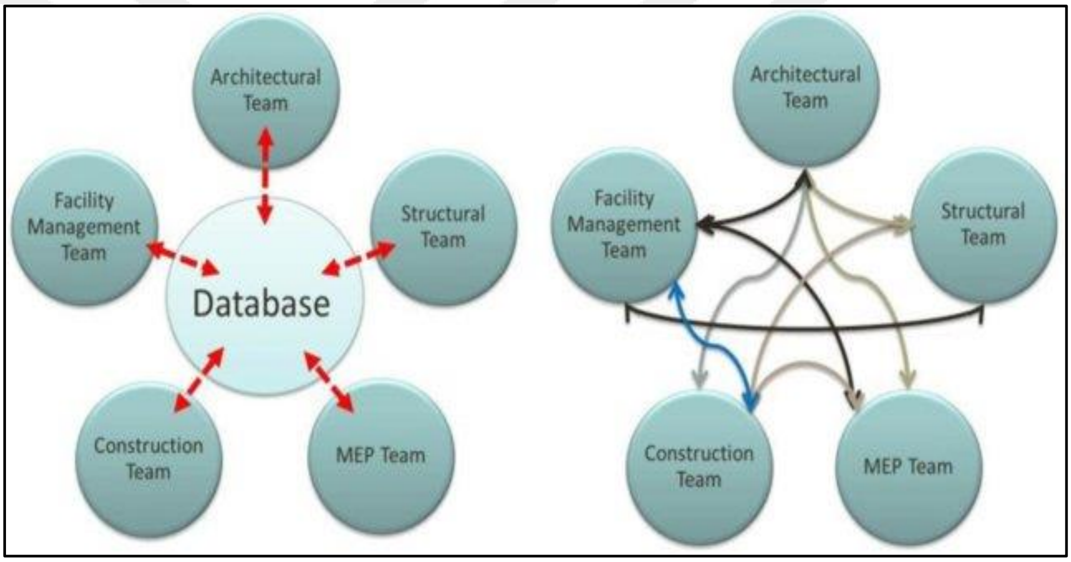

Figure 3.2: Distinctions between Conventional and İntegrated Methods of Coordinating and Correlating

Source: Elhendawi, (2018)

3.2 Building Information Modeling (BIM)

The construction sector has benefited greatly from computerization because of the time and effort savings it has brought. Building information modelling (BIM) entails creating a digital representation of a project's elements and then studying, documenting, virtually evaluating, and refining it until a final model is created and recorded. Before construction begins, BIM is a massive database that stores all of the project's relevant information, including but not limited to cost estimates, timetables, change requests, and construction papers (Yalcinkaya & Arditi, 2013).

“Autodesk®”, maker of the software used to create Building Information Models, is pushing this innovation with its Revit® product. The purpose of “Building Information Modeling (BIM)” software is to eliminate the need for repetitive “computer-aided drafting (CAD)” procedures through the use of a dynamically linked interface. The idea is that the architect may focus on design, and the program will take care of creating the necessary blueprints, cross-sections, and elevations. Any revisions made to the documents will automatically update all other references to them in the drawings. Lessening the number of “requests for information (RFIs)” can help boost productivity. In order to reduce non-productive time on a job site and increase construction job efficiency and productivity, it is crucial for the on-site general contractor to have a thorough understanding of the program and to consider recommendations to the architects and engineers who discuss unanticipated field requirements.

3.2.1 Review on BIM

The notion of building information modelling (BIM) may be traced back to the early 1970s, specifically to the work of “Professor Charles Eastman” of the “Georgia Institute of Technology's School of Architecture”. Before the widespread availability of personal computers, the “Building Description System (BDS)” was the pioneering piece of software to use discrete library items culled from the “Program Data Processor (PDP)”. Similar computer systems first appeared in the UK in the late 1980s. More widespread implementations of similar ideas became feasible with the advent of the personal computer. During 1984, “Graphisoft Company” created “ArchiCAD”, a piece of software that would eventually incorporate the concept of virtual construction.

The new software's impressive capabilities stem from the parametric library component written in ‘Geometric Description Language (GDL)”. From the middle of the “2000s” onward, the “AEC” industry practically began implementing “BIM” in projects using the “Revit” program, which was developed by a firm, was built in “C++”, and made use of a parametric processor.

Autodesk invested substantially in developing the Revit program after purchasing it in 2002 because of its potential as a bridge to building information modelling (Dobelis, 2015). The software that was created allows businesses better command of their resources in terms of price, efficiency, and output quality. Figure (3-3) illustrates the need for a collaborative visual building model, such as the BIM model, to bridge the gap between the existing management approach and the virtual design concept.

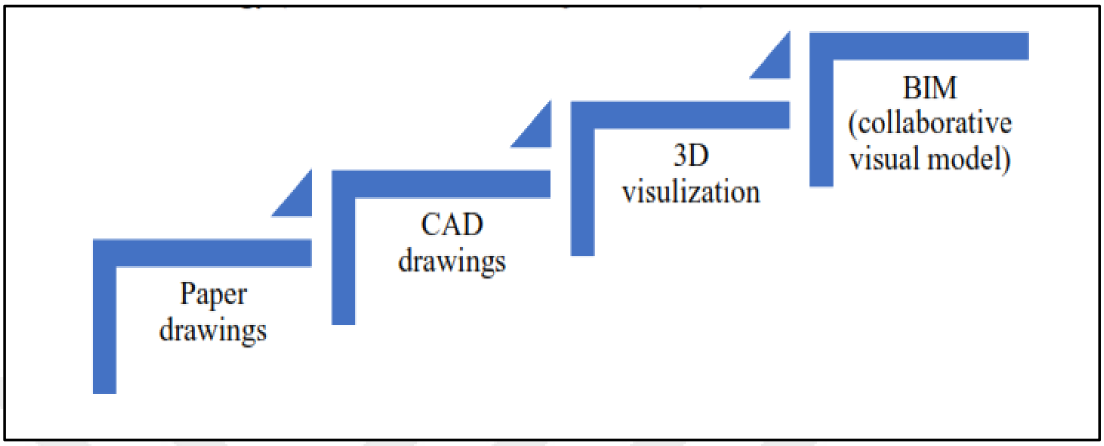

Figure 3.3: Advances in AEC Sector Technologies

In the past seven years, BIM has evolved from industry jargon to an essential part of AEC software (Azhar et al., 2012).

3.2.2 BIM description

Because of its usefulness in fostering cooperation across the various fields that make up the building business, BIM is now widely employed.

BIM can be defined in a variety of ways, each of which is unique to the individual who is doing the defining (Abbasnejad & Moud, 2013).

- Design viewpoint: The term "Building Information Modeling" (BIM) is used to describe the technological procedure through which a model of a building or other structure is created digitally to reflect its physical and functional qualities.
- Construction viewpoint: "Building information modelling "(BIM) refers to the practice of using a computer modelling program to plan for and test out various building and operational scenarios.
- Facility managers' viewpoint: When completed, BIM will have provided all the information needed to run the construction project from the time of occupancy to the time of demolition.

From the viewpoint of institutions and organizations, BIM can also be understood in several ways. The "National Institute of Building Sciences (NIBS)" describes BIM as "a repository of information for the facility owner/operator to use and maintain throughout the life-cycle of a facility." This definition emphasizes the use of digital technology to create a "computable representation" of a building's physical and operational aspects and related project/life-cycle information.

In table (3.1), we find a list of alternative definitions (Abbasnejad et al., 2021).

Table 3.1: Several Descriptions of BIM

Researchers or Institutions	Description
Van Nederveen	includes everything needed to carry out all phases of the lifecycle and is easily understood by software programs. Information regarding the building and its parts is included, as is data regarding the building's properties throughout its lifespan, including its purpose, form, composition, and operation.
NIBS	Assist collaboration between stakeholders by providing a parametric model that accounts for the addition, removal, updating, and modification of physical and functional building qualities at each process phase.
Cheol and Shik	Through information exchange and sharing based on projects and procedures that emphasize interoperability, information may be managed and used comprehensively across the full construction lifespan, from initial planning to final demolition.
GSA	The term "object-oriented artificial intelligence information model" is used to describe the comprehensive procedures for sharing, reusing, and managing data created all throughout the building's lifespan.
Gang	Manage all aspects of the building process, from initial planning through design, construction, maintenance, and eventual demolition, including all relevant data, organization, roles, and operations.

Source: Abbasnejad et al., 2021

Nevertheless, several users believed that Building Information Modeling (BIM) is an upgraded “Computer-Aided Design (CAD)” system, but BIM is a technique that is entirely distinct from “CAD”. BIM delivers more sophisticated services than “CAD” since the BIM model is more than just a 3D model; it manages and regulates the information to prevent data redundancy and disputes caused by miscommunication among the project's team.

The possibilities of BIM are (Popov et al., 2006):

- Control and coordinate information flows using a visual model and description of organizational processes.
- Convert the distributed tools into intricate solutions.
- Create a plan for the design, construction, and operation of the building in advance.
- Increase the building's efficiency throughout its useful lifespan with less time and money spent on the endeavour.

Succar and Kassem (2016) have compiled a list of definitions for the most frequent BIM words, which can be seen in figure (3.4) as shown in the following.

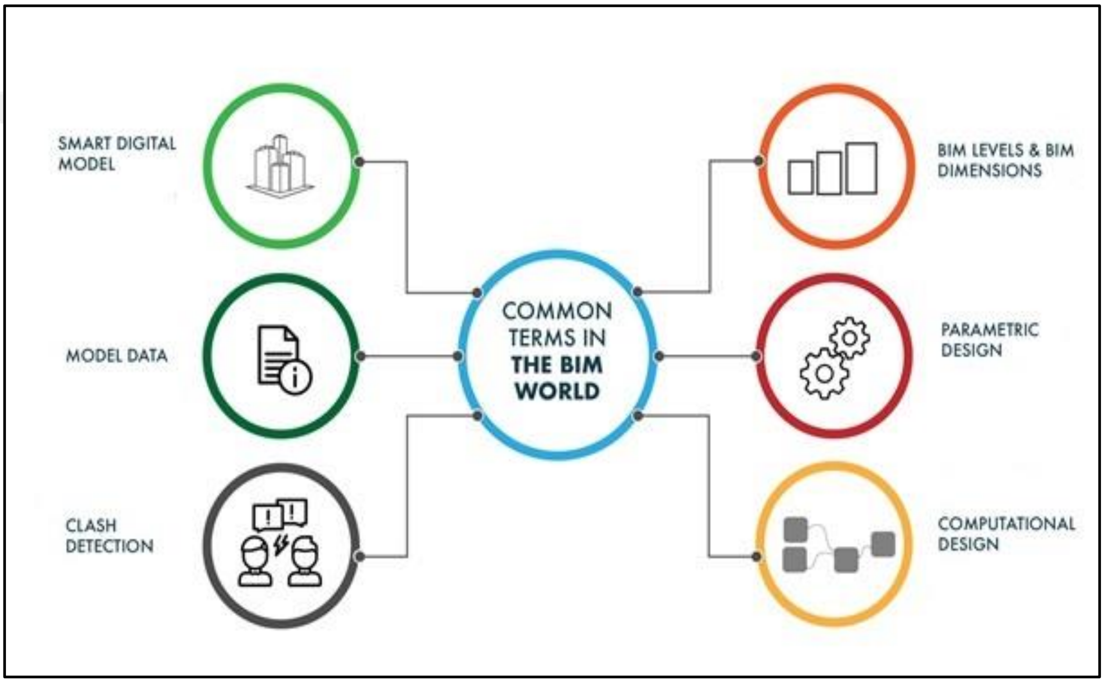

Figure 3.4: Typical BIM Terminology

Source: Succar and Kassem (2016)

The evident discrepancies in the ways that CAD and BIM define structural elements may be seen when comparing the two programs' respective outputs.

BIM creates each piece as an intelligent object with all of its information in the form of a 3D model, whereas “CAD” refer to the construction components as “2D” geometry.

Furthermore, BIM maintains the connection between project components in such a way that the modification of one object impacts the others.

3.2.3 BIM Advantages for building industry

The advantages of BIM can be seen in all stages of a construction project (planning, preconstruction, construction, and post-construction), as stated by (Saraireh et al., 2020). the steps that save expenses boost productivity and enhance product quality and consistency.

The precision of the BIM model also aids in creating a superior product in terms of design, the efficiency of a process, management of whole-life costs and environmental information, ease of automated assembly, quality of service provided to customers, and information about the product's lifecycle. Numerous studies have shown that building information modelling (BIM) is beneficial for those involved in the construction sector (Saraireh et al., 2020).

The following is an explanation of these advantages:

3.2.3.1 Owner

1- Check that the project specifications are being followed right from the beginning of the design phase.
2- Measure the effectiveness and ease of upkeep of the building.
3- The probability of monetary loss is low because of accurate cost projections and few required course corrections.
4- Using 3D walk-through animations and renders helps promote the project more successfully.
5- All the data you need on the building and all of its components, all in one place.

3.2.3.2 Designer

1- Improving design is achieved by exhaustive examination of digital models and visual simulations, as well as increased value of feedback from project managers.
2- Predicting a building's environmental performance by the early adoption of sustainability measures in the design process.
3- Increased adherence to the rules thanks to analytical and visual inspections.
4- Preliminary forensic investigation using visuals to evaluate the likelihood of various failures, leaks, evacuation preparations, etc.

5- The rapid development of shop or manufacturing blueprints.

3.2.3.3 Contractor

1. The procedure of calculating costs and quantities.
2. Prevention of potential design flaws early on by means of clashes.
3. Preconstruction and constructability investigations.
4. Supporting, guiding, and verifying on-site building tasks.
5. Prefabrication and modularization take place away from the construction site.
6. Location safety preparation.
7. Construction projects benefit from value engineering and the application of lean construction ideas.
8. More effective interaction between the project's manager, designer, suppliers, and on-site employees.
9. Superior profitability.
10. Customer service enhancements.
11. Expense and time constraints.
12. Improved output.
13. More enlightened decision-making
14. Enhanced safety management and planning.

3.2.3.4 Facility managers

1. The same essential data is contained in a single digital document.
2. The BIM database makes it possible to get any knowledge on any item of equipment involved in the project with simply the click of a button, which means that the building managers do not need to sift through the mountains of information to collect the data they need.

3.2.4 BIM Implementations in planning phase

When used as a lifecycle assessment instrument, BIM technologies deliver seamless operations all the way through a building's lifespan.

Figure (3-5) showing demonstrates the many ways in which BIM provides facilities that improve coordination and communication amongst project stakeholders during the project lifetime (McClements et al., 2017).

Figure 3.5: Typical BIM Terminology

Source: McClements et al. (2017)

According to what was covered in chapter 2, the pre-construction phase of the project is where the vast majority of significant decisions are settled upon. The phases of conceiving of the project, preparing the design for the project, and acquiring materials for the project are all included in the pre-construction phase.

At this stage, the utilization of BIM provides expert oversight of the construction project through the application of many different technologies. By utilizing the tools and techniques offered by BIM, all of the stakeholders involved in a project are able to improve their ability to communicate with one another, reduce the amount of money that is wasted, and, ultimately, reduce any potential risks. BIM does modify the way that owners, designers, and contractors communicate with one another while the building phase is in progress; however, the fundamental functions that participants of the project play do not shift in any manner. Table 3-1 provides examples of such implementations.

Table 3.2: BIM Implementations at Pre-Construction Phases

Project Conception	Design Preparation	Project Purchasing
Options Evaluation (to compare multiple design options)	Extensive 3D modelling, inside and out (visualization)	Using 4D sequencing and rescheduling (e.g. clash detections)
Composite pictures (to integrate photo-realistic images of the project with its existing conditions)	Flying systems and aerial animations	Assessment of building systems, including energy, illumination, structural, and complete design evaluation
Evaluation of costs and finances	Building effectiveness evaluation (e.g. energy modelling)	Architectural or shop drawings
Possibility report	Complete design collaboration	

Source: McClements et al. (2017)

3.2.5 BIM Tools used in the planning phase

BIM technologies make use of a variety of specialized computer tools to facilitate the generation of building models that are accurate, efficient, and capable of being built. In order to facilitate seamless data imports and exports, the BIM software in question needs to be capable of supporting intelligent information sharing.

There is a requirement for a domain or central location where all BIM software may be seamlessly connected because there are so many BIM platforms. “International Alliance for Interoperability (IAI)” created the object-oriented “Industry Foundation Classes (IFC)” file format to improve communication across different construction-related businesses.

ISO has officially recognized the IFC database schema as an international standard under the designation ISO/IS 16739. To facilitate the transfer of model object hierarchy, characteristics, and behaviour from one BIM program to another for the purposes of study and use, the IFC data file format was developed (Malsane et al., 2015).

According to the authors (Tan et al., 2021), the IFC is an open and vendor-agnostic data model with a neutral specification. Moreover, the IFC is a common BIM format since it is an open web format that prioritizes software compatibility. The IFC cooperation programs are shown in figure (3.6).

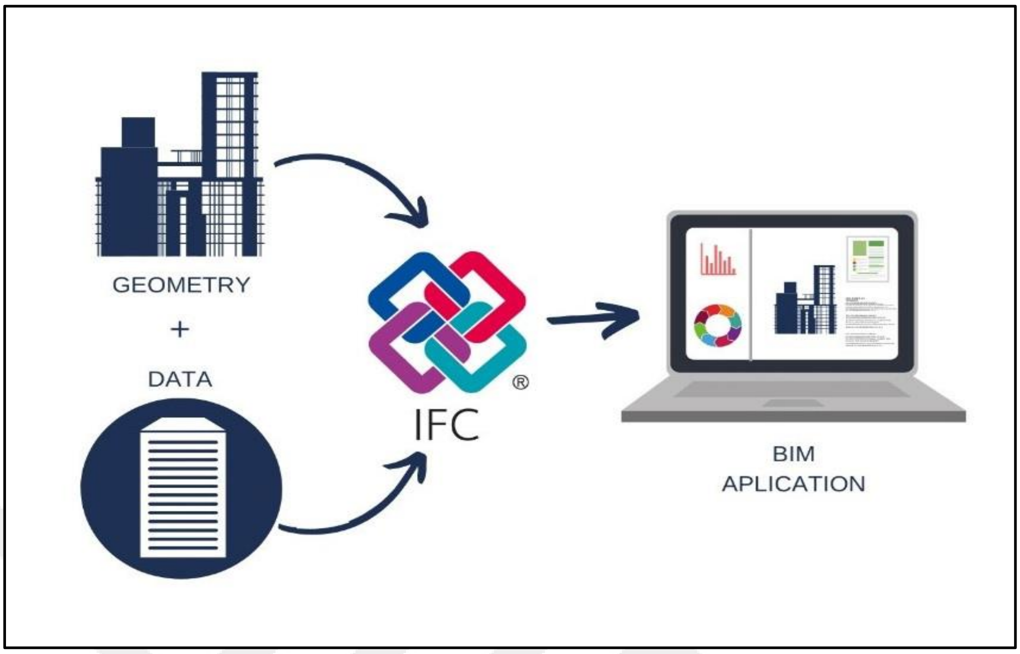

Figure 3.6: The Inputs and Outputs of FC Systems

Source: Justo et al., (2021)

The table (3.2) that are listed below describes the BIM tools, the disciplines that use them, and the company that manufactures them.

Table 3.3: BIM Applications Discipline and Manufacturing

	Program	Manufacture
Structure	Revit structure	Autodesk
	AutoCAD civil	
	Robot Structural Analysis	
	Structural Modeler	Bentley
	RAM, STAAD and Pro-Steel	
	Tekla Structures	Tekla
Sustainability	Ecotect Analysis	Autodesk
	Green Building Studio	
	Visera	
	EcoDesigner	Graphisoft
	Virtual Environment VE-Pro	IES Solutions
	Tas Simulator	Bentley
	Hevacomp	
	DesignBuilder	Design Builder

Table 3.3: (Cont.) BIM Applications Discipline and Manufacturing

	Program	**Manufacture**
	Program	Manufacture
Architecture	Revit Architecture	Autodesk
	AutoCAD Architecture	
	Archi CAD	Graphisoft
	Vector works Designer	Nemetschek
	Allplan architecture	
	Affinity	Trelligence
	Digital Project	Gehry technologies
	Architecture	Bentley systems
	Architectural Design	4MSA IDE
	Envisioneer	CADSoft
	Rhino BIM	Rhino
	Spirit	Softtech
MEP	Cype CAD	Cype CAD
	Advance Design	Graytec
	Metal Wood Framer	Structure Soft
	Scia	Nemetschek
	Strad and Steel	4MSA
	Revit MEP (3D Detailed MEP Modeling)	Autodesk
	Hevacomp Mechanical Designer	Bentley
	Fine (HVAC, LIFT, ELEC, SANI)	4MSA
	Digital Project MEP Systems Routing	Gehry Technologies
Construction	Naviswork Manage (clash detection – scheduling)	Autodesk
	Project Collaboration	Bentley
	ConstrucSim (clash detection – scheduling)	Solibri
	Solibri Model Checker (Spatial Coordination)	
	Office Suite (Coordinate Scheduling Estimating)	Vico
	Field BIM	Vela systems
	BIMSight	Tekla
	Glue	Horizontal Systems
	Synchro Professional (Planning & Scheduling)	Synchro software
	Virtual simulation (Scheduling)	Innovaya
	Gehry	Technologie
	Program	Manufacture
Sustainability	Ecotect Analysis	Autodesk
	Green Building Studio	
	Visera	
	EcoDesigner	Graphisoft
	Virtual Environment VE-Pro	IES Solutions
	Tas Simulator	Bentley
	Hevacomp	
	DesignBuilder	Design Builder

Source: Author

3.2.6 Methodology for BIM cooperation

In order to achieve a common purpose, members of a team must cooperate. There are several positive results that may be expected from implementing BIM in the building industry, such as reducing costs and saving time while simultaneously enhancing output and effectiveness. Construction project demands a critical collaboration partnership to establish a cooperative interaction system amongst the cross-specialities.

The construction sector has been plagued with low productivity and widespread fragmentation, and experts agree that this communication mechanism is crucial to addressing these issues (Liang et al. 2016).

There are three components necessary for effective teamwork:

- Cooperative team
- Environmental features
- Cooperative activities

Effective communication is crucial to collaborative processes, which in turn depend on the team's possession of the necessary skills, knowledge, and attitude to work together in a shared environment that requires both technological and organizational assistance.

BIM isn't just a way to use technology; it's also a method for coordinating efforts on a project. By the use of BIM, the project team is able to have earlier and more thorough conversations about the design requirements and coordinate the data throughout the many stages of the project lifecycle. An efficient BIM project is distinguished by its ability to enable team cooperation among the project shareholders, and these interactions improve the project's productivity (Adhikari and Keung, 2018).

“Integrated Project Delivery (IPD)” is a crucial construction project deployment strategy that boosts teamwork and moves the goal of excellent communication along more quickly. The “American Institute of Architects (AIA)” describes the “IPD” as "a strategy to engaging people, technology, procedures, and corporate structure in a cooperative approach". The “IPD” allows all parties involved in a project to increase productivity, cut down on unnecessary costs, and improve quality, all while minimizing waste (Lu and Rowlinson, 2013).

In comparison to conventional methods of distribution, the new strategy has the following distinguishing features:

1. The participation of major influencers at the outset.
2. Group consensus building.
3. Sharing of both risks and benefits.
4. Multiple-party interaction.
5. Parallel targets for the project's growth.

By coordinating the efforts of all parties involved in a project and encouraging them to work together from the beginning, the objective of integrated project delivery (IPD) is to foster the teamwork that is essential to the successful implementation of building information modelling (BIM). Using BIM and IPD for teamwork not only increases productivity and reduces the number of errors but it also opens the door to exploring new avenues of growth and new markets (Becerik-Gerber, and Kent, 2010).

In addition, the collaboration between IPD and BIM has altered the conventional delivery method. In this method, all members of the project team (builder, installer, supplier, fabricator, and designer) worked together to anticipate and mitigate challenges during the construction phase, such as unanticipated risks and buildability issues. This method has been altered as a result of the collaboration between IPD and BIM. In addition to this, the project is capable of being accurately modelled and simulated by making use of BIM tools.

In addition, the expenditure of more time and money during the pre-construction stage results in a more reliable timeline and expenditure plan for the construction phase. In addition, the technique for managing the facility benefits from having this system integrated. In light of what has been discussed thus far, it is absolutely necessary to make certain that your project is adequately specified and integrated before commencing the phase in which documentation will be created (Sturton and Tree, 2015).

Figure (3.7) illustrates how the IPD method modifies the conventional method by bringing in stakeholders at an earlier stage of the project, as recommended by the AIA (Ho, 2021).

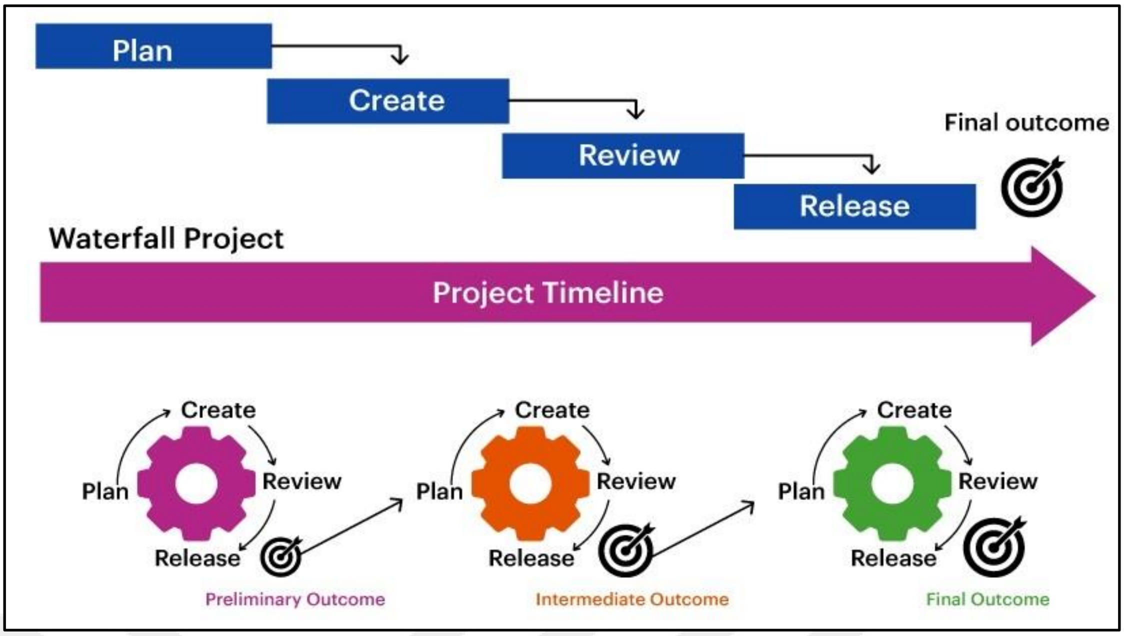

Figure 3.7: IPD Restructures Conventional Project Phases

Source: Ho (2021)

3.3 The Advantages of BIM in the Planning Stage

From the first planning stages to the final tear-down, BIM can be relied upon to supply accurate data throughout the whole project lifespan. Pros can use this method to zero in on the unique aspects of a project, which in turn facilitates more informed choice-making. Specifications, energy analysis, and a materials take-off are all part of the BIM model, along with data that has been organized by the project's multidisciplinary team and presented in a single, smart model for improved design, planning, implementation, and management (as shown in figure (3-8) (Song et al. 2019).

Videika and Migilinskas (2020) summarized the advantages of BM as follows:

- Precise geometry.
- Faster and more efficient procedure.
- Maintain cost management throughout the life of the project.
- Improved design options.
- Improved production quality.
- Improved client service and lifecycle information.
- Automatic production.
- 8-15 per cent time savings for new projects.

- More to 35%-time savings in duplicated data among projects as a result of simply reusing information, resulting in improved decision-making and earlier stage assessment.
- Decrease costs and increase estimation precision and speed.
- Decrease project duration by up to seven per cent.
- Avoiding conflicts can save up to 10 per cent of the contract's value.
- Facilitates collaboration in construction.
- Reduce up to 40 per cent of unbudgeted adjustments as a result of the decrease in information and modifying orders.
- Achieve lower costs over the duration of the project by employing sustainable design
- Enable building project simulation and visualization.
- Facilitate building document compilation.
- Accuracy of cost estimation within 3%.
- A decrease of up to 80% in the time required to compile cost estimates.

3.4 BIM and Constructability

The goal of the constructability concept is to reduce the discrepancy between the designs made in the office and the actual construction. Some case studies show that by adhering to constructability concepts, projects are able to save 10.2% in time and 7.2% in money. Evaluating the building design, analyzing it critically, and offering constructive criticism are all made easier by the use of virtual construction during the design development stage. Building information modelling (BIM) allows for a rule-based, automated method to constructability verification, which aids decision-making (Boton, 2018). as shown in figure (3.8).

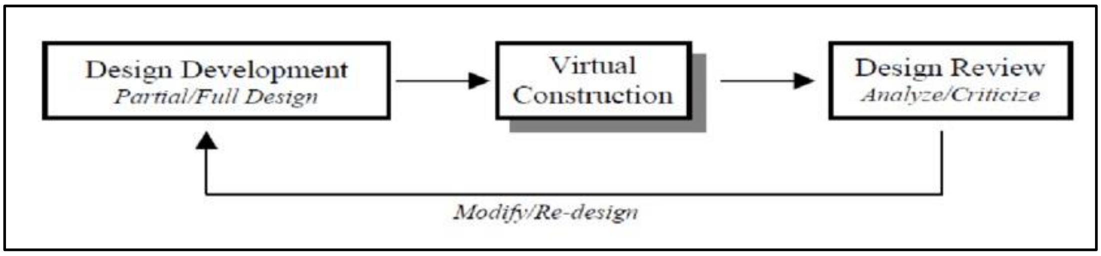

Figure 3.8: Integration of Design and construction activities

Source: Boston, (2018)

Figure (3.9) illustrates the four phases that comprise the rule-based methodology to constructability, all of which occur prior to physical construction.

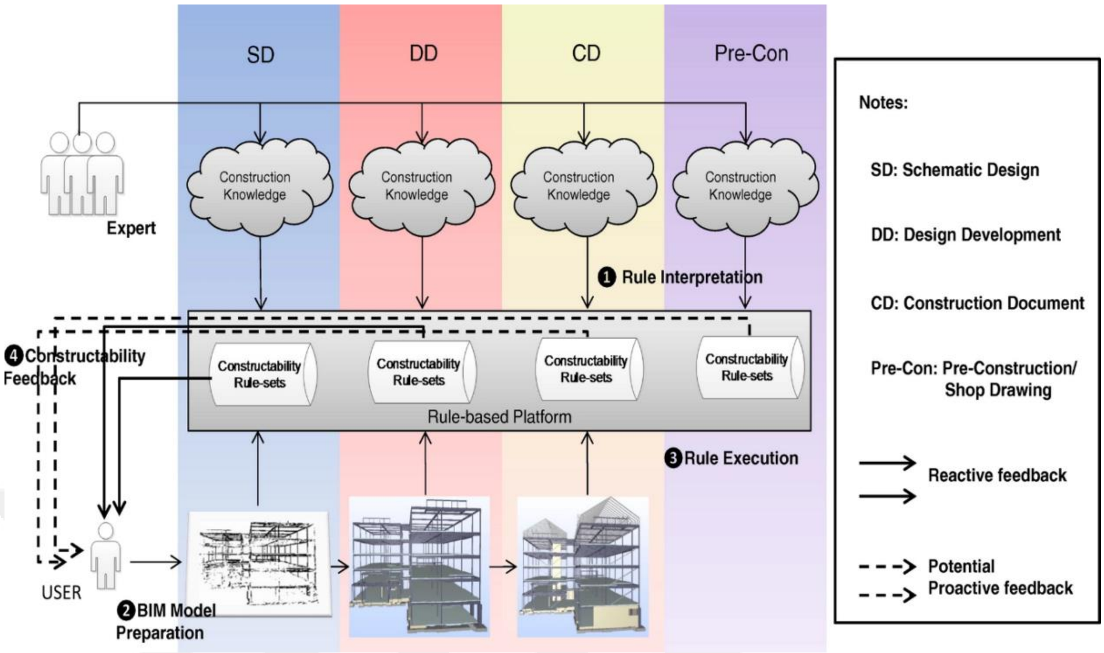

Figure 3.9: Integration of Design and Construction Activities

Source: Jian et al., (2014)

The BIM procedure is detailed at each step. The project team can benefit from the automatic generation and assessment of constructability comments. The "2D" and "3D" CAD systems, for instance, are not suited for the purpose of accurately portraying a room in its actual physical state. On the other hand, the BIM model supplies information regarding the spaces and the relationship between the walls, ceilings, and floors, which is employed in the constructability performance study (Jian et al., 2014).

BIM is capable of managing not only the time (4D) and money (5D) of a project but also the cooperation and communication within a team, as well as the procurement concerns. In addition, the modifications to the design are immediately reflected in the results of the project (Tiwari, 2017).

With BIM, the many members of the construction team may work together, and the various stages of the building process can flow into one another seamlessly. Furthermore, implementing BIM at the outset of a project aids in effective design review for various possibility analyses, which in turn aids in the decision for the optimum construction technique, elements prefabrication, timeline generation, and delivering drawings free of mistakes for construction. The use of BIM in the construction industry helps achieve the industry's three primary goals of saving money, finishing projects on schedule, and producing high-quality results. Better material management and less waste throughout the project's lifecycle are two additional benefits of building with BIM. Figure (3.10) shows how useful BIM may be in the building business.

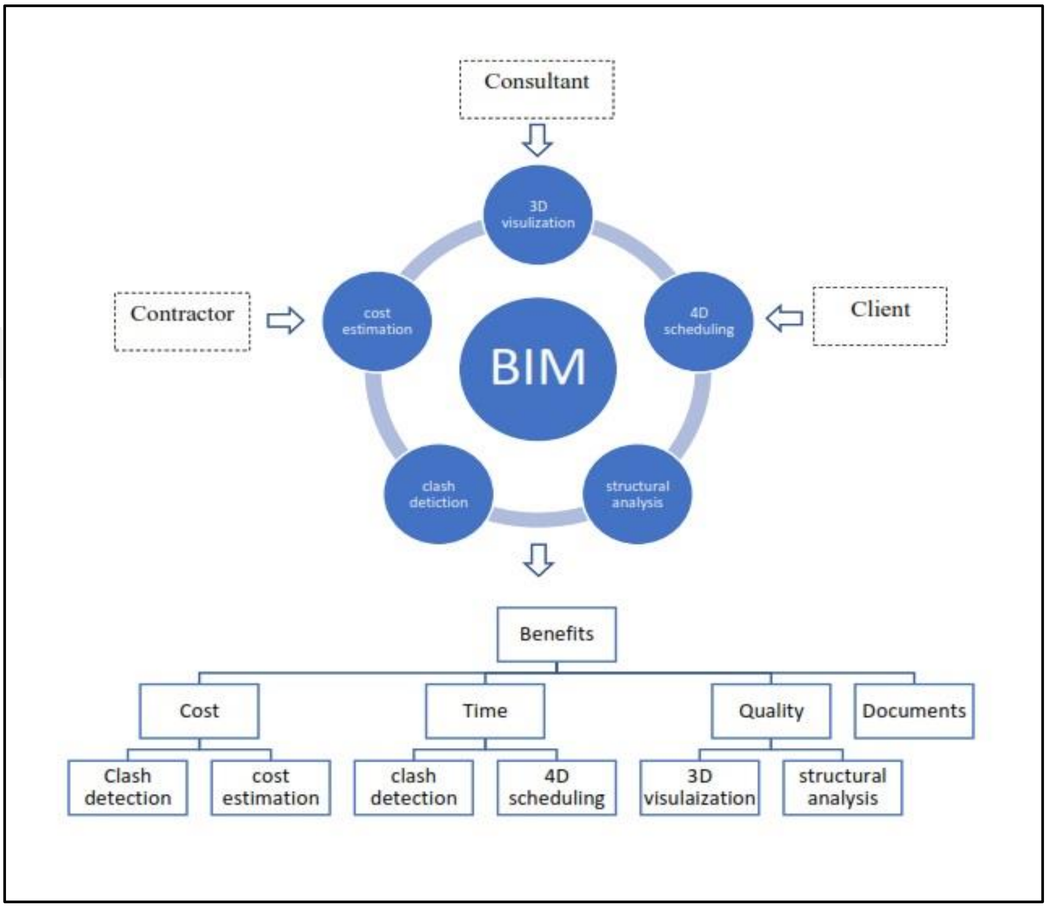

Figure 3.10: Advantages of BIM for the Construction Sector

Source: Author

3.5 BIM and Sustainability

The infamously low rate of adoption of information and communication technologies (ICTs) is a major obstacle to green building. The majority of currently utilized information systems are single-entry focused, meaning they are only used for one function within a building and do not facilitate teamwork between the many AEC professionals. Several of the software also couldn't communicate with one another properly.

While both Cad and project management applications deal with things like geometry, quantity, time, and money, neither can update another's data without manual intervention. By facilitating application compatibility, information availability, intelligent documentation, and integrated data sharing, “ICT” in the construction industry throughout the design and pre-construction phases can greatly facilitate the sustainable construction procedure (Matar, 2010).

Sustainable building is another area where BIM may help. BIM is a technology that uses a virtual environment to create a representation of a construction project, complete with all of the related data, including geometry, geographic knowledge, quantities, relationships, and attributes of the various pieces that make up that structure. As an added bonus, it allows designers to select the best construction plan by simulating the building's effectiveness in a variety of areas (Oduyemi and Okoroh, 2016).

3.5.1 BIM for sustainable construction

BIM is able to provide assistance in delivering sustainable design through the following:

BIM is able to provide assistance in delivering sustainable design by (Ebrahim and Wayal, 2020).

1- Conducting an investigation into the building's orientation (choosing the most advantageous building orientation in order to cut down on energy costs).

2- Maintaining temperature regulation of the interior ventilation system.

3- Conducting an examination of the soundness of the structure.

4- Daylighting assessment.

5- Water gathering (water conservation throughout building construction and maintenance).

6- Simulation energy (analyzing and reducing energy requirements, maximizing the use of renewable energy sources, and cutting energy costs).

7- Conduct an investigation of the building masses (optimize the building envelope and analyze the form).

8. The choice of materials (sustainable materials choosing).

9- Analysis of the location and management of the logistical issues (reduce the construction's environmental impact and pollution).

Atta et al. (2021) have created the green BIM triangle, which they call the "BIM green construction nexus," in order to demonstrate the interaction that exists between BIM and sustainable construction buildings as well as how BIM encourages green buildings at various stages throughout the entire building lifecycle as shown in figure (3.11).

The environmentally friendly structure can be broken down into three primary dimensions thanks to the triangle: the "project stage," the "green characteristics," and the "BIM characteristics."

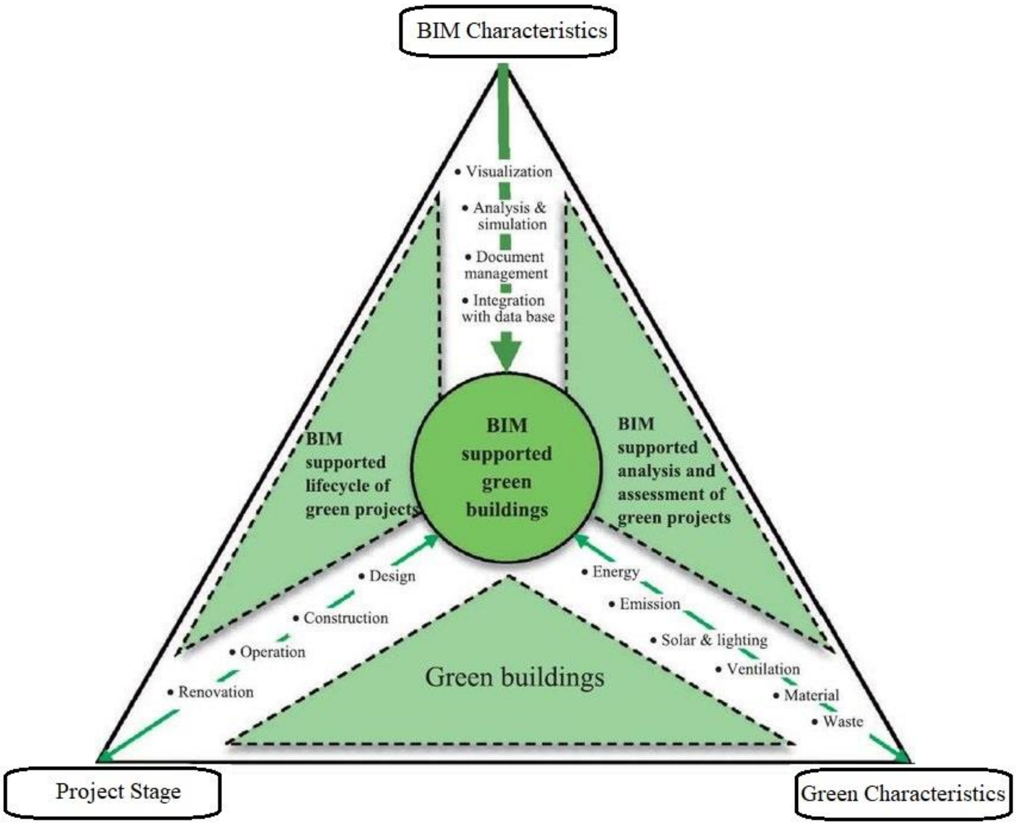

Figure 3.11: Three Sustainability Considerations for BIM Projects

Source: Atta et al., (2021)

The viewpoint on the project lifecycle is incorporated into the phase component of the project (project design, construction, maintenance and operation, and demolition). The sustainability aspects of a project are factored into the characteristics dimension of the project. These aspects include day illumination, air circulation, energy efficiency, thermal comfort, water efficiency, material choice, waste materials, and sound absorption analysis.

The BIM characteristics dimension explains how building information modelling (BIM) software can contribute to the other two green building dimensions through visualization, assessment and simulation, documentation, and interaction database.

The following are some of the areas in which it was discovered that BIM could support green building:

1- an examination of the entire lifecycle of environmentally friendly buildings.

2- an examination and evaluation of environmentally friendly projects.

Implementations for building information modelling (BIM) have been created to cover sustainable design considerations during the design stage. The majority of BIM green implementations are designed to evaluate the performance of buildings; these implementations help designers by supplying an interconnected visualized model for the effectiveness of buildings in the early design stage (Utkucu and Sözer, 2020).

Figure (3.12) by (Aranda et al., 2020) shows how BIM interoperability software can be used to create sustainable construction. The financial, environmental, functional, and technical information was translated from the input data, such as a “MasterFormat WBS”, households and keynotes about the materials and providers, the needed rating system for green building assessment, and the orientation and data from the project site. The BIM framework and the environmental assessment software used to evaluate sustainability initiatives can be integrated using an interchange interface tool like “IFC” or “gbXML”.

Figure 3.12: Compatibility of BIM Tools and A Sustainable Design Approach

Source: Aranda et al. (2020)

Figure (3.13), for instance, illustrates how BIM design instruments and dynamic modelling accredited technology can communicate with one another (Bastos Porsani et al., 2021).

The integrated model ought to provide assistance to the designers in selecting suitable building materials, structure orientation, and resource models for the structure. The results will not only contain an analysis of sustainability and costs but also a visualization in the form of a three-dimensional model, which will contain a simulation of energy use and daylighting, as well as the effect of the building on the ecosystem.

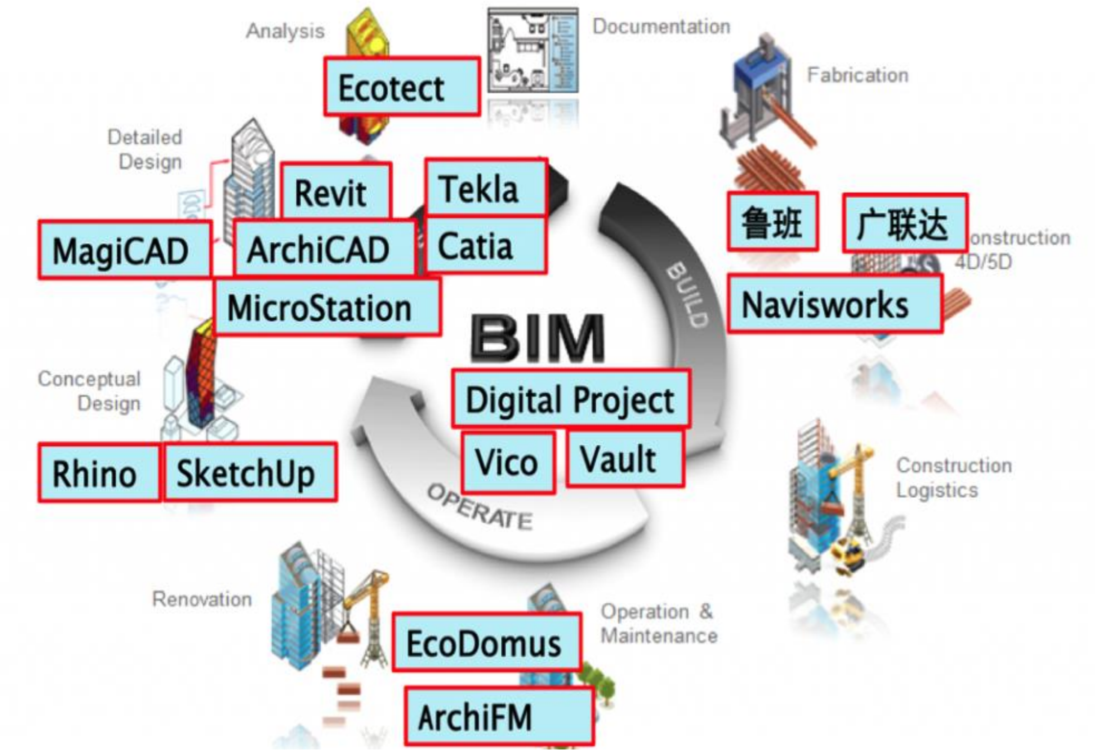

Figure 3.13: Integration Among BIM Authoring Systems With Approved Dynamic Simulation Technology

Source: Bastos Porsani et al. (2021)

(Wang et al., 2019) utilizes a BIM framework to obtain an example of the advantages of merging BIM and IPD to generate a sustainable building design. Specifically, these benefits include: (sun cast shadow studies, internal sun penetration, shading design, day lighting analysis, artificial day lighting analysis, visual impact studies, environmental cost impact analysis, and energy use analysis).

In addition, the elimination of the cost of modifications later on, is achieved by the evaluation of various design alternatives made during the early design stage.

As a consequence of this, Building Information Modeling (BIM) delivers precise environmental analysis and minimizes the operating costs, lifetime costs, and greenhouse gas emissions of a project.

3.5.2 BIM and assessment methodology

The principles of design that direct a project in the direction of a sustainable end include (building orientation, energy modelling, daylighting analysis, building mass studies, sustainable materials, water harvesting, and renewable energy). As was established in the prior conversation, Building Information Modeling (BIM) has demonstrated that it is capable of assisting in the construction of sustainable buildings through the use of its various applications and frameworks (Seghier et al., 2018).

This aspect is a driving force behind the implementation of BIM in construction projects in several nations. Using the information contained in the model elements, BIM software can make a contribution to the process of determining rating system scores (Laali et al., 2022).

For particular, table (3.3) presents an illustration of the points that can be awarded immediately from implementing BIM for the "LEED" grading system. The information that is presented in the BIM modelling can directly lead to attaining the "LEED" silver accreditation. This is due to the fact that the BIM software is able to calculate 38 points out of the 69 points that are necessary to obtain the "LEED" gold accreditation.

Table 3.4: BIM Accomplishment in LEED Ranking

Criteria	Maximum points	Weighting %	BIM points	BIM weighting %
Sustainable sites	14	20.3%	6	8.7%
Water efficiency	5	7.2%	5	7.2%
Energy & atmosphere	17	24.6%	10	14.5%
Materials & resources	13	18.9%	9	13.1%
Indoor Environmental quality	15	21.8%	4	5.8%
Innovation & design process	5	7.2%	4	5.7%
Total	69	100%	38	55%

Source: Jin et al., (2019)

The remaining 31 credits, which are not provided by BIM technology, are attainable in a roundabout way by making use of some essential details from the BIM modelling (Jin et al., 2019).

3.5.3 BIM and sustainability principles and performance indicators

Every day, there is a greater demand for the construction of environmentally responsible structures. Recently, there has been a shift toward making sure that the effect of the built environment on various capitals, including economic, social, and environmental capital, is fast diminishing. At the early stages of the design process for the building project, the decisions that are made regarding sustainability will have the greatest impact.

Because BIM is capable of analyzing data from multiple disciplines within a single model, it has the potential to play an important role in the analysis and simulation of sustainability. Furthermore, BIM has the potential to contribute to sustainable building at all stages, from the early concept stage to the demolition step. BIM contributes to the sustainability of buildings by enhancing the integration of economic, social, and environmental elements (Oti et al., 2016).

3.5.3.1 Environmental responsibility

The power of building information modelling (BIM) to produce, store, and exchange various types of building information data makes it simpler to reach a choice that will lead to improved environmental building performance. Therefore, it is now simpler and more feasible for the experts working in the construction industry to reduce their environmental effects in areas such as the consumption of water and energy, the use of sustainable components, the recycling and repurposing of materials, waste management, life cycle assessments, and their carbon footprints (Ögmundarson et al., 2020).

3.5.3.2 Economic responsibility

Several scholars have discussed the economic benefits of Building Information Modeling (BIM) for investors, consultants, and contractors, in which it ensures the economic sustainability of a project, minimizes waste, and increases productivity. Because utilizing the BIM technology leads to early conflict detection, productive logistics, and accurate expense calculation across the entire building lifespan, efficient resources management, and improved decision regarding the selection of building frameworks and materials, BIM is becoming increasingly widespread in the construction industry (Ögmundarson et al., 2020).

3.5.3.2 Social responsibility

BIM helps to create healthy and habitable communities by giving the data and assessment tools necessary to enhance aspects such as waste management, construction safety on the job site, and the quality of the interior air. In addition to keeping the activity plans up to date, reduce the amount of noise pollution and the number of operations that are disruptive to the municipal infrastructure. In addition to this, Building Information Modeling (BIM) facilitates improved communication between the many stakeholders of a project by way of improved analytic and decision-making capabilities, as well as simpler access to information provided by BIM software (Ögmundarson et al., 2020).

3.6 The Prospects of BIM in Local Region

Since the implementation of BIM is taking place on a worldwide scale, nations that are dragging their feet in embracing the new approach will fall further and further behind. The building industry in Iraq could benefit from adopting some of the promising practices (thanks to government initiatives) of the building industry in Malaysia to encourage BIM (Whyte, et al., 2016). These practices include leveraging data from a self-assembling 3D printer, which will be at stage 5 after 2030 (Davies, et al., 2015). Soft skill requirements in a BIM project team., 2014). The construction industry in Iraq could also benefit from adopting some of the promising practices (thanks to government initiatives) of the building industry in Malaysia.

According to the Saudi Gazette (2014), the partnership between the parent company of “Tekla” , Trimble, and Gehry Solutions, which is a technology company founded by the renowned architect “Frank Gehry”, is viewed as a key step toward increasing the use of BIM in the Middle East.

More research into BIM knowledge, BIM descriptions, BIM shifts, and solutions is required. Both a consensus on what BIM is and how its benefits can be measured from a business viewpoint are essential first steps. It is important to have standards and/or foundations that are widely used and accepted (Whyte, et al., 2016).

4. RESEARCH METHODOLOGY

4.1 Introduction

Methodology refers to the set of rules and procedures that guide logical thought practices in research (Crowther and Lancaster, 2012). The exploratory character of the research led to the selection of the social science research approach as the research methodology of choice. In the exploratory study, it was determined that conducting interviews and reviewing relevant literature was the methodology that was most suitable for the type of research being conducted.

In this chapter, we will discuss the methodologies that were utilized throughout the course of this research. Prior to beginning this chapter, we first conducted a comprehensive literature review to gain a better understanding of the attributes of BIM advantages for the construction sector and its participation in the sustainable building projects sector. In addition, the BIM application approaches for associations and countries were investigated. The study strategy, the research method that was used, the method for data gathering, the design of questionnaire questions, and the procedure all provide the foundation for the following chapter of assessment and analysis. This chapter also discusses research ethics, the limitations of the study, and the difficulties involved.

4.2 Research Approach

The progressive "down-up" method is used for this research because the manner of research being conducted is the learning method type that promotes the progression of the research through particular to generalized “Deduction & Induction”. For a visual representation of this methodology, see figure (4.1. This study intends to investigate the Advantages of BIM for the Building Sector as well as the approach to application for a Sustainable Building Sector in Iraq.

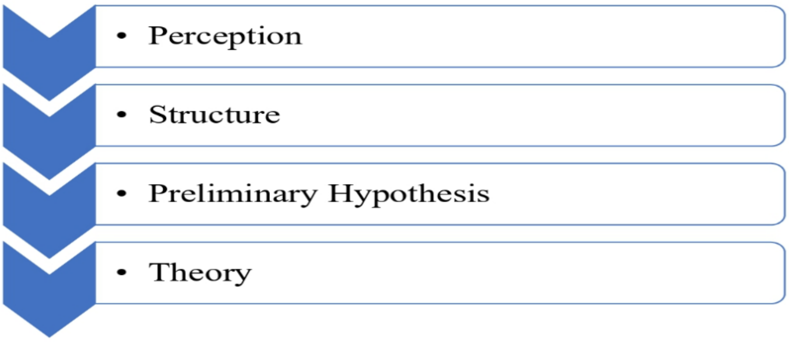

Figure 4.1: The Progressive "Down-Up" Method

Source: Reichertz,(2013)

The research design is a structured overview of how the research study is to be performed, where the overall approach is chosen to systematically and logically combine the various components of a study, effectively solving the research issue and forming a basis for data collection, calculation, and analysis.

The selected approach can be qualitative, quantitative, and mixed methods to guide research procedures that follow some philosophical theories, design techniques, and study methods (Creswell, 2018). Figure (4.2) demonstrates the definition of a research design.

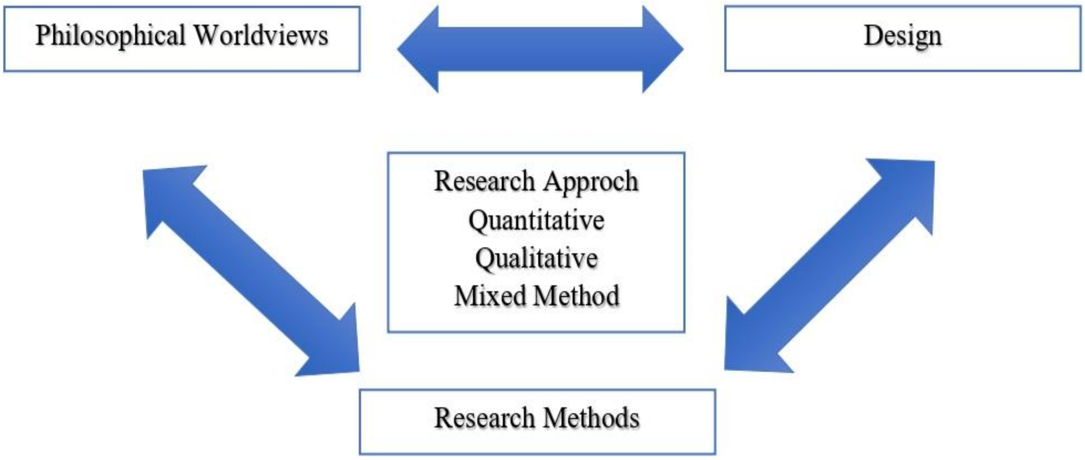

Figure 4.2: Demonstrates the Definition of A Research Design

Source: Creswell, (2018)

4.3 Philosophical Theories

Philosophical theories may be described as overall guidelines and understanding of the world or the purpose of a study carried out by the researcher (Creswell, 2018).

Usually, the author uses those principles and theoretical concepts in a research paper. However, some people might never agree that they should accept a particular assumption or agree on the role these hypotheses play in the study process (Mertens, 2015). Philosophical assumptions include ontology, epistemology, axiology, methodology, and philosophical assumptions of rhetoric (Creswell, 2018).

Figure (4.3) demonstrates these philosophic assumptions according to Gunatilake (2013), focusing on particular issues like what is the method of the study? How does the investigator relate to the examined person? Which are the principles that contribute to the study? What was the study's reality? What's learning communication?

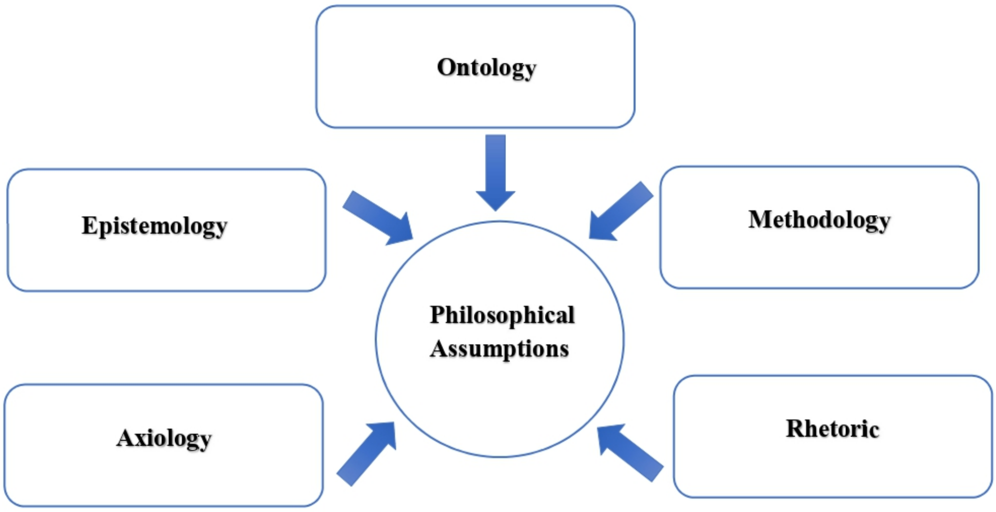

Figure 4.3: Framework for Research Design

Source: Creswell, (2018)

Ontology is a philosophical assumption regarding the essence of truth in which the investigators believe the multiple reality of their subjects, and this is illustrated by the use of various themes using the technique (What is the study process?) Rhetorical tale (What is the language of research?). Epistemology is a metaphysical theory of the relation between the researcher and the known and how empirical knowledge has been gained. Axiology is an assumption philosophy on the role of ethics in science. The methodology is a logical theory of the research process and method, which is defined as inductive by the expertise of the scientists in data collection. Rhetoric is the practice of language study and the practice of convincing the public.

From the viewpoint of research goals, a research plan can be categorized as descriptive, correlational, illustrating, or exploratory. The aim of the study will decide the kind of research to be implemented from a perspective of the study goals (Neuman, 2014):

• Research is known as descriptive research when attempting to explain a situation, practice, service, or procedure in a systematic manner or when attitudes regarding certain problems are identified and how to study issues.

• Research includes a correlation between several parts of a situation if the study focuses on attempting to find or assessing the nature of an interaction, interdependence, or partnership.

• Research is defined as explaining when the main goal of explaining why events happen and constructing, creating, extending, or testing the theory. It helps to explain why and how two parts of a phenomenon are related.

• Research can be exploration if the purpose of a study is to either explore a field where minimal research needs to be done or to explore possibilities for specific research and to establish preliminary concepts and research issues.

The study is descriptive in concept as it aims to explain the various practices of to analyze the impact that BIM adoption has had on sustainable construction practices and to examine the current trends in BIM implementation during the design process phase in the Architecture, Engineering, and Construction industry. The study is also considered an exploration of the method of inquiry, where the study takes both qualitative and quantitative methods into account, and the synthesis between the two methods to sufficient to accomplish the purpose of the study.

4.4 Choice of Research Methodology

The approaches of the analysis adopted by the study are based on the research researcher's philosophical concepts, research design, and fundamental research procedures for gathering, analyzing, and interpreting information, according to Creswell (2018).

Study approaches are defined as the kind of qualitative, quantitative, and mixed techniques that guide the research design processes (Mertens, 2015).

Quantitative research, as per Aliaga and Gunderson (2005), is effective at generating knowledge from a wide range of units in the broadest possible field, but quantitative methods can be very shallow when a topic or idea is to be studied in depth.

The qualitative method is best for a detailed investigation of a study issue. It is a system, which studies subjects in their natural environment, which attempts to explain or perceive a phenomenon with regard to the meanings that people bring to them, where data are inductively analyzed in this method based on details to general concepts, and the researcher interprets the importance of the information (Creswell, 2018).

Qualitative study can define an approach to analysis and try to understand the significance of individuals that are dedicated to social issues, whereas the qualitative study is intended to examine the real circumstances in their time-based and local circumstances (Flick, 2022).

On the other side, mixed methods given quantitative and qualitative benefits. Researchers regarded the selection between the quantitative and qualitative approaches as important. Nevertheless, they are no better than the other because they both have distinct traits and have their strengths and limitations (Mertens, 2015).

4.4.1 Choosing a mixed method

This study uses a mixed-methods approach because the study aims to get a detailed understanding of the significance of the concept of analyzing the impact that BIM adoption has had on sustainable construction practices and to examine the current trends in BIM implementation during the design process phase in the architecture, engineering, and construction industry.

Regarding Creswell (2018), if a practice or theory requires to be investigated and clarified since few studies have been done, then a mixed approach is needed.

Valen and Olsson (2012) conducted a study to determine the extent of the importance of the occupational service management career for the owners of buildings in relation to their buildings in fine, functional, and up-to-date conditions by performing the questionnaire investigation and thorough interviews. The qualitative approach was the first proposed, but due to the limited literature in this field, the research analysis is exploratory and requires explanatory studies to validate findings. The quantitative approach was then used to verify and generalize results for a population and to analyze the results of the qualitative process by means of a questionnaire survey.

4.4.2 Selection of research methods

This section describes effective research approaches by choosing mixed approaches for this study analysis as an acceptable methodology. The search method is the technique for the gathering of observation research information and may be classified into four main topics: documentation, interviews, analysis, and questionnaires (Denscombe, 2021).

The selected methods used for gathering information in this research include documentation and questionnaires. The study mandated an exploratory development approach involving the collection first of qualitative information and then quantitative data. The study began with gathering qualitative information from related literature and documentation to collect as much knowledge about sustainable building components; it was the first step of the study. The second step of the study involved the acquisition of quantitative data. The results of the documentation gathered were used for designing a questionnaire that was created and then brought up to engineering specialists working in construction fields.

4.4.3 Framework of study

The study approach implemented in this study could be shown by means of a three stages research framework as shown in figure (4.4). Stage one consists of the literature review and study of sustainable building documents and their ingredients.

A literature review on BIM application was involved in the literature review and document study, and stage one also included the highlight on the challenge to analyze the impact that BIM adoption has had on sustainable construction practices and to examine the current trends in BIM implementation during the design process phase.

Stage two consists of a questionnaire investigation to assess the results and review additional documents. Stage three consists of validating and analyzing the research results in depth.

The literature review in the study was presented to provide a strong theoretical structure for the field of research and to promote the study's aims and purpose. When findings were made, the literature review proceeded to the latter stages of the study process.

A review of the relevant literature positions of a study defines the information gaps, provides a structure for establishing the value of the study, and thus provides an explanation for the problem statement (Creswell, 2018).

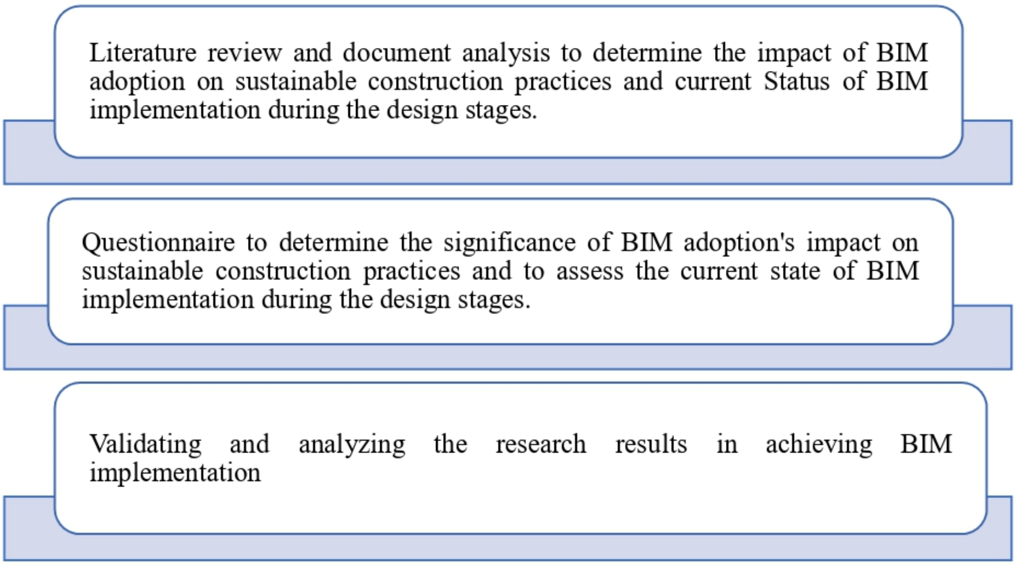

Figure 4.4: Literature Review on BIM Application Research Stages

Source: Author

The literature review provided the study regarding the theoretical framework for the impact that BIM has had on sustainable construction practices and examined the current trends in BIM implementation during the design process phase.

Denscombe (2021) suggests that such a method aims at arriving at a result based on the proposed information of a subject depending on a detailed and impartial review of studies carried out on the topic. This method was helpful, where numerous publications on the study subject were identified, but these publications needed to recognize to define the impact that BIM adoption has had on sustainable construction practices and BIM implementation during the design process phase.

The study was included selecting the literature from several sources, including books, seminars, blogs, and databases, in addition to several journals like the Journal of Building and Environment, Journal of Construction, Engineering and Management, and Journal of Sustainable Development.

The relevance of the analysis included results from earlier studies on the components that establish a sustainable facility. While this consistency of the contents involved concern with the rich data on research objectives available in the literature, the results and suggestions are typically set out in the abstracts.

A total of (16) purpose of the advantages and primary factors that are influencing the implementation of Building Information Modeling (BIM) in the building projects, and (22) obstacles that stand in the way of BIM implementation refined to meet the ingredients detected in the analysis of information.

4.4.4 Questionnaire survey

Scientists have designed a questionnaire survey to offer a quantitative or mathematical explanation of population patterns, behaviours, or views by analyzing a sample of that population (Creswell, 2018).

Figure (4.5) shows the research process at this point, where this part is dedicated to designing and processing the survey questionnaire and evaluating the survey results.

The questionnaire aims to highlight the advantages and primary factors that are influencing the implementation of Building Information Modeling (BIM) in building projects and obstacles that stand in the way of BIM implementation. Questionnaires are a documented set of queries designed to specifically gather details from persons and gather details utilized for information analysis. Questionnaires must be designed in a method that may be completed easily method and not need any help.

They can be difficult because respondents cannot speak in their own words, and sometimes the researcher has no chance to verify if the responses are valid. However, these are very simple to organize, and all participants have required essentially the same queries and chosen from the recorded responses, it's suitable for quantitative study (Denscombe, 2021).

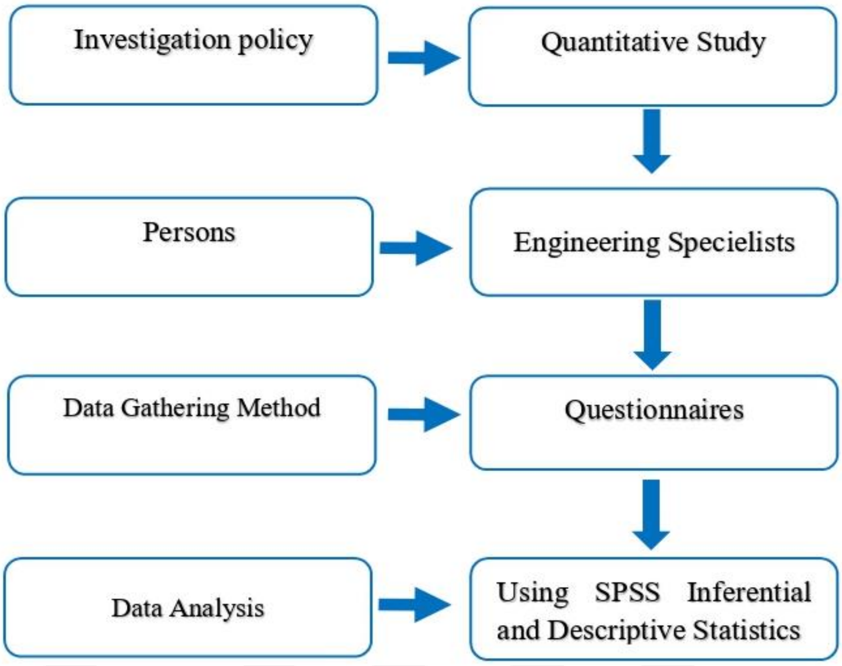

Figure 4.5: Steps of Questionnaire Survey

Source: Author

4.4.5 Questionnaires sample

The questionnaire study includes a quantitative approach specifically to the use of the sample primarily, which selects individuals, choosing a number for several and generalizing findings that might represent a wider population.

According to Bryman (2016), the degree to which a specimen is a community depends on specimen volume, the basic design of choice processes, and the specimen structure, where the specimen volume is the number of persons from the community through which the investigator gets data, the specimen design or sampling the strategy be referred to the

basic plan choice process, where specimen structure is a list representing persons in a community. The questionnaires were targeted at (207) members of engineering specialities working in the fields of building construction. The participants were contacted by printing the questionnaire and distributing it in papers, social media numbers, and email addresses. Where participants have been required to answer the questionnaires and send them back through the same receipting method, and then questionnaires (188), have been returned after giving them a specific duration (21) days.

4.4.6 Questionnaires design

The questionnaires should be designed to gather data that could be used for evaluation, provide a list of questions, and must ask people for data on identified research matters (Denscombe, 2014). where four key criteria must be met while questionnaires are designed:

• Theoretical awareness of the study conducted and obtained by analyzing submitted literature or other qualitative study methods that may function as a pilot approach.

• The validity of the questionnaire, how the question tests what it has been designed to test, and the reliability of the questions, whether these are consistent or relevant.

• Experience in writing a questionnaire and the utilization of a broad variety of questionnaires published.

• Knowledge of the target demographic.

A sample of the questionnaire is included in appendix A. The questionnaire includes a group of specific questions designed to gather the knowledge that will assist in achieving the aims and objectives of the study.

Specific questions are designed with answers that only permit the answers to match into categories defined by the researcher in advance. The questionnaire also included the scales defined as measurement levels, which are a method for arranging information in the measurement of indicators into the nominal and ordinal level, and also scales to determine the intensity, direction, amount, or power of a variable measuring in quantitative data. Scales include Likert, Thurston, the social distance of Borgadus, semantic differential, numerical ranking, and the scale of Guttman.

They are utilized by social scholars to provide strong data quality, high precision and reliability, compare data sets, and improve data collection and analysis (Neuman, 2014). The scale of measurements utilized for this study is nominal and ordinal (numerical and Likert) measurement scales. The nominal measurement scale is used in section 1 of the questionnaire. It's required from the respondent to select the speciality of his/her occupation and years of experience.

Section 2 (part 1 and part 2) deals with issues by using the ordinary measurement scale (Likert scale), Where they included a 5-point Likert scale, which requires respondents to indicate to what extent they agree or disagree about the effects and criticality of the advantages, and primary factors that are influencing the implementation of Building Information Modeling (BIM) in the building projects, and obstacles that stand in the way of BIM implementation, where; No.5=Strongly Agree, No.4=Agree, No.3=Neutral, No.2=Disagree and No.1= Strongly disagree. Due to its simplicity, flexibility, and reliability, the Likert scale is the most widely used form of scaling (Neuman, 2014).

4.5 Data Collection

According to Crowther and Lancaster (2012), conducting a questionnaire survey is an efficient way to collect information that has not been influenced by the respondents. In light of this, a qualitative semi-structured questionnaire has been selected for usage, one in which the conceptual framework of themes is incorporated into the questions and which will be used to evaluate the information gathered from the participants.

The response ratio for the data collection is beneficial in assessing the efficiency of the questionnaires returned in the study. Where the distribution of the questionnaire for the survey method. (207) questionnaires were distributed directly, either by printed papers or by sent questionnaire link (google format) through the social media numbers and email addresses, and then (188) completed questionnaires were then returned, which resulted in a (90.8%) of participants. Table (4.1) displays the number of responses depending on the various specialists in construction projects of buildings.

Table 4.1: Questionnaire Distribution

Position of Participant	Rate %	No.
Upper manager	2.7	5
Project manager	2.1	4
Designer Engineer	10.1	19
Technical Office Engineer	14.4	27
Construction Engineer	56.4	106
Architect	14.4	27
The total number of completed questionnaires returned	100	188

4.6 Data Analysis

In order to acquire a deeper comprehension of the BIM application strategies and applications that are utilized during the construction phase by construction companies, a questionnaire has been formulated to serve that purpose.

The questions were posed in order to guarantee the dependability of the research and to enable the formation of a comprehensive picture regarding the BIM application situation in the companies (strengths and weaknesses), application drivers, and the anticipated government's involvement from the participant's point of view, as well as the types of projects and BIM's place in the environmentally responsible building from the claimant's personal experience. In order to accomplish the goals of the research, the questions were designed to fill in the information that was lacking from the previous literature review.

Due to the fact that the sharing of data collected about research papers was not available, it was not possible to analyze data about the projects that were described by the participants in the questionnaire. This was the case either because the construction companies did not permit it or because the construction manager did not allow it. In light of this, the difficulties experienced by limited information projects were discussed.

The deductive research coding approach known as "grounded assessment" has been selected as the technique for the qualitative approach because it was thought to best meet the requirements of the themes that were derived from the questionnaire. The grounded assessment was defined as a qualitative method that identifies concepts or ideas for a methodology, action, or engagement regarding priorities (Crowther and Lancaster, 2012). As a direct result of this, the codes and concepts for the research methodology were derived from the questions in the questionnaires.

Through the application of the themes that were obtained from the questionnaire questions, as shown in table (4-2), the aims of the questionnaire questions were to accomplish the gap in the past research concerning the application of BIM. Specifically, the following aims were intended to be met:

1- Aspects that play a role in determining whether or not consulting companies will use BIM.

2- Obstacles in the way of companies and organizations implementing BIM

3- Factors that contributed to the overall success of the application

4- The stage of BIM competence within the companies

5- The guidelines or protocols for BIM that were utilized in the projects

6- Some of the repercussions that the implementation of BIM has had on the company

7-The requirement for the participation of the government in the BIM implementation procedure.

8- According to the opinions of the participants, the application of BIM can help provide a sustainable building projects sector.

Table 4.2: The Primary Factors That Are Influencing the Implementation of Building Information Modeling (BIM) in The Building Projects

No.	Items	Code
1	The implementation of BIM results in an improvement in the information management of building projects	B1
2	The implementation of BIM ultimately leads to an improvement in the overall quality of the work packages	B2
3	The implementation of BIM in the project allows for more efficient collaboration between the members of the project group	B3
4	The implementation of BIM leads to improved environmental building analysis, as well as its enhancement, facilitation, and improvement	B4
5	The implementation of BIM leads to improved outcomes and helps contribute to a decrease in the amount of waste materials generated	B5
6	The implementation of BIM is one of the primary goals that must be accomplished in order to successfully implement the technology	B6
7	The implementation of BIM is one of the primary goals that is being worked towards to improve the procedures that are used in the construction industry	B7
8	The implementation of BIM is one of the main goals that need to be accomplished in order to realize the sustainable advancement strategies	B8
9	The implementation of BIM is one of the main goals is to improve the construction industry's sustainability	B9
10	The implementing of BIM is the primary goal of improving a project's construction documents, and this is especially true for large and complicated projects	B10
11	The main objective of implementing BIM in construction is to lessen the number of disagreements and conflicts that arise during the building process	B11

Table 4.2: (Cont.) The Primary Factors That Are Influencing the Implementation of Building Information Modeling (BIM) in the Building Projects

No.	Items	Code
12	The main objectives of BIM implementation are obtaining accurate material takeoffs and timetables	B12
13	According to specialists, BIM has the capacity to facilitate and assist in sustainable construction	B13
14	The application of BIM contributes to the improvement of sustainable building construction	B14
15	To achieve sustainability in the construction sector and in the design of sustainable buildings, the government must extend the use of BIM	B15
16	The implementation of BIM makes a contribution to the analysis of the performance and maintenance on projects	B16

The study followed initial steps to insert data gathered in the program SPSS, after which the data inserted were reviewed and errors verified. It was a required practice to verify the data input process was correct. SPSS was used descriptively and differentially to analyze the data from the survey.

The study involved the analysis of the percentile form, Cronbach's Alpha, and frequency variables indexes. The study also involved the engineering specialization of the different participants in the questionnaire survey, as shown in figure (4.7).

The results show that (56.4%) have a construction engineering background that, carries the highest percentage of participants that they were working in the field of buildings construction in this survey, the results also show each of architectural and technical office engineer that have (14.4%) from the participants, while result shows (10.1%) have a designer engineer background, the results also showed (2.7%) have an upper manager background, while (2.1%) have project manager background.

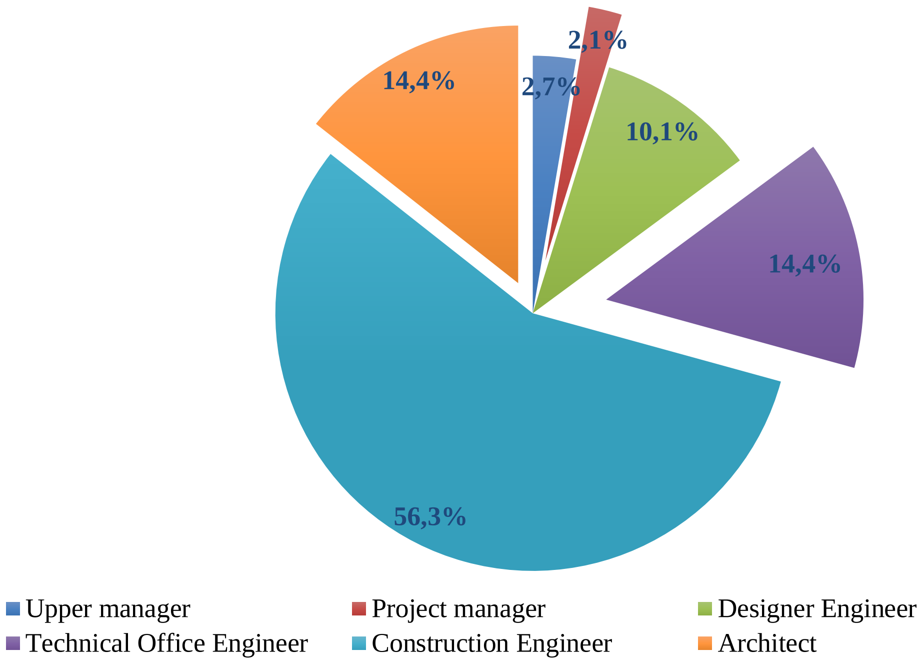

Figure 4.6: Participant's Specialization

The study involved how much do the participants know about building information modelling (BIM) of the different participants in the questionnaire survey, as shown in figure (4.7).

The results show that (50.5%) have a BIM researcher, with the highest percentage of participants. The results also show not using BIM but intend to use that have (33.0%) from the participants, while the result shows (8.0%) have a BIM expert, the results also showed (5.3 %) have a BIM user, while (3.2%) have Not interested.

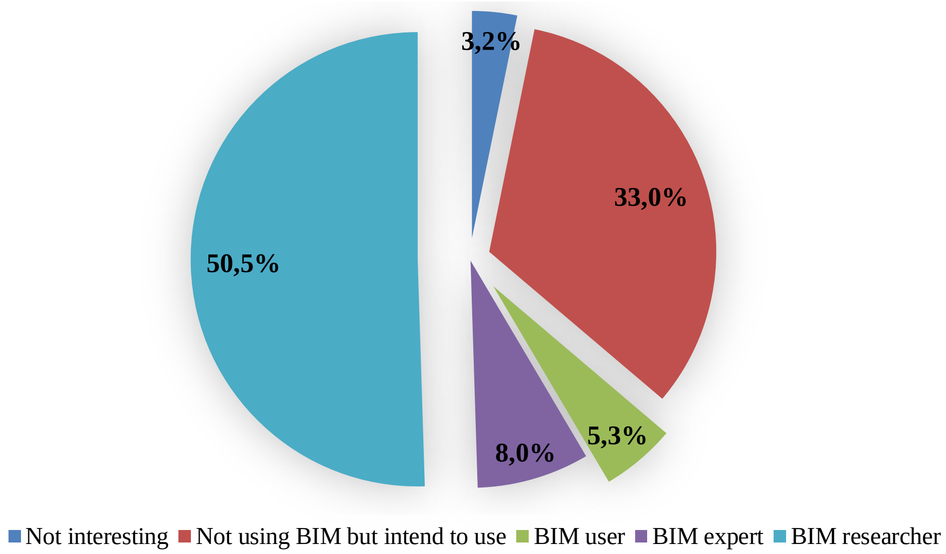

Figure 4.7: How Much do You Know About Building İnformation Modelling (BIM)

The results show that (61.2%) have a BSC background, another side the results also show that (16.0%) have an MSC background, while the result shows (13.8) % have other qualifications, and the results also showed (9.0%) have PHD, figure (4.8) showing participants' qualifications regarding education.

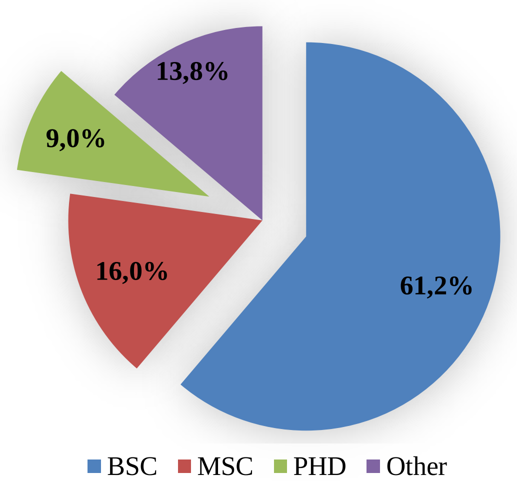

Figure 4.8: Participant's Qualification

The study shows the years of experience of the different participants as per figure (4.9), where (48.9%) of participants less than (5) years of professional experience, in another side (19.7%) of participants from 11 to15 years of working experience, while (14.9%) with 16 to 20 years of professional experience, whereas (13.8%) for 5 to 10 years of professional experience, and (2.7%) more than 21 years of professional experience.

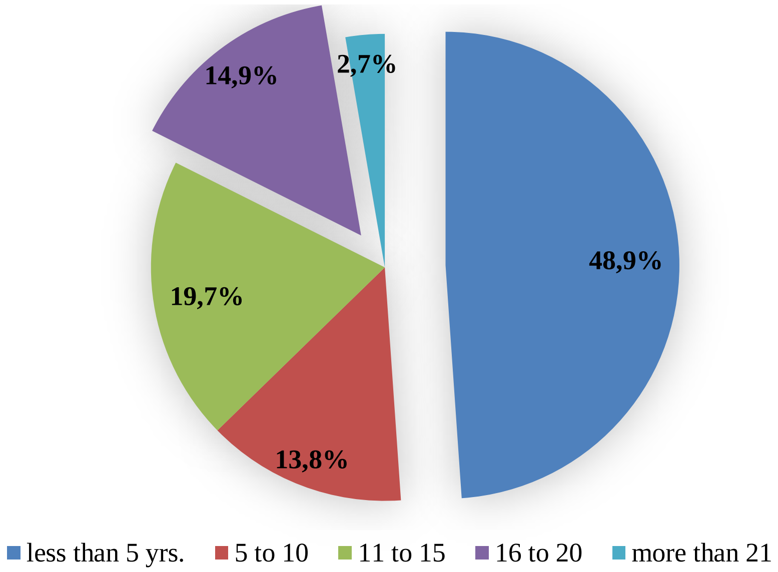

Figure 4.9: Years' Experience of Participants

4.6.1 Assessing the level of data reliability

The value of the Cronbach's alpha coefficient can range anywhere from 0 to 1. However, there is no consensus regarding the value that provides a level of reliability that is regarded as acceptable. According to Ott and Longnecker (2015), the acceptable range is determined by the circumstances in which the equipment is going to be used and the goal or purpose of the research being conducted. In most contexts, the hypothesis that a larger sample size results in a more accurate reliability estimate is widely accepted (Bell, 2014).

The SPSS data analysis software was used to conduct a reliability test on the 5-point Likert scale that served as the primary scale in this investigation. The results of this test demonstrated that the scale was reliable. The reliability test is used to assess the consistency of the selected scale, and the alpha in Cronbach is the most popular reliability test, as shown in equation (4.1). The reliability test was carried out to demonstrate the reliability of the scales to determine what important sustainable building ingredients are for credibility in sustainable buildings and the challenge of achieving sustainable buildings;

$$\boldsymbol{\alpha} = \frac{n}{(n-1)}\left[1 - \frac{\sum_{i=1}^{n}\sigma_{yi}^{2}}{\sigma_{x}^{2}}\right] \qquad \textbf{(4.1)}$$

Where:

$\boldsymbol{\alpha}$ = alpha Cronbach

$\boldsymbol{n}$ = refers to the number of scale items

$\boldsymbol{\sigma_{yi}^{2}}$ = refer to the variance associated with the item i

$\boldsymbol{\sigma_{x}^{2}}$ = refer to the variance associated with observed total scores

Where the values of (0.70) or larger are accepted.

4.6.1.1 Data reliability of the advantages that influencing implementation of BIM at building projects

To mention to Bell's (2014) task, reliability evaluation is utilized to measure the uniformity of a level, and Cronbach's alpha has become the most common indicator of scale reliability. The examination of the internal characteristics of a scale, which refers to the degree to which the components of a scale are able to remain attached to one another, is connected to the process of determining whether or not a scale can be relied upon. The purpose of the reliability evaluation that was conducted out was to indicate the reliability of levels for ranking the degree to which significant improvements that influence the implementation of BIM at building projects.

The internal reliability of the scales was analyzed with the help of Cronbach's coefficient. According to Ott and Longnecker (2015), values of 0.70 or greater are considered to be appropriate for use. Cronbach's alpha is an indicator of the overall reliability of a questionnaire, and table (4.4) shows that all of the values are greater than the value of 0.70, which is considered to be a satisfactory value for Cronbach's alpha. It also shows that the scales used in this research are reliable, and they are in accordance with what is stated in this reference, which specifies that Cronbach's alpha implies the whole reliability of a questionnaire.

4.6.1.2 Data reliability of the obstacles that stand in the way of BIM implementation

The reliability evaluation was performed in order to show the reliability of levels for ranking the significance of which the obstacles that stand in the way of BIM application. Table (4.3) shows that all of the values are above the 0.70 value, regarded as an acceptable significance for Cronbach's alpha specifying that the scales for this research are reliable, and this refers to states that Cronbach's alpha implies the whole reliability of a questionnaire.

Table 4.3: The Cronbach's Alpha Values

Items	No. of Items	Value	Cronbach's Alpha	Internal Reliability
Benifites (B1 to B16)	16	0.885	$0.9 > \alpha \geq 0.8$	Good
Obstacles (O1 to O20)	20	0.913	$\alpha \geq 0.9$	Excellent

4.6.2 The advantages of influencing implementation of BIM at building projects

The purpose of this research was to investigate the advantages of using BIM in terms of offering sustainable buildings. Within this framework, the research looked at the following secondary goals.

Where table (4.4) describes the level of the advantages and primary factors that are influencing the implementation of Building Information Modeling (BIM) in the building projects.

It shows B11, “The main objective of implementing BIM in construction is to lessen the number of disagreements and conflicts that arise during the building process”, as the maximum rank with summation of collected points (813).

This is followed by B9, “The implementation of BIM is one of the main goals is to improve the construction industry's sustainability”, the second rank with summation of collected points (811).

B16 “The implementation of BIM makes a contribution to the analysis of performance and maintenance on projects” level the third rank with summation of collected points (806).

In the other side B2, the implementation of BIM ultimately leads to an improvement in the overall quality of the work packages”, ranked with level fourth with summation points (804). and the B7, “The implementation of BIM is one of the primary goals that is being worked towards to improve the procedures that are used in the construction industry”, ranked fifth with collected points of (800).

While the B15 “To achieve sustainability in the construction sector and in the design of sustainable buildings, the government must extend the use of BIM” ranked lowest with an index of (720).

Table 4.4: Levels of the Advantages And Primary Factors That are Influencing the Implementation of (BIM) in the Building Projects

No.	Code	Mean		Std. Deviation	Variance	Sum.	Rank	
		St.	Std. Error of Mean					
1	B1	4.02	0.062	0.846	0.716	756	15th	
2	B2	4.28	0.053	0.723	0.522	804	4th	4.37
3	B3	4.24	0.055	0.748	0.560	798	7th	
4	B4	4.20	0.065	0.889	0.790	789	10th	
5	B5	4.12	0.054	0.739	0.546	775	14th	
6	B6	4.23	0.050	0.691	0.477	795	8th	
7	B7	4.26	0.053	0.723	0.523	800	5th	
8	B8	4.24	0.051	0.697	0.485	798	6th	
9	B9	4.31	0.053	0.733	0.537	811	2nd	

Table 4.4: (Cont.) Levels of the Advantages And Primary Factors That are Influencing the Implementation of (BIM) in the Building Projects

No.	Code	Mean		Std. Deviation	Variance	Sum.	Rank	
		St.	Std. Error of Mean					
10	B10	4.18	0.051	0.701	0.491	786	12th	
11	B11	4.32	0.049	0.667	0.445	813	1st	
12	B12	4.21	0.051	0.705	0.497	791	9th	
13	B13	4.19	0.056	0.764	0.583	788	11th	.634
14	B14	4.18	0.055	0.752	0.566	786	13th	
15	B15	3.83	0.057	0.783	0.613	720	16th	
16	B16	4.29	0.056	0.762	0.580	806	3rd	

4.6.3 The obstacles that stand in the way of BIM implementation

The obstacles that prevent the application of BIM have been brought to light at Building Projects, where table (4.5) details the information provided by participants that were used to evaluate these obstacles.

Table 4.5: Levels of the Obstacles that Stand in the way of BIM Implementation in the Building Projects

No.	Code	Mean		Std. Deviation	Variance	Sum.	Rank	
		St.	Std. Error of Mean					
1	O1	4.16	0.062	0.850	0.723	782	10th	
2	O2	4.34	0.053	0.731	0.534	815	2nd	4.37
3	O3	4.34	0.047	0.638	0.408	816	1st	
4	O4	4.04	0.069	0.953	0.907	760	16th	
5	O5	3.99	0.065	0.890	0.791	750	20th	
6	O6	4.16	0.062	0.857	0.734	782	11th	
7	O7	4.00	0.061	0.840	0.706	752	8th	
8	O8	4.02	0.066	0.898	0.807	755	19th	
9	O9	4.05	0.053	0.733	0.538	761	15th	
10	O10	4.16	0.058	0.798	0.638	782	9th	
11	O11	4.12	0.056	0.772	0.596	774	13th	
12	O12	4.04	0.061	0.843	0.710	759	18th	
13	O13	4.22	0.064	0.884	0.781	793	4th	.634
14	O14	4.17	0.065	0.897	0.805	784	7th	
15	O15	4.13	0.060	0.824	0.679	776	12th	
16	O16	4.08	0.067	0.919	0.844	767	14th	
17	O17	4.04	0.069	0.953	0.907	760	17th	
18	O18	4.21	0.053	0.729	0.532	792	5th	
19	O19	4.18	0.055	0.752	0.566	786	6th	
20	O20	4.32	0.050	0.683	0.466	813	3rd	

Where the results revealed (20) obstacles that stand in the way of BIM application at building projects. The first five the as the maximum value with a ranking index are:

O3 "Lack of access to suitable technologies and frameworks" (1st) with calculated points (816).

O2 "Inadequate BIM technical expertise and awareness" (2nd) with calculated points (815). O20 "Modern technologies are adequate" (3rd) with calculated points (813).

O13 "Staff resistance" with calculated points (793) (4th), O18 "Issues with interoperability and consistency" (5th) with calculated points (792). While O5 "Absence of suitable BIM standards" with calculated points (750) (20th).

5. CONCLUSION AND RECOMMENDATION

5.1 Introduction

The Building Information Modeling (BIM) methodology is innovative and extremely effective in the building sector. Although the potentials and benefits of BIM have a significant impact on both humanity and the environment, the technology still requires additional development time before it can be used effectively.

The value that BIM brings to owners has been characterized as follows: Spending less money and getting more done over the course of a building's whole lifetime. Education in the scientific facets of BIM for individuals who use it, from proprietors and designers to constructors and maintenance employees, as well as encouraging the social context of BIM in communities, is an essential component that should be implemented more carefully; alternatively, BIM can only be looked at a great opportunity that will eventually go unused due to a shortage of knowledge and understanding about it. Education in the technical elements of BIM for individuals who use it can be found here.

Besides the fact that the implementation of BIM has a number of positive effects on the environment, however, it also has a number of positive effects on owners in a variety of aspects, particularly with regard to large projects rather than smaller ones. In recent years, a number of developing countries have shown a much greater interest in making use of BIM in a variety of fields of building and facility management.

To decrease the detrimental effect of buildings on the environment, the construction industry also developed sustainable construction strategies. Buildings have been highlighted in research studies as a significant contributor to the use of large quantities of energy and water and the intensive use of land.

Several governments have developed policies that support sustainable construction to generate sustainable buildings.

In design instruction of building projects, sustainability is sadly neglected; this is obvious for the current unsustainable environment. There is inattention at environmental, economic, and social effects evaluation, life cycle evaluation, and life cycle cost evaluation for the completed projects or the materials that have been used, where there is an absence of evidence to recognize sustainable building ingredients.

The purpose of this research is to look into not only the benefits of utilizing a BIM application in the design and construction sector but also the drawbacks and difficulties associated with doing so. It is possible to forecast the benefits of how Building Information Modeling (BIM) will boost efficiency in the building sector with an understanding of the program and how it operates. Their viewpoints will also be gathered regarding the implementation of BIM on projects, including the merits and disadvantages of this methodology in terms of efficiency.

The demand for the usage of complex advancements within a limited span of time and budget has increased the necessity for a more unexpected and advanced strategy for advancement rather than the conventional approach.

This requirement has increased the necessity for a more propulsive strategy for advancement. At the end of the working day, in order to keep from exceeding the confinements, we need to think about a more planned and technology-involved strategy for design initiative and, in addition, the assembly advance in the improvement process. This is something that we need to do so that we don't wind up exceeding the limitations.

Because of this, the role of the planner will need to be expanded to that of a general venture arranger of the geometric approach, which will call for adjustments to both the way the activity is performed and the way it is understood. Utilizing in a BIM-based strategy, some academics believe, may deprive the brain of a draftsman of its capacity for clean and adaptable innovation as well as the creative energy it contains. On the other hand, numerous specialists are working to improve society's acquaintance with BIM, its compositional benefits, and other benefits.

The literature review obtained (16) of the advantages and primary factors that are influencing the implementation of (BIM) in building projects and, at the same time, the obstacles that stand in the way of BIM implementation in the building projects. And helped create a historical knowledge of the structure and its components and reviewed documents.

The second stage of the study involved sending a questionnaire to (188) members of the engineers and specialists those working in buildings construction fields.

Step three includes validating the development of a management system with a view to achieving factors that implementation of (BIM) in construction projects.

5.2 Conclusions of Study

The purpose of the research was to evaluate the benefits that adopting BIM could bring to providing building projects. Within this framework, the research looked at the following secondary goals:

1. BIM procedures that are environmentally friendly are implemented during the pre-construction stage by consulting companies.
2. The implementation of BIM in several regions.
3. BIM application condition.
4. Recommendations for the necessary steps to take to ensure the effective implementation of BIM.

The study covered its aims, and this section presents the recommendations that were derived from that investigation. The most important takeaways from the investigation are as follows:

- According to the findings of the study, implementing BIM leads to a number of advantages for construction methods, all of which have a beneficial impact on the construction sector's capacity to remain sustainable. As a result of the use of BIM, the management of knowledge pertaining to the construction project is improved, the quality of the deliverables is increased, greater cooperation between the members of the project team is made possible, environmental building assessment is improved, and the amount of waste materials produced is decreased.
- There are a lot of obstacles standing in the way of successful BIM applications for organizations and nations. The adoption process faces many challenges, the most significant of which include opposition to change from top management, the expense of new technology, poor application, and a shortage of training and specialists.

- There are a lot of obstacles standing in the way of successful BIM applications for organizations and nations. The deployment process faces many challenges, the most significant of which include opposition to change from top management, the expense of new technology, poor application, and a shortage of training and specialists.
- The requirement of BIM in the local construction market is the most important factor that drives BIM application consulting companies.
- BIM is required by the client in order to produce the construction papers for their project, particularly in the case of big and complicated projects. Their primary objectives are to cut down on construction-related conflicts and disagreements, obtain precise material take-offs, and adhere to established timetables.
- Experts are of the opinion that building information modelling (BIM) has the potential to facilitate and promote construction projects for environmentally sustainable buildings. The issue, however, is that there is a lack of demand for environmentally friendly structures, and the country does not support them.
- The study showed that there are some potential initiatives from academics and the corporate sector towards enhancing BIM techniques. This is despite the fact that the rate of application is somewhat modest.
- The expansion of BIM as a tool for achieving sustainability in the building sector and in the planning and design of environmentally friendly buildings was another topic that was discussed at length by industry professionals.

Furthermore, the literature provided support for this perspective by indicating that the involvement of governments and publicly organizations in the adoption of BIM is significant. This is because governments and publicly organizations have the ability to exert pressure on national governments to start applying BIM.

5.3 Recommendations

Based on the findings of the interviews and the assessment of the relevant literature, the study made several recommendations for steps that the government and various participants in the construction sector should take in order to embrace BIM in order to create a more environmentally friendly construction sector.

5.3.1 Governments and publicly organizations

- Implementation of Building Information Modeling (BIM) as part of a strategy for sustainable advancement should focus on maintaining the built environment and enhancing construction sector procedures.
- Determine the overarching objectives for the implementation of BIM with the assistance of the stakeholders in the sector, and establish a time schedule for accomplishing these objectives.
- Make available a road plan for the implementation of BIM requirements in the construction sector.
- Deliver a BIM education that is of the highest professional standard.
- Building information modelling should be implemented in building license organizations.
- Raise the level of awareness between the various construction stakeholders regarding the significance of adopting BIM.
- Improve BIM guidelines and best practices with the help of the private sector by working together to draw on their previous experiences.
- Establish a platform for benchmarking and sharing best practices in order to assist a greater number of companies with the application procedure.
- In order to promote construction companies to use building information modelling (BIM) and to construct environmentally friendly structures, we can provide training, reduce taxes, and lend money to construction organizations so that they can update their technological infrastructure.
- Establish objectives, create a BIM application plan, and share the strategy with the employees of the company to get their assistance for the process of application.
- Explain the upper management about the advantages of BIM by offering education in the BIM management instruments and their capacity to increase both efficiency and quality over the long term. In addition to this, show them examples of successful BIM applications and projects.
- It is the responsibility of the building's designers and providers to supply the engineering group with the necessary BIM objects so that the building may be analyzed and simulated accurately.

5.3.2 Institutions of academic learning

- Because of the rapid change in building technology and practices regarding more environmentally friendly methods, schools need to adopt curricula that are flexible enough to follow these developments and keep students' knowledge and abilities current.
- Utilize the building information modelling (BIM) apps in the environmental courses to instruct the students on how to use simulation to evaluate the efficiency of buildings.
- Promote the engineering divisions' interaction and cooperation through shared initiatives.

5.3.3 Recommendation for future studies

- A Plan of Action toward a BIM requirement in the construction sector following the completion of this study, the next step that needs to be taken is the suggestion of a road map for the introduction of BIM.
- The request to form a comprehensive perspective on the procedures and visions of the building industry, this step requires communication with federal government mortuaries and public officials.
- The communication with the private sector is required to assessment the current operations and application process of BIM in order to help in the formation of the plan of action.
- The framework for BIM guidelines does not permit the publishing of example studies. There is a requirement for doing case study evaluations in order to quantify the impact that utilizing BIM has had on the regional market as well as the quality of the results.
- BIM application techniques include working directly with a variety of companies to explore the various practices that are used during the application process as well as the issues that are faced by those companies.

REFERENCES

Abbasnejad, B., Nepal, M. P., Ahankoob, A., Nasirian, A., & Drogemuller, R. (2021). Building Information Modelling (BIM) adoption and implementation enablers in AEC firms: a systematic literature review. Architectural Engineering and design management, 17(5-6), 411-433.

Adhikari, A., & Keung, C. W. (2018, November). The impact of BIM on quantity surveyor's role: the contractor perspective. In Proceedings of the 11th International Cost Engineering Council (ICEC) World Congress and the 22nd Annual Pacific Association of Quantity Surveyors (PAQS) Conference (ICEC-PAQS Conference 2018), Sydney, Australia (pp. 18-20).

Akadiri, P. O., Olomolaiye, P. O., & Chinyio, E. A. (2013). Multi-criteria evaluation model for the selection of sustainable materials for building projects. Automation in construction, 30, 113-125.

Al-Yami, A., & Sanni-Anibire, M. O. (2021). BIM in the Saudi Arabian construction industry: State of the art, benefit and barriers. International Journal of Building Pathology and Adaptation, 39(1), 33-47.

AlWaer, and Kirk. (2012). Building sustainability assessment methods. In Proceedings of the Institution of Civil engineers-engineering Sustainability (Vol. 165, No. 4, pp. 241-253). Thomas Telford Ltd.

Aranda, J. Á., Martin-Dorta, N., Naya, F., Conesa-Pastor, J., & Contero, M. (2020). Sustainability and interoperability: An economic study on bim implementation by a small civil engineering firm. Sustainability, 12(22), 9581.

Atta, I., Bakhoum, E. S., & Marzouk, M. M. (2021). Digitizing material passports for sustainable construction projects using BIM. Journal of Building Engineering, 43, 103233.

Bell, B. A. (2014). Encyclopedia of research design.

Berardi, U. (2012). Sustainability assessment in the construction sector: rating systems and rated buildings. Sustainable development, 20(6), 411-424.

Becerik-Gerber, B., & Kent, D. (2010). Implementation of integrated project delivery and building information modelling on a small commercial project. International Journal of Project Management, 1-6.

Bastos Porsani, G., Del Valle de Lersundi, K., Sánchez-Ostiz Gutiérrez, A., & Fernández Bandera, C. (2021). Interoperability between building information modelling (BIM) and building energy model (BEM). Applied sciences, 11(5), 2167.

BREEAM-NC. (2018). BREEAM International New Construction: Technical Manual.

BREEAM (2012). BREEAM In-use: BRE Environmental & Sustainability Standard. UK, BRE Global Limited.

Boton, C. (2018). Supporting constructability analysis meetings with Immersive Virtual Reality-based collaborative BIM 4D simulation. Automation in Construction, 96, 1-15.

Bryde, D., Broquetas, M., & Volm, J. M. (2013). The project benefits of building information modelling (BIM). International journal of project management, 31(7), 971-980.

CASBEE (2011). CASBEE homepage. Viewed: htttp://www.ibec.or.jp/CASBEE/english/ Accessed on 04/02/2023.

Carmody, J., Weber, W., & Jacobson, R. (2009). Design guidelines for Sustainable housing. Centre for Sustainable Housing Yonsei University, South Korea.

Chatti, M. A., Dyckhoff, A. L., Schroeder, U., & Thüs, H. (2012). A reference model for learning analytics. International Journal of Technology Enhanced Learning, 4(5-6), 318-331.

Creswell, J. W. And Creswell, J.D (2018). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Fifth Edition, International Students Edition. Los Angeles, Sage Publications.

Crowther, D., & Lancaster, G. (2012). Research methods. Routledge.

Du Plessis, C. (2007). A strategic framework for sustainable construction in developing countries. Construction Management and Economics, 25(1), 67-76.

Denscombe, M. (2021). Ebook: The Good Research Guide: Research Methods for Small-Scale Social Research Projects. McGraw-Hill Education (UK).

Ebrahim, A., & Wayal, A. S. (2020). Green BIM for sustainable design of buildings. In ICRRM 2019–System Reliability, Quality Control, Safety, Maintenance and Management: Applications to Civil, Mechanical and Chemical Engineering (pp. 185-189). Springer Singapore.

Elhendawi, A. I. N. (2018). Methodology for BIM Implementation in KSA in AEC Industry. Master of Science MSc in Construction Project Management), Edinburgh Napier University, UK.

Flick, U. (2022). An introduction to qualitative research. Sage.

Gerges, M., Austin, S., Mayouf, M., Ahiakwo, O., Jaeger, M., Saad, A., & El Gohary, T. (2017). An investigation into the implementation of Building Information Modeling in the Middle East. Journal of Information Technology in Construction, 22, 1-15.

Guerriero, A., Kubicki, S., Berroir, F., & Lemaire, C. (2017, June). BIM-enhanced collaborative smart technologies for LEAN construction processes. In 2017 International Conference on Engineering, Technology and Innovation (ICE/ITMC) (pp. 1023-1030). IEEE.

Gunatilake, S. (2013). The uptake and implementation of sustainable construction: transforming policy into practice (Doctoral dissertation, University of Central Lancashire).

Gordon, R., Carrigan, M., & Hastings, G. (2011). A framework for sustainable marketing. Marketing theory, 11(2), 143-163.

Hategan, C. D., and Ivan-Ungureanu, C. (2014). Frameworks for a sustainable development indicators system. Theoretical and Applied Economics, 3(592), 31-44.

Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). Life cycle assessment (Vol. 2018). Springer International Publishing, Cham. https://doi. org/10.1007/978-3-319-56475-3.

Ho, P. H. (2021). Mapping out BIM contract conditions by way of a comparative study. Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 13(1), 05020017.

Hodges, C. P. (2005). A facility manager's approach to sustainability. Journal of facilities management.

Horman, M. J., Riley, D. R., Lapinski, A. R., Korkmaz, S., Pulaski, M. H., Magenta, C. S., ... & Dahl, P. K. (2006). Delivering green buildings: Process improvements for sustainable construction. Journal of Green Building, 1(1), 123-140.

Justo, A., Soilán, M., Sánchez-Rodríguez, A., & Riveiro, B. (2021). Scan-to-BIM for the infrastructure domain: Generation of IFC-compliant models of road infrastructure assets and semantics using 3D point cloud data. Automation in Construction, 127, 103703.

Jiang, L., Leicht, R. M., & Okudan Kremer, G. E. (2014). Eliciting constructability knowledge for BIM-enabled automated, rule-based constructability review: A case study of formwork. In Construction Research Congress 2014: Construction in a Global Network (pp. 319-328).

Jin, R., Zhong, B., Ma, L., Hashemi, A., & Ding, L. (2019). Integrating BIM with building performance analysis in project life-cycle. Automation in Construction, 106, 102861.

Kardos, M. (2012). Romania On The Path To Sustainable Development. Comparative Analysis Within The European Union. Annals of the University of Oradea, Economic Science Series, 21(2).

Kikwasi, G. (2012). Causes and effects of delays and disruptions in construction projects in Tanzania. In Australasian Journal of Construction Economics and Building-Conference Series (Vol. 1, No. 2, pp. 52-59).

Khoshfetrat, R., Sarvari, H., Chan, D. W., & Rakhshanifar, M. (2022). Critical risk factors for implementing building information modelling (BIM): a Delphi-based survey. International Journal of Construction Management, 22(12), 2375-2384.

Khalfan, M., Azizi, N., Haass, O., Maqsood, T., & Ahmed, I. (2022). Blockchain technology: Potential applications for public sector E-procurement and project management. Sustainability, 14(10), 5791.

Knollenberg, W., McGehee, N. G., Boley, B. B., & Clemmons, D. (2014). Motivation-based transformative learning and potential volunteer tourists: Facilitating more sustainable outcomes. Journal of Sustainable Tourism, 22(6), 922-941.

Larsson, N., and Macias, M. (2012). Overview of the SBTool assessment framework. The International Initiative for a Sustainable Built Environment (iiSBE) and Manuel Macias, UPM Spain.

Liang, C., Lu, W., Rowlinson, S., & Zhang, X. (2016). Development of a multifunctional BIM maturity model. Journal of construction engineering and Management, 142(11), 06016003.

Laali, A., Nourzad, S. H. H., & Faghihi, V. (2022). Optimizing sustainability of infrastructure projects through the integration of building information modelling and envisioning rating system at the design stage. Sustainable Cities and Society, 84, 104013.

Lei, J., Huang, B., & Huang, Y. (2020). Life cycle thinking for sustainable development in the building industry. In Life Cycle Sustainability Assessment for Decision-Making (pp. 125-138). Elsevier.

Lu, W., Zhang, D., & Rowlinson, S. M. (2013). BIM collaboration: A conceptual model and its characteristics. In Proceedings of the 29th Annual Association of Researchers in Construction Management (ARCOM) Conference. Association of Researchers in Construction Management.

Marszal, A. J., Heiselberg, P., Bourrelle, J. S., Musall, E., Voss, K., Sartori, I., & Napolitano, A. (2011). Zero Energy Building–A review of definitions and calculation methodologies. Energy and Buildings, 43(4), 971-979.

Malsane, Sagar, Jane Matthews, Steve Lockley, Peter ED Love, and David Greenwood. (2015): "Development of an object model for automated compliance checking." Automation in Construction 49 51-58.

Matar, M. M., Georgy, M. E., & Abou-Zeid, A. M. (2010, September). Developing a BIM-oriented data model to enable sustainable construction in practice. In Proceedings of the 8th European Conference on Product and Process Modelling (pp. 79-87).

Mertens, D. M. (2019). Research and evaluation in education and psychology: Integrating diversity with quantitative, qualitative, and mixed methods. Sage publications.

McClements, S., Cunningham, G., Comiskey, D., & McKane, M. (2017, November). The potential to enhance and develop BIM capabilities of companies in the AEC sector through collaboration with third-level institutions in knowledge transfer partnerships (KTPs). In CITA BIM Conference: BIM in Ireland.

Morrison-Saunders, A., & Retief, F. (2012). Walking the sustainability assessment talk—Progressing the practice of environmental impact assessment (EIA). Environmental Impact Assessment Review, 36, 34-41.

Ögmundarson, Ó., Herrgård, M. J., Forster, J., Hauschild, M. Z., & Fantke, P. (2020). Addressing environmental sustainability of biochemicals. Nature Sustainability, 3(3), 167-174.

Ott, R. L., & Longnecker, M. T. (2015). An introduction to statistical methods and data analysis. Cengage Learning.

Oduyemi, O., & Okoroh, M. (2016). Building performance modelling for sustainable building design. International Journal of Sustainable Built Environment, 5(2), 461-469.

Oti, A. H., Tizani, W., Abanda, F. H., Jaly-Zada, A., & Tah, J. H. M. (2016). Structural sustainability appraisal in BIM. Automation in Construction, 69, 44-58.

Popov, V., Mikalauskas, S., Migilinskas, D., & Vainiūnas, P. (2006). Complex usage of 4D information modelling concept for building design, estimation, scheduling and determination of effective variants. Technological and economic development of economy, 12(2), 91-98.

Reichertz, J. (2013). Induction, deduction (pp. 123-135). Sage Publications.

Reyers, B., Moore, M. L., Haider, L. J., & Schlüter, M. (2022). The contributions of resilience to reshaping sustainable development. Nature Sustainability, 5(8), 657-664.

Samimpay, R., & Saghatforoush, E. (2020). Benefits of implementing building information modelling (BIM) in infrastructure projects. Journal of Engineering, Project, and Production Management, 10(2), 123-140.

Seghier, T. E., Ahmad, M. H., Wah, L. Y., & Samuel, W. O. (2018). Integration models of building information modelling and green building rating systems: A review. Advanced Science Letters, 24(6), 4121-4125.

Silva, M. J. F., Salvado, F., Couto, P., & e Azevedo, Á. V. (2016). Roadmap proposal for implementing building information modelling (BIM) in Portugal. Open Journal of Civil Engineering, 6(03), 475.

Succar, B., & Kassem, M. (2016, May). Building information modelling: Point of adoption. In CIB World Conference Proceedings (Vol. 1).

Saraireh, A. Q., Moh'd, I., & Haron, A. T. (2020). Understanding the concept of building information modelling: a literature review. International Journal of Civil Engineering and Technology, 11(1), 165-171.

Song, Z., Shi, G., Wang, J., Wei, H., Wang, T., & Zhou, G. (2019). Research on management and application of tunnel engineering based on BIM technology. Journal of Civil Engineering and Management, 25(8), 785-797.

Shipman, C., & Siemiatycki, M. (2022). Building in common:(re) integrating social services and community space in church redevelopment projects. Journal of Urbanism: International Research on Placemaking and Urban Sustainability, 1-20.

Srinivasan, R. S., Ingwersen, W., Trucco, C., Ries, R., & Campbell, D. (2014). Comparison of energy-based indicators used in life cycle assessment tools for buildings. Building and Environment, 79, 138-151.

Stirton, L., & Tree, J. (2015). IPD and BIM: a new dimension to collaboration. Australian Construction Law Bulletin, 27(2), 31-36.

Tan, T., Mills, G., Papadonikolaki, E., & Liu, Z. (2021). Combining multi-criteria decision making (MCDM) methods with building information modelling (BIM): A review. Automation in Construction, 121, 103451.

Tan, Y., Shen, L., & Yao, H. (2011). Sustainable construction practice and contractors' competitiveness: A preliminary study. Habitat International, 35(2), 225-230.

Torcellini, P., Pless, S., Deru, M., & Crawley, D. (2006). Zero energy buildings: a critical look at the definition (No. NREL/CP-550-39833). National Renewable Energy Lab.(NREL), Golden, CO (United States).

Tokbolat, S., Karaca, F., Durdyev, S., & Calay, R. K. (2020). Construction professionals' perspectives on drivers and barriers of sustainable construction. Environment, Development and Sustainability, 22, 4361-4378.

Tronchin, L., and Fabbri, K. (2008). Analysis of buildings' energy consumption by means of the exergy method. International Journal of Exergy, 5(5-6), 605-625.

LEED-NC (2009). New Construction and Major Renovations Rating System. US Green Building Council

Videika, G., & Migilinskas, D. (2020). Evaluation of the main standards for sustainable buildings and evaluation of BIM details in the commercial project. Mokslas–Lietuvos ateitis/Science–Future of Lithuania, 12.

Utkucu, D., & Sözer, H. (2020). Interoperability and data exchange within the BIM platform to evaluate building energy performance and indoor comfort. Automation in Construction, 116, 103225.

Wang, Q., Guo, J., & Kim, M. K. (2019). An application-oriented scan-to-BIM framework. Remote sensing, 11(3), 365.

Weißenberger, M., Jensch, W., & Lang, W. (2014). The convergence of life cycle assessment and nearly zero-energy buildings: The case of Germany. Energy and Buildings, 76, 551-557.

Xu, Z., Chau, S. N., Chen, X., Zhang, J., Li, Y., Dietz, T., ... & Liu, J. (2020). Assessing progress towards sustainable development over space and time. Nature, 577(7788), 74-78.

Yalcinkaya, M., & Arditi, D. (2013). Building information modelling (BIM) and the construction management body of knowledge. In Product Lifecycle Management for Society: 10th IFIP WG 5.1 International Conference, PLM 2013, Nantes, France, July 6-10, 2013, Proceedings 10 (pp. 619-629). Springer Berlin Heidelberg.

Zabalza, I., Scarpellini, S., Aranda, A., Llera, E., & Jáñez, A. (2013). Use of LCA as a tool for building ecodesign. A case study of a low-energy building in Spain. Energies, 6(8), 3901-3921.

Zakari, Z., Ali, N. M. A., Haron, A. T., Ponting, A. M., & Hamid, Z. A. (2014). Exploring the barriers and driving factors in implementing building information modelling (BIM) in the Malaysian construction industry: A preliminary study. The Journal of the Institution of Engineers, Malaysia, 75(1).

APPENDICES

Appendix A

Part I: The purpose of the following questionnaire is to research the advantages, and primary factors that are influencing the implementation of Building Information Modeling (BIM) in the building projects.

Part I	The purpose of the following questionnaire is to research the advantages, and primary factors that are influencing the implementation of Building Information Modeling (BIM) in the building projects.					
No.	Items	1	2	3	4	5
1	The implementation of BIM results in an improvement in the information management of building projects					
2	The implementation of BIM ultimately leads to an improvement in the overall quality of the work packages					
3	The implementation of BIM in the project allows for more efficient collaboration between the members of the project group					
4	The implementationof BIM leads to improved environmental building analysis, as well as its enhancement, facilitation, and improvement					
5	The implementation of BIM leads to improved outcomes and helps contribute to a decrease in the amount of waste materials generated					
6	The implementation of BIM is one of the primary goals that must be accomplished in order to successfully implement the technology					
7	The implementation of BIM is one of the primary goals that is being worked towards to improve the procedures that are used in the construction industry					
8	The implementation of BIM is one of the main goals that needs to be accomplished in order to realize the sustainable advancement strategies					
9	The implementation of BIM is one of the main goals is to improve the construction industry's sustainability					
10	The implementing of BIM is the primary goal of improving a project's construction documents, and this is especially true for large and complicated projects					
11	The main objective of implementing BIM in construction is to lessen the number of disagreements and conflicts that arise during the building process					
12	The main objectives of BIM implementation are obtaining accurate material takeoffs and timetables					
13	According to specialists, BIM has the capacity to facilitate and assist sustainable construction					
14	The application of BIM contributes to the improvement of sustainable building construction					
15	To achieve sustainability in the construction sector and in the design of sustainable buildings, the government must extend the use of BIM					
16	The implementation of BIM makes a contribution to the analysis of performance and maintenance on projects					

Part II: The Obstacles that stand in the way of BIM implementation

Part II	The Obstacles that stand in the way of BIM implementation					
1	Insufficient senior management assistance.	1	2	3	4	5
2	Inadequate BIM technical expertise and awareness.					
3	Lack of access to suitable technologies and frameworks.					
4	Personal perspective or opinion.					
5	Absence of suitable BIM standards.					
6	The absence of a conducive setting.					
7	Massive BIM upfront costs.					
8	Absence of profit outlook.					
9	Expenses associated with training.					
10	Software pricing.					
11	The magnitude of cultural transformation necessary.					
12	Competitive endeavors.					
13	Staff resistance.					
14	Financial and legal duties.					
15	Insufficient Internet connection.					
16	Frequent power disruptions.					
17	Insufficient client demand.					
18	Issues with interoperability and consistency.					
19	Shortage of policymaker backing.					
20	Modern technologies are adequate.					

RESUME

EDUCATION:

- Bachler Degree in Civil Engineering / Al- Mustansriya University.
- 2017 Mini MBA from Cambridge UK.
- 2021 studying Master Degree in Engineering Management/ Istanbul Gedik University.

CERTIFICATIONS:

- Facility Management Professional FMP / IFMA
- Measuring Learning Effectiveness / LinkedIn
- COVID-19: Operational Planning Guidelines / WHO
- Productivity & Time management / Udemy Project Management Fundamentals / Udemy
- Project Management: Beginner to PROject / Udemy
- Leadership / Udemy
- Women Leadership / Udemy

TECHNICAL SKILLS:

- Office program (word, excel, MS, Power Point & Visio).
- AutoCAD: prepare drawings, as built drawings, measuring areas, edit plans to be more efficient & realistic.
- Site Inspections.
- Preparing reports with KPIs & SLA. Preparing Annual Budget for the planned projects.
- Handling Financial documents related to projects.
- Preparing BOQs for projects based on engineering specs.
- Assets Inventory that related to my work.
- Experienced with ERP & DocuWare systems.

WORK EPERIENCE:

- **2022 Jan. TTI (TASC Telecom. IQ):** Reporting & Documentation Manager / Asset & Property Department.
- Collect the data of the technical sites, contracts, etc...
- Upload the data to the DocuWare system
- Manage monthly expenses of the contracts.
- **2019 - 2022 Zain IQ Telecom:** Managing projects such as ROSs, MGWs, etc...
- Senior Facility Engineer
- Manage daily operation for Zain premises.
- Budget management.
- Preparing Accurate BOQs with all required specs.
- Preparing monthly Gap analysis Data and information in order to make accurate monthly & annual reports.
- **2017 - 2019 Baghdad Aqua Park:** Hydro Mechanical Site Engineer
- Supervise, execute and shop drawing for water and sewage networks underground.
- Heat and cooling system of games and hydro mechanical plans of the projects
- **2011 - 2017 Iraq Middle East Bank**: Project Manager & Site Coordinate
- Supervise the construction of HQ of IMBD in Baghdad & other providences prepare BOQs & as built drawings for all services (civil, MEP, etc...).
- **2010 - 2011 Babylon Renovation Project Site Engineer**
- Site engineer responsible of scape land work.

WORK SKILLS:

- Excellent leadership Behavior in Office although site .
- Working under pressure environment.
- Ability to learn new skills and experiences Fastly.
- Good communication and organized skills.
- Team spirit with others peers. Solve Problems in scientific method and find solutions in reasonable way.
- Motivated and energetic person.