Addis Ababa University

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ROLE OF BUILDING INFORMATION MODELING (BIM) ON PROJECT SUCCESS AND ITS IMPLEMENTATION CHALLENGES: THE CASE OF OVID CONSTRUCTION PLC.

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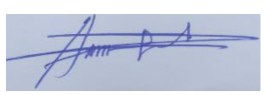
Dr Afework K.		July-10-2023
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Declaration

I hereby declare that the project thesis entitled "***Role of Building Information Modelling (BIM) on project success and its implementation challenges: the Case of OVID Construction Plc***.", has been carried out by me under the guidance and supervision of Adane A. (PhD). The thesis is original and has not been submitted for the award of any degree or diploma to any university or institution.

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Certificate

This is to certify that the thesis entities "*Role of Building Information Modelling (BIM) on project success and its implementation challenges: the Case of OVID Construction Plc.*", submitted to Addis Ababa University School of Commerce for the award of a degree in Master of Project Management and is a record of bona fide research work carried out by Ms Hermela G/egziabher, under my guidance and supervision.

Therefore, I hereby declare that no part of this thesis has been submitted to any other university or institution for the award of any degree or diploma.

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List of Acronyms and Abbreviations

α	-	Cronbach Alpha
AEC	-	Architecture, Engineering, and Construction
APM	-	Application and Performance Monitoring
BIM	-	Building Information Model
CAD	-	Computer-Aided Design
CDE	-	Common Data Environment
CID	-	Continuous Iterative Development
CSFs	-	Critical Success Factors
ECPMI	-	Ethiopian Construction Project Management Institute
FM	-	Facility Management
GDP	-	Gross Domestic Product
iBIM	-	Integrated Building Information Modeling
IC	-	Interdisciplinary Collaboration
IFC	-	Industry Foundation Classes
LSE	-	London School of Economics
NBE	-	National Bank of Ethiopia
NBIMS	-	National Building Information Modeling Standards
NBS	-	National Building Standards
NIBS	-	National Institution of Building Science
PMBOK	-	Project Management Book of Knowledge
PSFs	-	Project Success Factors
r	-	Pearson Correlation Coefficient
RII	-	Relative Importance Index
SPSS	-	Statistical Package for Social Sciences

Abstract

Construction projects usually need proper attention in terms of cost, quality, and time which in turn helps project stakeholders achieve the required success. However, the industry is highly characterized by project delay, failure, and abonnements. The construction industry has acknowledged Building Information Modeling (BIM) as a highly effective technological innovation in addressing its challenges. The purpose of this paper was to explore the role of the Building Information Model (BIM) on construction project success and its implementation challenges: the case of OVID Construction Plc. Moreover, the study considered the BIM implementation process steps, uses, implementation barriers and factors affecting the adoption of BIM (independent variables) in the success of the construction project (dependent variable). A descriptive and explanatory survey was used for conducting the study. Both quantitative and qualitative survey tools were used to collect the data from respondents. The target population of the study was 80 and a purposive sampling method was conducted through a Google format questionnaire. 90 % of the responses to questionnaires were analyzed. The validity and reliability of the research instrument were ascertained using the relevant research instruments. Descriptive statistics and Correlation (using Karl Pearson's coefficient of correlation) were used to analyze the data and establish the relationship between the dependent variables and the set of independent variables using the SPSS version 27 software. The adoption barriers are categorized into the process, human, technology and external factor related. The relative importance index (RII) was used to analyze and rate the identified variables. The top-ranked adoption factors are high initial cost, lack of client demand, incompatibility and interoperability problems, and lack of BIM national standards and guidelines. The four predictor variables were found to have a positive and substantial correlation with the dependent variable (Project Success).

Key words: BIM, Barrier, Process steps, Project success

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Project success is a foundation for future project planning and orientation and for managing and regulating ongoing initiatives (Chovichien et al., 2020). According to (Ika, 2017) there are two distinct components of project success: Project management success that focuses on the project process and, in particular, the successful accomplishment of cost, time, and quality objectives, and how the project management process was conducted. Product success deals with the effects of the project's final product.

Some criteria need to be fulfilled for project management to be successful: careful selection of a qualified project manager, good planning to complete the project, allotting enough time to define the project adequately, ensuring accurate and sufficient information flow, changing activities to accommodate frequent changes in response to project dynamics, accommodating employees' personal goals with performance and rewards, and making sure that all stakeholders are satisfied (Munns & Bjeirmi, 2016). Numerous definitions of successful project management include the three factors of time, budget, and specifications (Shlomo & Ofer, 2018). However, factors like the effectiveness of the project management process and the satisfaction of the project stakeholder's expectations must also be taken into account to quantify project management success. Time, money, and specifications alone are not sufficient in this regard (Baccarini, 2020; Schwalbe, 2015).

Digital transformation has altered many industrial sectors over the past decades, leading to a remarkable rise in product quality, variety, and productivity. Digital tools are widely used in the Architecture, Engineering, and Construction (AEC) industry to design, build, and maintain infrastructure assets.

Nonetheless, the ongoing use of digital information lags considerably behind other business industries in the entire technology chain. Many parties are involved in construction projects, including clients, suppliers, engineers, contractors, subcontractors, and architects. The involvement of so many parties can disrupt information flow, negatively affecting the overall life cycle of a facility. Enhancing project management and successful completion of construction projects depend on cooperation and communication between these stakeholders (Chileshe et al., 2022). (Crotty, 2019) claims that inadequate standard information is the main reason for the industry's underperformance. The improvement of information quality amongst stakeholders should be at the highest level possible to support the construction sector's successful operation.

Processes used in construction projects typically degrade and have a convoluted life cycle. From the beginning of a project to its potential demolition, documentation and information are needed at various stages. The interaction and integration of many professionals from different organizations to carry out specific activities within the scope and objectives of the project is a must for successful construction projects (Al-Ashmori et al., 2020). As a result of the abundance of documents and the dissemination of fragmented information, there are frequent misunderstandings, repeated requests for explanation, disappointment, a lack of confidence, and conflicts between the project stakeholders. The issues mentioned above typically have an impact on a project's goals, such as time, cost, and quality, as well as productivity.

As per ISO 19650-1 (2018), building information modelling (BIM) refers to utilizing a collaborative digital representation of a constructed asset to simplify the procedures of designing, constructing, and operating. This approach also serves as a strong basis for making informed decisions.

BIM is a ground-breaking method and technology for virtually managing and designing construction projects (Azhar, 2020). One of the most promising advancements in the architectural, engineering, and construction (AEC) industries is BIM, a digital technology that makes it possible to create precise virtual models and supports additional project delivery process activities (Eastman et al., 2019).

Over the last two decades, the usage of BIM in the construction sector has grown significantly. BIM can revolutionize and improve performance by decreasing inefficiencies, increasing efficiency, and encouraging greater collaboration among project stakeholders (Abanda et al., 2018). These days, BIM technology is used for objectives such as cost estimation, project construction planning, visualization, and design. According to an analysis of BIM adoption rates from 2007 to 2015, several significant businesses in the public and private sectors switched to the BIM process because of its advantages of quicker delivery, dependable quality, and cost-effectiveness. For the past ten years, developed nations, particularly those in Europe, the United States, Australia, and Hong Kong, have benefited from a range of BIM advantages (Chan et al., 2019b). The BIM approach has been made necessary in the USA and the UK to strengthen the AEC sector and achieve and surpass owner goals (Lee et al., 2020). Even though BIM has a low adoption rate in construction projects, it is currently gaining significant acceptance in developing nations (Chan et al., 2019).

Ethiopia's construction sector contributes significantly to the nation’s GDP and is expanding quickly. The construction sector experienced an average annual growth rate of nearly 25% between the years 2011 and 2018 (Belete & Gabore, 2020). Similar to other developing countries, Ethiopia's building industry faces numerous difficulties. Lack of project specifications, poor quality, incorrect project delivery techniques, project overruns, and several of these challenges include a failure to adhere to best practices (Ayalew et al., 2016). Although BIM may not be able to address every issue facing the construction sector, it is currently the most productive method of building. Using BIM enhances existing communication, provides a platform for teamwork, and promotes interoperability between many business domains. If successfully implemented, it can also increase performance and productivity throughout a project.

1.2 Background of the Organization

OVID Construction Plc was founded in 2013 as a Design and Build (DB) firm possessing a G-1 building construction license. The company is duly registered and conducts operations in Ethiopia, Djibouti, and Kenya, having over 1,000 permanent and temporary employees with a vision – “To research, develop and implement affordable solutions to help meet the basic needs of people in developing countries”, mission -“To focus on the basic needs of people and to meet these needs at the right price & quality, empower employees through professional development and inspire them with clear opportunities to share in the growth of the company, create wealth that will enhance the lives of our employee and in part will be given back to the communities we serve by supporting worthwhile programs and services” and core value of Dependability: timely delivery, reliability, and trustworthiness; innovative: using new technologies, thinking creatively and independently, and being solution-focused; Excellence: Exceptional caliber and distinctiveness; using environmentally sustainable and safe construction techniques, minimizing waste; Passion: a motivating, independent, and enthusiastic quality.

As more and more contractors struggle to differentiate themselves and execute their projects, the construction sector has become more competitive in recent years. Due to the involvement of several parties, managing the enormous amount of information generated during the process and effectively sharing it between parties, in addition to project delays and poor quality, pose significant challenges. Due to the industry's dynamic nature, OVID construction is encountering challenges within and across projects. To address these issues, the adoption and implementation barriers of BIM, BIM implementation process, and its role on project success will be evaluated and suggestions will be proposed.

1.3 Statement of the Problem

Projects need to be managed well from their inception to close-up. Proper management of projects is the key success factor in the project management discipline to make the project successful (Silva & Warnakulasooriya, 2016). Budget, time, requirements, the quality of the project management process, and meeting the expectations of the project stakeholders are the main factors that determine if a project is successful (Baccarini, 2020).

Researchers and management experts looked for weaknesses in the AEC sector, such as fragmented teamwork, inadequate coordination, poor communications, underperforming buildings, excessive energy use, and unsustainable structures (Latham, 2019; Egan, 2020).

Many construction projects usually exceed the original cost, get cancelled before completion, while others fail in terms of the delivered functionality (Alaghbari et al., 2020). While significant amounts of time and resources are spent choosing, developing, contracting, and implementing projects, it is still crucial to manage projects properly in organizations to meet their success goals.

However, compared to Europe and North America, managerial practices in Africa are inadequate, according to a recent analysis from the London School of Economics (LSE) in the UK. According to this assessment, Mozambique is second to last, followed by Ethiopia, indicating that management in Ethiopia is much worse than in those underperforming emerging nations in Africa. And one of the challenges hampering the performance and development of the industry is the poor technological base of the industry (Mengistu & Mahesh, 2019). Studies showed that so many factors also contributed to such kind of delay, abonnements and failure to the project.

According to (Crotty, 2018) miscommunication during construction could result in errors such as design blunders, outdated drawings, delays, cost overruns, low-quality work, and design conflicts. Therefore, Information Communication Technology (ICT) is necessary to supply consistency and reliability of the information in construction as well as to manage the collection of information and documents and decision-making duties. As a result, Building Information Model (BIM) has to be introduced in construction projects effectively and efficiently. Using new technological advancements and techniques, such as Building Information Modeling (BIM), in the operations of the construction industry is one way to solve the issues mentioned above (Ahn &; Kim, 2016; Olanrewaju et al., 2020).

The abundance of documents and the dissemination of fragmented information, poor project management system, design errors and complexity of designs, frequent misunderstandings, repeated requests for explanation, disappointment, a lack of confidence, conflicts between the project stakeholders price Inflation and the like are widely cited problems (Kuhil & Seifu, 2019).

Building information management (BIM), as a tool and technological base, is an important building block for effective and efficient project management in the construction sector (Eastman et al., 2019). In the Ethiopian, construction sector, as a major economic engine of the country, BIM implementation is not well known as compared to other industries.

Bayou, (2020) identified the pushing factors on the implementation of BIM and showed the benefit of BIM implementation, it does not illustrate the impact of BIM implementation on project success. (Belete & Gabore, n.d., 2020; Belay et al., 2021) also look into the adoption barriers and benefits of the BIM but it does not disclose the BIM implementation processes and its impact on project success. Besides, even though studies related to BIM practice were conducted in Ethiopia, to the best knowledge of the researcher no research conducted regarding BIM in relation to the project success of the construction industry (Muluken & Prof. Dr. Ing Hans, 2020; Dires, 2018; Mohammedneja, 2016; Taddese, 2016; Addissie & Theo, 2018; Dawit, 2019).

In this regard, it calls the attention of the researcher to conduct the study with the purpose to explore the BIM implementation process, barriers and influencing factors in implementation of BIM, and its role on the project's success.

1.4 Research Questions

The followings are the research questions that was raised in this study:

a) What are the BIM implementation processes applied in construction projects?
b) What are the key challenges in implementing BIM in construction projects?
c) What are the factors that influence the adoption of BIM in construction projects?
d) What is the role of BIM in project success?

1.5 Objectives of the Study

1.5.1 General Objective of the Study

The aim of this study, but not limited to exploring Building Information Modeling (BIM) implementation challenges or problems as well as identifying its implementation impact on project success. The study was supported by an in-depth study of the subject taking OVID constructions.

1.5.2 Specific Objectives of the Study

The specific objective of the study is:

I. To identify the BIM implementation processes applied in construction projects.
II. To identify the key challenges in implementing BIM in construction projects.
III. To identify the factors that influence the adoption of BIM in construction projects.
IV. To look into how Building Information Modelling (BIM) affects a project's success.

1.6 Significance of the Study

The study, primarily articulated to pinpoint how implementation of BIM is important in project success and is the main tool to produce quality outputs in the construction sector. Hence, the research results allow contractors, especially high-grade contractors, to implement BIM tools in their companies to compete nationwide and in the global industry.

Moreover, it serves as a source of secondary data for further study on the topics for researchers and academicians. Besides, it is hoped that the paper may add to a larger global debate in the area of BIM in the construction industry. Further, the findings and the recommendations were served the company under the case to investigate the existing BIM and serve as a springboard to establish and upgrade the existing BIM implementation in the company.

Apart from that, government officials and the regulatory bodies of the construction industry in Ethiopia, especially the Federal Construction Bureau, consider it as input to formulate policies regarding the subject under consideration.

1.7 Scope of the Study

The study is bounded geographically as it focuses only on Ethiopia and the narrowest end of Addis Ababa. Projects and project offices of the organization under consideration are dispersed in different locations of the country, purely the study bounded to the head office too. Besides, the study only accentuates the construction sector and does not consider other sectors.

Moreover, it also narrowed to a single construction company, OVID construction, a design and building firm. Due to these facts, the study paper only essences on the project managers, senior managers, site managers, and architects of the stated construction company. It also focuses specifically on the variables under study, BIM implementation process steps, BIM use, barriers and influencing factors, and their role on the project's success.

1.8 Potential Limitations of the Study

Project management, as a discipline, is an infant and still required different approaches, theories, practices, and systems to be implemented. Due to these, more books, articles, and theoretical analyses for each project knowledge area and project process group are yet expected though many publications are produced under the discipline. BIM, as one part of project management, has the same trend as the main theme whereby inadequate and insufficient information, studies, and written materials are available. Thus, finding abundant reference materials in the area of study, especially in Ethiopia was one of the limiting factors and the major challenge. Further, the implementation of BIM in Ethiopia in the construction sector is not well known, even in any other industry it is not as such promising to say more.

1.9 Organization of Study

There are five chapters in the study. The first chapter contains an introduction providing background knowledge, and justification of the study. A review of some relevant information and documents that support the study's goal is crucial and is found in chapter two. This chapter offers a thorough summary of the BIM implementation-related research.

The research approach utilized to conduct the study is described in chapter Three. In chapter four, the main discussion is provided. Chapter Five presents a conclusion and a recommendation.

1.10 Description of Key Terms

Building Information modeling (BIM)- The improvement of facility design and construction is achieved through the development and use of computer models and teamwork between architects, engineers, clients, project managers, and contractors (Al-Ashmori et al., 2020) .

Architecture, Engineering and Construction industry (AEC)- The area of the building industry that offers services for architectural design, engineering design, and construction services. (Bouchlaghem et al., 2019).

Information Communication Technology (ICT)- A broad category of technology resources and techniques used to exchange, produce, distribute, store, and manage information. (Anyakoha et al.., 2018).

ISO-19650- A collection of international standards that guide how to manage information during building, use, and maintenance to manage information during the construction, use, and maintenance of buildings and civil engineering projects.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The chapter discusses a review of related literature regarding the Building Information Model (BIM). The reviews were from books (Project Management, Construction, BIM), previous research by different scholars, journals, and publishing. In this regard, the basics of the building information model (BIM) and its elements, the construction project management, and BIM and its practice in the Construction Industry, BIM implementation processes, and barriers of BIM are discussed. Finally, the conceptual model of the researcher is introduced.

2.2 Theoretical Review: BIM in Project Management

2.2.1 Project

According to Project Management Body of Knowledge *(PMBOK® Guide, 5th Ed.*, 2013) a project is defined as a brief undertaking made to provide a unique good, service, or outcome. Although they are ephemeral, projects usually have a distinct beginning and end. Every project is unique from the others because of its specific purpose, objectives, location, structure, resources, activities, and other task characteristics.

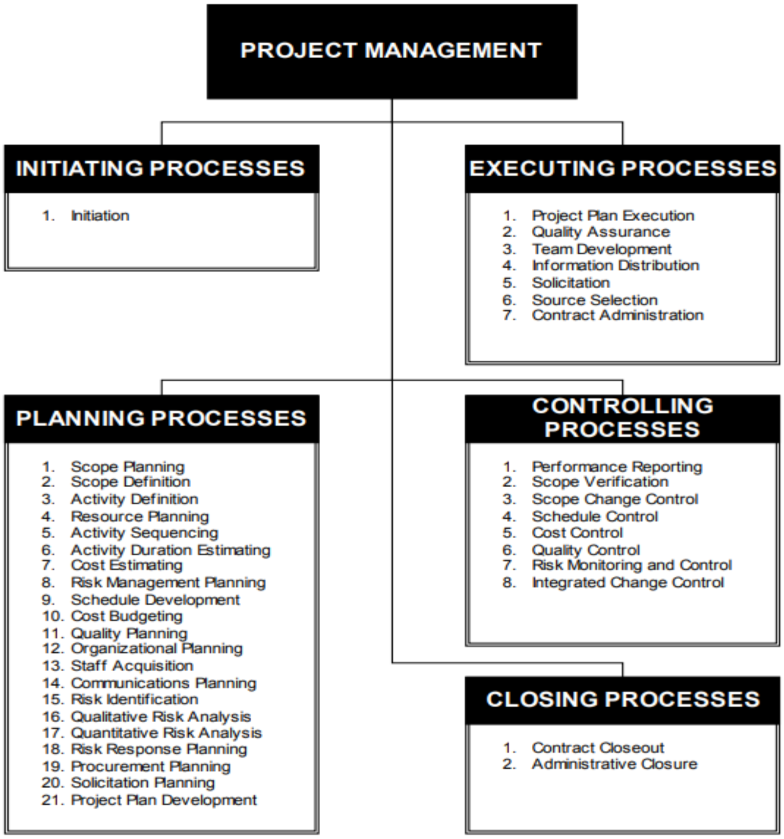
APM Body of Knowledge (2017) stated the definition of a project in the same manner as PMBOK as a singular, condensed endeavor carried out to achieve certain goals, which may be expressed in terms of outputs, outcomes, or benefits.

According to (Wysocki, 2019), a project is defined as a series of distinctive, complex, and related activities with a single goal or purpose and must be finished by a specific date, within the allocated budget, and by the stakeholders' requirements. However, poor management practices exist in Africa. Additionally, he described the business definition as a series of constrained interdependent tasks whose successful execution yields the supply of the predicted business value that justifies undertaking the project.

2.2.2 Project Management

The sixth edition of the PMBOK® Guide states that project management is the process of applying knowledge, skills, tools, and processes to project activities in order to achieve project requirements. To finish the project, a project management technique chosen for it is properly implemented. Organizations can achieve their objectives by successfully and efficiently managing projects. The five Process Groups of grouped project management procedures are used to implement project management effectively.

Figure 2.2: Project Management Process Groups



Source: A New Approach to PMBOK® Guide 2000, (2021)

Table 2.2: Comparisons of Project Management and General Management

Dimension	Project Management	General Management
Work Activity Type	Unique	Routine
Management Approach	Adaptability to change	Manage by exception
Planning	Critical	Important
Budgeting	Various budget periods and a fresh start	Budget adjustments from the prior budgetary period
Sequence of Activities	Must be determined	Often predetermined
Location of Work	Crosses organizational units	Crosses organizational units
Reporting Relationships	Informal	Well defined

Source: Jack R. Meredith Broyhill, Scott M. Shafer and Samuel J. Mantel, 7th ed.,(2017)

2.2.3 Construction Project Management

The construction business is a sector of the economy that deals with the planning, building, utilizing, and modifying of structures as well as their dismantling or deconstruction (Rußig et al. 2019, Cited by Fachbereich and Yong, n.d.).

S. & a. Sears (2015) Construction projects are difficult, time-consuming tasks. The various stages of a project's development often require several specialized services. The average task develops through several stages that call for participation from a variety of organizations, including financial institutions, governmental organizations, engineering and architectural firms, law firms, insurance and surety firms, contractors, material suppliers and manufacturers, and tradespeople that work in the construction industry. From initial planning to project completion, these phases are included.

Multiple parties are involved in modern public construction projects, including contractors, subcontractors, project managers, consultants, and experts from various fields. Conflicting goals and interests between the many stakeholders are normal in a multi-agency work setting (Tabish & Jha, 2019).

According to the National Bank of Ethiopia's (NBE) report, the industrial sector in Ethiopia experienced 7.3% annual growth, made up 29.3% of the country's total GDP, and contributed 33.6% to GDP growth overall. 23.4% of industrial output came from the manufacturing sector, which expanded at a 5.1% rate. The construction industry's 6.6% growth and 72.2% share of industrial output were impacted by roads, railroads, dams, and residential home building (*NBE National Report*, 2020).

Despite all contributions to the economy, according to Desalegn Girma (2019), Construction industry development the management practice in Africa is poor and consultant capacity, a lack of teamwork and professionalism, and a lack of CID practice metrics from the role of government, resource-related variables, the nature of the industry, and the industry's vision for its growth have all been identified as the industry's major challenges. Results give stakeholders knowledge they may utilize to make key decisions and actions for the industry's successful development.

Endris Yadeta (2020) also stated that the main risks in construction projects include Price inflation, bribery and corruption, an inadequate timetable, insufficient labor and equipment productivity, delays in payment, submission and approval of construction documents, changes in design standards and practices, the engineer's authority, project management, and subcontractor performance.

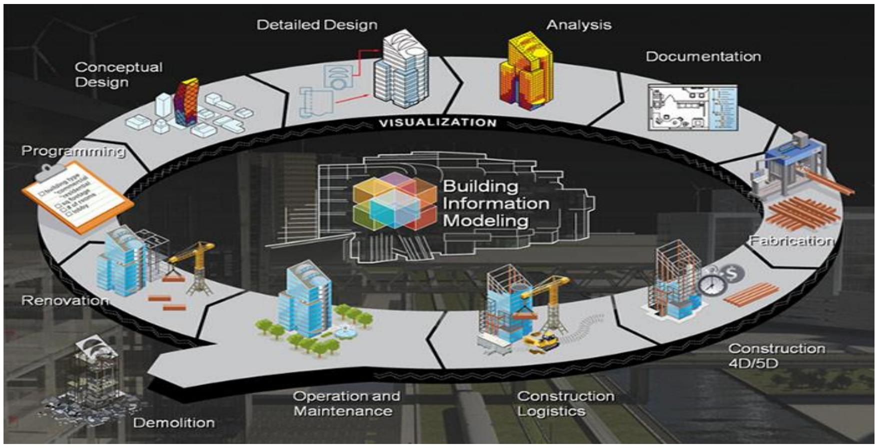
2.2.4 BIM in Construction Projects

The building sector is extremely beneficial to the socioeconomic development of any nation. However, due to its complexity, the construction industry still faces several challenges, such as low productivity, poor quality, rising costs, wasteful building practices, delays, and a lack of information sharing among project stakeholders (Ullah et al., 2019). Additionally, the construction industry still frequently uses paper-based project documentation for cooperation and data exchange (Volk et al., 2019).

Abanda et al. (2018) Over the past two decades, BIM has become more and more popular in the construction industry. BIM has the potential to transform and improve performance by reducing inefficiencies, boosting efficiency, and promoting greater collaboration among project stakeholders.

General contractors, specialty contractors, and owners can digitally develop a project before actual construction ever starts thanks to BIM systems. Beyond the straightforward benefit of being able to interpret the meaning of 2D plans, some advantages of BIM in construction include increased productivity, cost savings, risk mitigation, project visualization, clash detection, easier and more accurate prototyping, safer sites, and smoother handovers are all benefits of model-based cost estimating (Ullah et al., 2019).

Figure 2.2: Building Information Modeling (BIM) in Construction



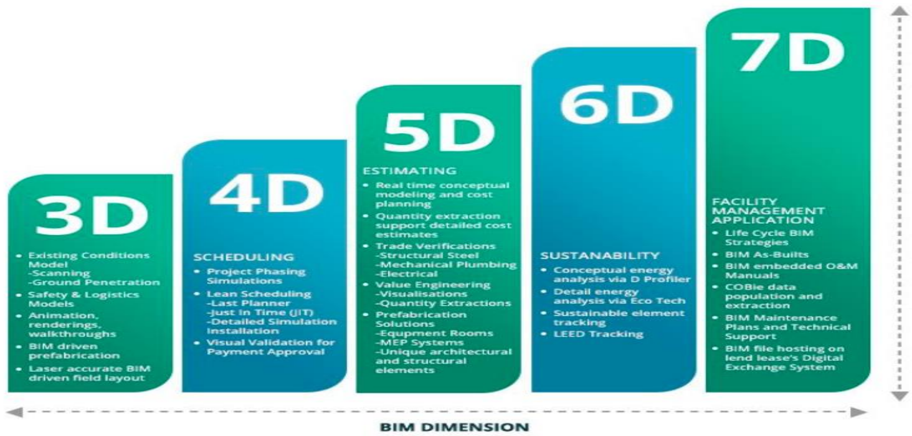
Source: Building Information Modeling (BIM) in construction (What Is BIM in Construction, 2016.)

BIM 360 integrates BIM data and 3D models into workflows for construction management to guarantee that everyone is aware of the most recent changes and plans, to share information, and to alert the appropriate parties when conflicts and issues are found or modification orders are made.

Through BIM 360, which enables contractors and subcontractors to examine the 2D plans alongside the 3D models, architects and engineers are also able to clearly express the precise intent of 2D designs (Ocean, 2020).

Charef et al. (2018) stated that many firms are already employing 4D, 5D, and 6D modelling to handle vital data that affect schedules and budgets, even though 3D models are more often associated with BIM. The sequential development of the project is shown in 4D, together with information on lead times and expected installation times. This increases the schedule's dependability and efficiency and helps to foresee scheduling issues. The cost impact of the project over time is shown in 5D. This can be used by teams to plan their designs and budgets as well as to keep track of ongoing project costs. The operational component is an addition to 6D that will help clients better understand asset planning and management over the whole life cycle. This raises customer satisfaction and boosts corporate results. To create a 7D BIM, a 3D project management model, a 1D schedule management model, and a 3D BIM are all efficiently combined. The sustainability of construction projects can be tracked using this BIM technology (Hamil, 2021).

Figure 2.3: BIM Dimension



Source: BIM dimensions – 3D, 4D, 5D, 6D BIM (Hamil, 2021)

2.2.4.1 Building Information Model (BIM)

Azhar (2017) stated any nation's socioeconomic progress is significantly influenced by the building industry. However, because of its complexity, the construction sector encounters several difficulties, including comprising a lack of information sharing among project stakeholders, low productivity, poor quality, rising prices, waste in the construction process, and delays. These issues could potentially be resolved and the building industry's performance improved with BIM. BIM is a ground-breaking method and technology to virtually manage and plan construction projects.

BIM was first developed in the AEC sector to include all building design, construction, and operating aspects (Al-Ashmori et al., 2020).

The National Building Information Modelling Standards (NBIMS) committee of the United States has provided the following definition of BIM: BIM is a computerized representation of a facility's structural and functional components. When it comes to making decisions throughout a facility's life cycle, which is defined as starting with the initial design and ending with destruction, a BIM is a common knowledge base that holds data about the facility. The underlying idea behind BIM is that different stakeholders collaborate at different points throughout a facility's life cycle to add, remove, update, or modify data in the BIM to support and reflect those stakeholders' roles (NBIMS, 2019).

Alreshidi et al. (2017) stated BIM enables stakeholders to collaborate at various points in a building's lifecycle and allows them to input, remove, update, or amend data as needed.

According to (Azhar, 2019) with BIM, the entire design team (owners, architects, engineers, contractors, subcontractors, and suppliers) can collaborate more precisely and quickly than they could with conventional methods. BIM can be thought of as a virtual process that integrates all aspects, disciplines, and systems of a facility into a single, virtual model.

BIM is a process and software, which should be noted because it is not only software. BIM entails considerable adjustments to workflow and project delivery procedures along with the application of three-dimensional intelligent models (Chan et al., 2019b).

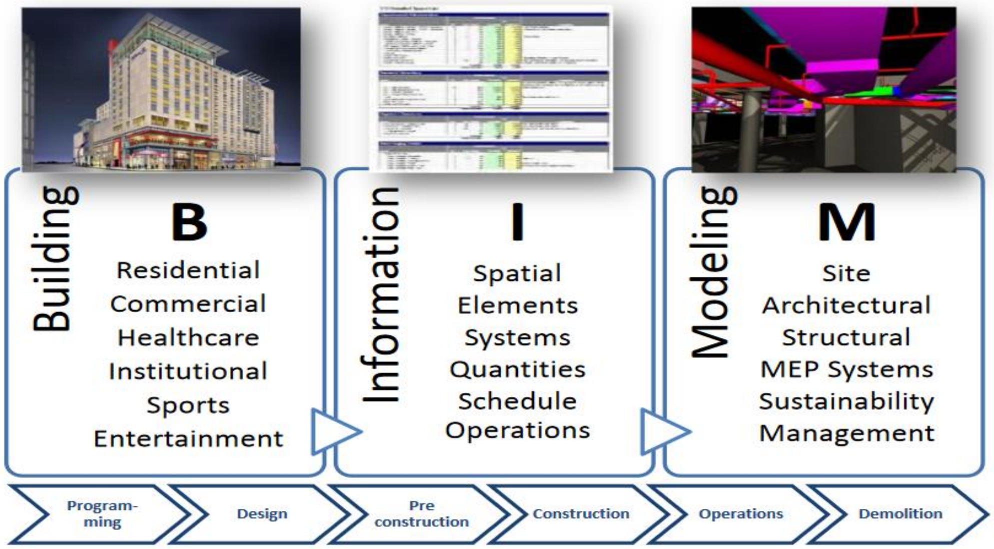
One technique for updating project management, design, and construction procedures is BIM. According to the BIM Handbook, BIM is a computer-aided modelling system that focuses on building data, models, production, communication, and analysis for the management of construction project data (Isikdag, 2020).

Chan et al. (2019b) describe to boost productivity in building design and construction, BIM is a process for creating and managing building data across the course of a building's life cycle. It is widely used in this method and is software for three-dimensional, real-time, dynamic building modelling.

CCI (2018) stated that a new technology called BIM is used to manage information about building projects at every stage, from design to construction and operation. Additionally, it asserts that BIM is a fresh approach to project management and execution that makes use of contemporary technology to enhance risk management, multi-disciplinary cooperation, internal collaboration, and interaction.

A building information model (BIM) is a technological simulation made up of 3D representations of the project's components connected to all the relevant information about the project's planning, design, construction, or operation (Azhar et al., 2019).

Figure 2.4: A Visual Representation of BIM Concept



Source: Building Information Modeling (BIM): Now and beyond (Azhar et al., 2015)

2.2.4.2 Scope of BIM

In terms of BIM's scope and meaning, there is a lack of agreement among professionals and individuals. The BIM scope, however, has been split into three frequently used categories by the American National Institution of Building Science (NIBS, 2018);

- BIM as a product
- BIM as a collaborative process
- BIM as a facility lifecycle management tool

BIM as a Product

The sophisticated digital portrayal of information about a facility utilized in BIM as a product is referred to as an "actual model" (NIBS, 2018). A 3D representation built only from items does not meet the criteria for intelligence. Beyond the graphical representation, it must also have additional data or attributes, and it is essentially this data that brings about the greatest advantages for the sector through BIM (Granroth et al., 2021).

BIM as a collaborative process

The notion of BIM as a process considers the stages needed in developing a BIM model (the BIM product) and utilizing it to improve project efficiency (*WSP Group*, 2018). At this level, the social components of BIM are also discussed. These include synchronous cooperation, organized work practices, institutional framework, and cultural context.

Carmona et al. (2017) stated BIM is a concept that allows all team members (owners, architects, engineers, contractors, subcontractors, and suppliers) to collaborate more precisely and successfully than with conventional methods by combining all aspects, disciplines, and systems of a facility into a single, virtual model. Team members constantly alter and revise their portions in response to project specifications and design changes to ensure the model is as accurate as is practical before the project starts. Two pillars communication and collaboration form the basis of BIM.

BIM as a facility lifecycle management tool

The last and most difficult of these perspectives is using BIM as a tool for facility lifecycle management. By emphasizing a sustainable, repeatable, and verifiable information-based environment, this perspective sees BIM as a management tool that ensures well-understood information exchanges, workflows, and procedures throughout the building's lifetime (*NBS, 2016*). This perspective is more intriguing for client companies since it is long-term.

2.2.4.3 Level of BIM

(Czmoch & Pėkala, 2019) state that the only information source for BIM is a virtual 3D model of the desired facility. Four design levels can be established using CAD and BIM. These levels are a way to gauge how well and how much information is shared and kept during the whole procedure.

Level 0: Paper-based drawings + zero collaboration

Projects that only use 2D CAD drafting on paper do not encourage collaboration. Printing Production Information on paper or digitally is the main goal. Business experts in this industry today seldom ever use this archaic level of communication (Victor, 2022).

Level 1: 2D construction drawings + some 3D modeling

Both 3D CAD and 2D drawing are used in Level 1 BIM. While 2D CAD is utilized to provide statutory permission papers and Production Information, 3D CAD is employed for conceptual work. At this level, digital data sharing occurs through a common data environment (CDE) managed by the contractor. There is very little to no cooperation between stakeholders at this level because each one creates and manages their data (BIMhub, 2017).

Level 2: Teams work on their 3D models

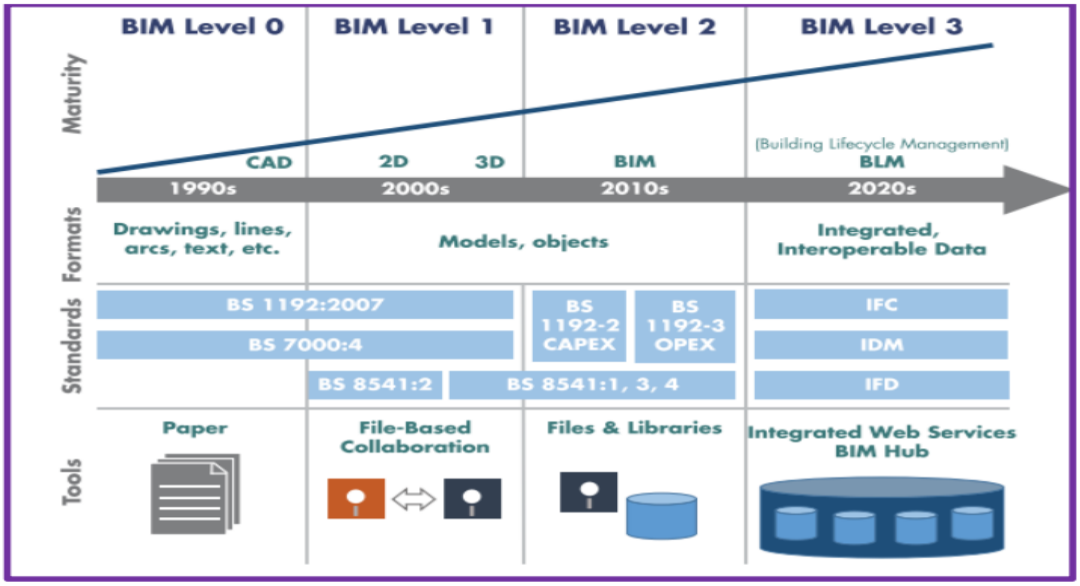
According to *BIM* (2022), Level 2 BIM is required by the UK government for projects involving the public sector. This level encourages collaboration by providing a distinctive 3D CAD model to each stakeholder. This level emphasizes teamwork, and it requires seamless coordination between all systems and stakeholders, as well as efficient information flow related to projects. Level 2 is distinguished by its emphasis on collaborative working. Each participant uses a local 3D CAD model, and information is shared via a standard file format. Companies can produce a federated BIM Model by merging their model with external data owing to such technology. Combining this with their data allows businesses to save time, money, and the need for modification.

Level 3: Teams work with a shared 3D model

At BIM level 3, there is even more cooperation. Level 3 refers to everyone using a single, shared project model as opposed to each team member working on their 3D model. Everyone has access to and can make changes to the model because it is located in a "central" location. Open BIM refers to the practice of introducing an additional layer of conflict prevention that benefits the project at every stage (BimTALK, 2019).

According to (Victor, 2022) Level 3 advises employing an integrated system built on open standards, like IFC (Industry Foundation Classes), where all project data is housed on a single server. Although progress is being made at this level, many businesses in the UK are still debating upgrading to Level 3. iBIM, or integrated BIM, can be used to potentially employ concurrent engineering procedures.

Figure 2.5: BIM Maturity Levels



Source: BIM adoption for precast concrete design (Sacks et al., 2018)

2.2.4.4 Traditional method Vs BIM

Transitioning from the conventional approach to the BIM idea necessitates modifications in numerous disciplines, process adjustments, software, and hardware upgrades, and organizational culture shifts to embrace BIM advantages. When comparing the conventional approach to process to the idea of the BIM process, it can be seen that traditional methods have a significant impact on the phases of building paperwork, which in turn causes several difficulties, delays in project delivery, and higher project costs overall. However, the BIM technique resolves these problems quickly (Alamri et al., 2018). According to (Alamri et al., 2018), traditional approaches have several drawbacks, including issues with information sharing, data loss, inadequate communication, and a lack of project knowledge, and ineffective teamwork.

Al Hattab & Hamzeh (2019) illustrate the difference between traditional projects and BIM-based projects in that traditional projects have a disorganized communication between the project's participants and stages. Using BIM for projects, however, the dialogue is more flowing and overlapping, allowing for the transparent sharing of information across many users.

Wahab & Wang (2021) provided an example of the distinction between BIM and traditional methods of data sharing. In the traditional method, information is obtained from various stakeholders through various channels is a form of interaction that is primarily paper-based. However, the BIM approach uses a centralized database to gather information.

The other comparison is based on crash detection in which the traditional design process, clashes are found by overlaying designs on tracing paper, however, in the computerized BIM method, and numerous work-shared models are examined simultaneously. The traditional method is far more difficult and time-consuming than the BIM process that turns all design data into a master model and detects clashes between architectural, structural, and MEP models (Reetie, 2022).

2.2.4.5 Pillars of BIM

When considering BIM, it can be helpful to keep these four significant criteria in mind. According to (*NBS*, 2020), the true benefit of BIM will only be realized when these components are combined and operating effectively. When adopting BIM, if all four components are properly taken into account, it creates the foundation for a strong understanding.

Table 2.2: Pillars of BIM

Pillars of BIM	
Process	There are several benefits to be gained later on from having a central 3D BIM model for the project and finishing the design phase in a BIM environment. The model can be analyzed, allowing for a variety of model interrogations, such as energy analysis, structural analysis, exact scheduling, and quantity take-offs. Construction projects are said to become more cost-effective, accurate on schedule, capable of reducing waste, and energy efficient when BIM techniques are used.
Technology	Over time, BIM technology has aided in pre-construction design analysis and investigation, minimizing disputes and changes made during the building stage, which can have a detrimental effect on a project's waste, quality, schedule, and cost. A project's performance in terms of low-impact design is further enhanced by the thorough energy analysis that can be carried out in the early stages of a BIM project.

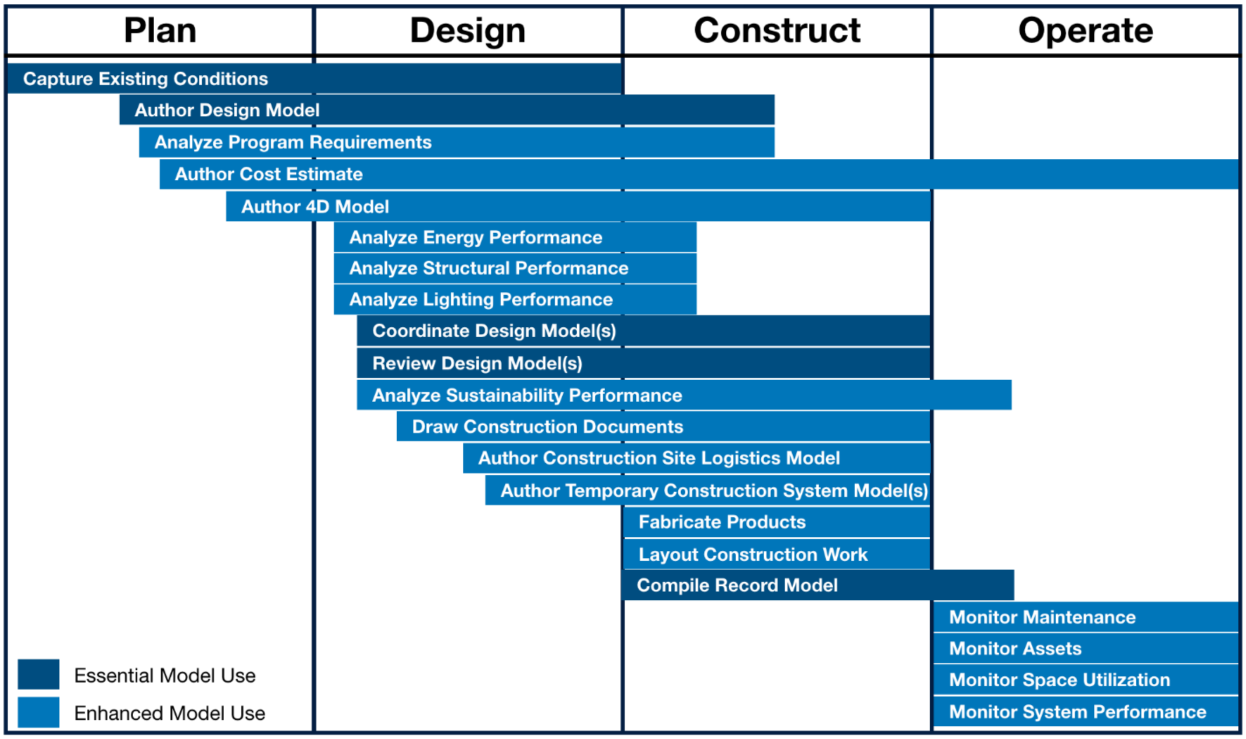
People	One of the most important aspects of working in a BIM environment is the endeavor to encourage multidisciplinary collaboration from the start of a project. Working together inside a single-core BIM system has several benefits for all disciplines. Conflicting design concerns are a serious issue that arises throughout non-BIM design processes. A core central BIM model aids in promoting a smoother transition through these issues by identifying conflicts early on in the project's stages, minimizing the negative effects on budget and time.
Policy	Different figures show that, despite some gaps still being there, BIM knowledge is growing. Realistically, awareness is not the only factor influencing BIM adoption in the AEC. But raising awareness can lead to changes in policy that favour BIM adoption when it makes sense. For instance, the government in the UK has requested that BIM be mandated for all public projects as a result of greater awareness of BIM and its benefits. The new policy has been adopted by the commercial sector.

Source: The Four Pillars of BIM, (2020)

2.3 Benefits of Using BIM

The initial step in building a BIM project execution plan is based on the project and team goals for BIM uses. The early project planning team is currently faced with the challenge of determining the optimal uses for BIM on a project given the project's characteristics, participant goals and skill sets, and anticipated risk allocations. The incorporation of BIM can be advantageous for a range of positions (Messner et al., 2019). These advantages are listed under BIM uses.

Figure 2.6: BIM Uses throughout a Building Lifecycle



Source: Identify Project Goals and BIM Uses (Messner et al., 2019)

BIM technologies bring about a new change in how buildings are designed, built, and maintained (Elmualim & Gilder, 2019). BIM enables owners to comprehend the order of construction operations over the course of a project as well as the spatial arrangement of the building.

The development of a performance-based design approach and a BIM-based early design decision-making framework by (Enshassi et al. 2018). It was developed to help decision-makers make informed decisions about the lifespan of a building performance.

One benefit of using BIM design is the fact that the BIM model saves information about the building's geometry, construction, materials, installation, and functional use. As a result, evaluating the building's energy efficiency requires less time and money (J. Park et al., 2019).

The main benefits of using BIM are increased production and efficiency. The integration of time and cost into BIM enables real-time updates and evaluates efficient tracking and monitoring techniques throughout the project phases (Tirunagari & Kone, 2019). Some advantages of BIM include its ability to show a definite, complete computer-generated image of the project and the work sequences is displayed before the project begins onsite, its facilitation and easement of cooperation and sharing of information within the sector, and its facilitation of a construction project's delivery project on time or earlier (Chan et al., 2019,Abdulsame et al., 2018).

Table 2.3: Benefits of BIM during design, construction, operations of a building project

BENEFITS OF BUILDING INFORMATION MODELING (BIM)

PRE-CONSTRUCTION STAGE	CONSTRUCTION STAGE	POST-CONSTRUCTION STAGE
- Concept, feasibility and design. - Increased building performance and quality. - Creating time based simulation of construction activities. **DESIGN STAGE** - Earlier collaboration of multiple design disciplines. - More accurate visualization of design changes. - Reduction in errors in generating construction drawing. - Early insight to design errors & omissions. - Early extraction of more accurate cost estimation & bill of quantities - Improved energy efficiency & sustainability. - Blending geospatial and building information for planning. - Information available earlier within the project. - Improved information delivery; can be reused, repurposed, reviewed, revised, corrected, controlled, checked and validated.	- Synchronization of design & construction revealing potential problems & possible improvements. - Clash detection. - Reduction in errors in generating construction drawing. - Improved co-ordinated approach between participating designers and contractors. - Using design model as basis for fabricated components. - Better implementation and lean construction techniques. - Substantial cost savings, time saving and waste on site. - Enhanced coordination. - Enhanced productivity. - Enhanced business operations. - Flexibility of output documentation. - Quick simulations. - Use of digital product data in manufacturing and assembly of structural systems.	- Better managed and operated facilities after completion. - Streamlined approach where data is shared in a collaborative approach. - Savings in design coordination, drawing production, information management & exchange. - Improved design quality, sustainability and client communication. - Reduces information loss when handing over project from design team to construction team to owner. - Controlled whole-life cost and environmental data.

Source: Assessment of building information modelling (BIM) knowledge in the Nigerian construction industry (Ryal-Net & Kaduma, 2015)

2.4 Steps to BIM Implementation

According to (Souhayl, 2022) different BIM guidelines have been created to offer instructions for the development and use of BIM models. Through the application of these standards, to enable their use, BIM models are made precise, uniform, interoperable, and efficiently for the duration of a building's life cycle. One of the key standards of BIM is ISO 19650 which serves as an organizational structure for managing and modelling building information.

The ISO 19650 standards aim to increase the speed and accuracy of BIM procedures. Additionally, it improves cooperation and communication among project stakeholders. They span every stage of a built asset's life cycle, from planning and building to using and decommissioning it (Milton & Hemel, 2022).

ISO standards offer various advantages, such as enhanced quality, improved efficiency, increased customer satisfaction, better safety measures, and heightened competitiveness (ISO, 2020, Souhayl, 2022). According to (Serin, 2021) the ISO 19650 procedure consists of the following 8 steps:

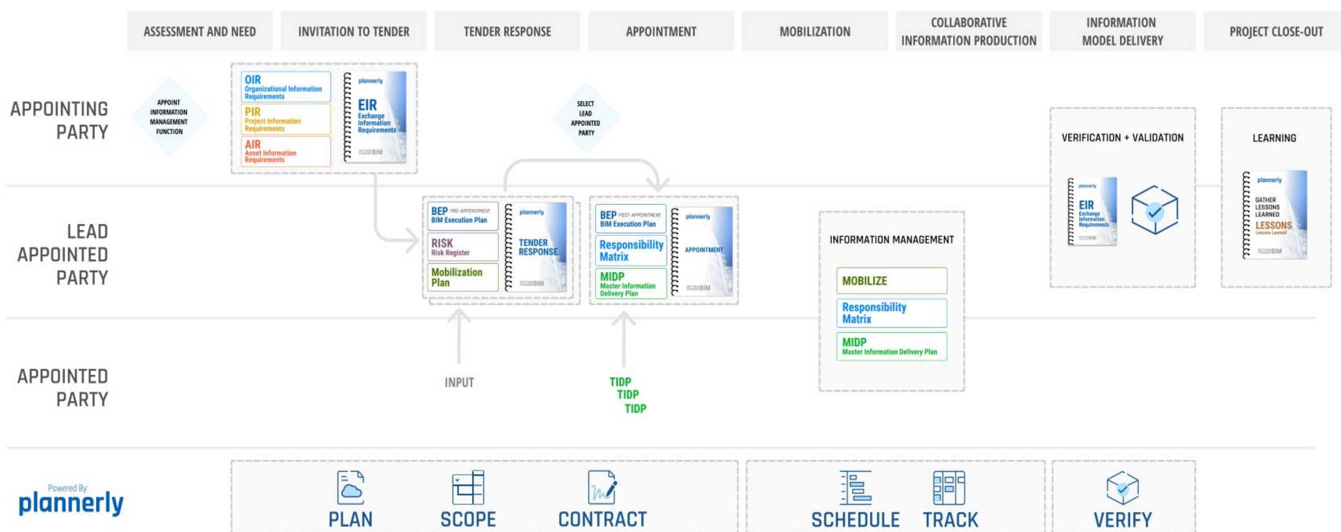
Table 2.4: ISO 19650 Workflow steps

	Workflow Steps	
1	Assessment and Need	The owner, customer, or appointing party appoints someone to be the information manager as the first stage in the workflow. This information manager is in charge of producing the collection of documents that include project summaries.
2	Invitation to Tender	The Client/Appointing party shall compile its criteria before launching the "Invitation to Tender" so that they can explain what is required to bidders.
3	Tender Response	Each potential team makes use different platforms to respond to inquiries and discuss their sympathetic reactions after receiving the “Invitation to Tender”. Multiple teams can work together simultaneously while remaining invisible to one another in the platform thanks to the integration of the tendering workflow.
4	Appointment	The Appointing Party/Client chooses the lead appointed party to build the Matrix of Responsibilities, Task Information Delivery Plans, and Master Information Delivery Plan in the Appointment/Contracting workflow.
5	Mobilization	The teams will have a clearer understanding of what they must provide after each and every contract related to BIM and information management have been agreed upon. To test the systems, a team must now be assembled by the Lead Appointed Party.
6	Collaborative Information Production	The team can filter for the breadth of their tasks as they begin to deliver and provide updates on their progress. The 3D model outputs, supporting materials, and other relevant data can be evaluated by utilizing a computerized process

		with defined and structured requirements.
7	Information Model Delivery	The workflow assists the Client/Appointing Party in defining their needs in terms of BIM, projects, and information and producing contract documentation in a structured way. Teams then carry out the duties after receiving responses to these requests and making a decision (an appointment).
8	Project Close-out	Project closer

Source: ISO 19650: The key actions (Serin, 2021)

Figure 2.7: ISO 19650 Workflow



Source: ISO 19650 BIM: Steps Of Implementation - BIM And Beam (Souhayl, 2022)

2.5 Barriers to BIM Implementation

Elmualim & Gilder (2019) research indicates that the main barriers are a lack of capital, the reality that implementing BIM is more expensive than it is beneficial, a resistance to using new methods, and the notion that BIM is too risky from a liability perspective.

The absence of standardized tools and procedures, concerns over data ownership, a lack of consumer interest, a lack of expertise, a lack of training, and a lack of standardized tools and procedures are all barriers to the adoption of BIM, according to a survey done by Enterprise Ireland (McAuley et al., 2017).

Ismail et al. (2019) examined BIM implementation in Malaysia, Indonesia, Thailand, Vietnam, China, India, Pakistan, and Sri Lanka. They emphasized that the main barriers to the implementation of BIM were cultural opposition, drawn-out processes, high investment costs, a lack of knowledge and consumer demand, and ambiguity regarding the ROI.

The challenges of BIM implementation were described by (Hosseini et al., 2016), the key barriers included the lack of BIM expertise among subcontractors, clients' ignorance of the benefits of BIM, high implementation and training expenses related to BIM, and reluctance to depart from the established norms in the construction sector. The implementation of BIM in the building industry in New Zealand is hindered by high initial costs, concerns regarding instruction and cultural resistance (Harrison & Thurnell, 2018).

(Belay, Goedert, et al., 2021b) list the main obstacles to BIM implementation in Ethiopia as IT infrastructure gaps and inadequate government assistance, a lack of BIM research and instructions in universities, a lack of BIM expertise, high initial implementation costs, and a lack of a uniform contract type for the implementation of BIM.

Table 2.5: Barriers to BIM Implementation

Barriers	**Reference**
High initial cost	(Ismail et al., 2017)
Lack of knowledge about the advantages of BIM	(Latiffi et al.,2016)
Inadequate instruction in BIM use	(K. Park & Kim, 2017)
Insufficient governmental support	(A. Enshassi et al., 2016)
Legal issues	(Bosch-Sijtsema et al., 2017)
Inadequate backing from the Senior Executives	(Ganah & John, 2015)
Concerns regarding ROI	(Eadie et al., 2019)
Lacking BIM specialists	(McAuley et al., 2017)
Concerns with data ownership	(K. Park & Kim, 2017)
Lack of demand from the contractors	(Gerges et al., 2017)
Complexity of the BIM model	(Ahmed et al., 2014)
The compatibility of software programs	(K. Park & Kim, 2017)
Lack of standardized techniques and procedures	(McAuley et al., 2017)

2.6 Factor Affecting the Adoption of BIM

According to (R. Zhang et al., 2020) variables impacting BIM adoption in the European construction sector concluded that labor-intensive projects, high investment costs, and prolonged employee training times were the main obstacles. The barriers were categorized into five main categories after being evaluated in various forms of literature to create measurement metrics for the project's future success after implementation (Wu et al., 2017). Whereas, (Gu & London, 2019) classify the barriers to BIM adoption into three categories to evaluate the industry's readiness in terms of product, process, and people to position BIM adoption in terms of current status and expectations across disciplines.

(Liu et al., 2015) Organize the key obstacles to BIM adoption into the following groups: a lack of a national standard, excessive application costs, labor scarcity, and organizational issues. On the other hand, (Sardroud et al., 2018) of a national standard, expensive application fees, labor scarcity caused by experienced workers, organizational issues, and legal issues. On the other hand, categorized barriers to BIM implementation include those related to security, management, finances, law and contracts, and culture.

(Zahrizan et al., 2021) also grouped the challenges to BIM adoption into technology, people, corporate culture, and recognition from the government. (Chen & Tang, 2019) categorized the challenges to BIM adoption as technical, economic, normative related, and education and training constraints.

(Costin et al., 2018) divides the barriers to BIM adoption into four categories: technical, procedural, mindset-related, legal, and return on investment-related. To determine the maturity stage of BIM once it has been adopted in a particular industry, it would be required to classify the barriers to adoption and use standard measurement tools for BIM implementation in each category.

i) Process-Related Barriers to BIM Adoption

In the context of this study, a process is defined as the coordination of numerous disciplines, a modelling process, a BIM information flow, and a documentation process (Wu et al., 2017).

Based on the previously analyzed research, the table below lists the process-related BIM barriers that are most frequently mentioned.

Table 2.6: Process-related Barriers to BIM adoption

	Process Related To BIM Barriers	Source Publications
1	Lack of collaborative initiatives from the industry / lack of information sharing in BIM	Siddiqui et al., 2019, Fadeyi, 2017, Chan et al., 2019, Sardroud et al., 2018)
2	Lack of Proven benefit / intangible business benefits	(Matarneh & Hamed, 2017, Zhang et al., 2019, Chan et al., 2019, Sardroud et al., 2018)
3	Initial setup of BIM is difficult / high initial cost	(Tan et al., 2019, Li et al., 2019, Oesterreich & Teuteberg, 2019)
4	Difficulty in allocating and sharing BIM-related risks and costs	(Zhang et al., 2019, Siddiqui et al., 2019, Miettinen & Paavola, 2014)
5	Lack of detailed processes or workflow to apply BIM technology	(Miettinen & Paavola, 2014, Siddiqui et al., 2019, Tan et al., 2019)
6	Lack of subcontractors who can use BIM technology	(Li et al., 2019; Chan et al., 2019)
7	Fragmented nature of the construction industry	(Masood et al., 2014; Amuda Yusuf et al., 2017)

ii) Human/Stakeholder-Related Barriers

In his three overlapping BIM domains activity, (Succar, 2019) linked human and stakeholder-related activities with process-related constraints. The skills, attitudes, and training of BIM professionals are considered human or stakeholder-related barriers (Wu et al., 2017).

Based on the previously analyzed research, the table below lists the Human/stakeholder-related BIM barriers that are most frequently mentioned.

Table 2.7: Human/stakeholder related barriers to BIM adoption

	Human/Stakeholder Related BIM Barriers	Source Publications
1	Lack of client awareness and Knowledge About BIM	(Amuda Yusuf et al., 2017; Oesterreich & Teuteberg, 2019; Hosseini et al., 2016)
2	Lack of skilled personnel	(Amuda Yusuf et al., 2017; Oesterreich & Teuteberg, 2019; Mohammad et al., 2018)
3	Resistance to change attitude	(Oesterreich & Teuteberg, 2019; Matarneh & Hamed, 2017; Diaz, 2016)
4	Higher cost of staff training	(Moreno et al., 2019; Zhang et al., 2019; Azhar et al., 2015)
5	Weak education and training in universities and government centers	(Hosseini et al., 2016; Mohammad et al., 2018)
6	Lack of Client demand	(Siddiqui et al., 2019; Ahuja et al., 2020)
7	Reluctant to introduce new technology	(R. et al., 2013; Kushwaha, 2016; Moreno et al., 2019)

iii) Technology-Related Barriers to BIM Adoption

According to the capabilities of BIM functions and the characteristics of appropriate software, hardware, and deliverables, this category includes barriers to BIM adoption (Wu et al., 2017).

Based on the previously analyzed research, the table below lists the BIM barriers relating to technology that are most frequently reported.

Table 2.8: Technology Related barriers to BIM adoption

	Technology Related BIM barriers	Source Publications
1	Insufficient ICT infrastructures	(Noor et al., 2018; Siddiqui et al., 2019)
2	The software programs are complex and are not easy to use.	(Oesterreich & Teuteberg, 2019; Azhar, 2016; Charef et al., 2019)
3	Incompatibility and interoperability problems	(Zhang et al., 2019; Jamal et al., 2019)
4	High-cost of BIM software and technology	(Hatem et al., 2018; Zhang et al., 2019; Li et al., 2019)

5	Longer time required to adapt to new technologies (BIM)	(Kushwaha, 2016; Zhang et al., 2019)

iv) External factors-related barriers to BIM adoption

This categorized group of barriers to BIM adoption includes standards, policies, and guidelines. Standards are established guidelines followed when making a product. The implementation of standards, directives, specifications, and contracts is measured under the standard category.

Table 2.9: External Factor Related barriers to BIM adoption

	External factors-related barriers to BIM adoption	Source Publications
1	Lack of BIM National Standards and guidelines/ lack of industry standard	(Chan, Olawumi, Ho et al., 2019b; Qin et al., 2020; Attarzadeh et al., 2015)
2	Legal and Security Issues/ Security of confidential data in BIM model/Ownership	(Qin et al., 2020; Attarzadeh et al., 2015)
3	Lack of legal framework for BIM application	Panuwatwanich & Peansupap, 2013; Mohammad et al., 2018; Wang et al., 2016)
4	Lack of law enforcement by local authorities on BIM	(Mohammad et al., 2018; Attarzadeh et al., 2015)

2.7 Role of BIM in Project Success

2.7.1 Project Success in Construction Industry

According to Baccarini (2020), there are two distinct components of project success: Project management success that focuses on the project process and, in particular, the successful accomplishment of cost, time, and quality objectives, and how the project management process was conducted. Product success deals with the effects of the project's final product.

Freeman & Beale (2021) stated that different people or stakeholders define success from their point of view. An architect can see success in terms of aesthetics, and an engineer in terms of technical competence an accountant in terms of under-spending, and so on.

According to Stuckenbruck (2019), a project's performance can be judged by a variety of stakeholders, including managers, consumers, employees, and shareholders. There is some agreement with the majority of researchers' definition that a project's success is a matter of perception, and that a project is likely to be perceived as an overall success if it fulfils the project's technical requirements and/or mission, and if the key members of the project team and the primary users of its output are extremely happy with its outcomes.

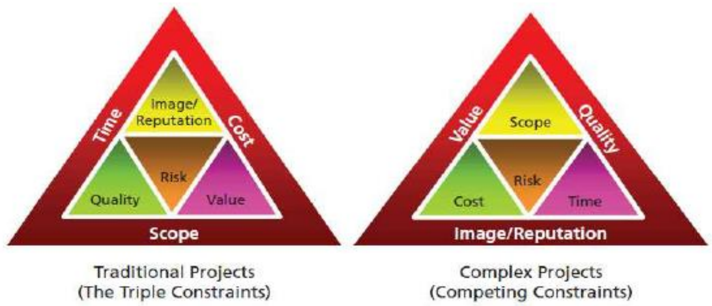
Project success, project management success, and project performance can occasionally be a bit ambiguous since these terms have been interpreted differently by many scholars in the literature. A common term for effective project management is "project performance." According to semantics, project performance is assessed during the project (Cook-Davies, 2019; Han et al., 2019 as referenced in Silva 2016), however, project success is only quantifiable once the project is completed. Project success factors are different in each field of the project.

According to Oberlender et al., (2022), there are three variables that are crucial for a project to be successful throughout construction. These elements include an effective cost management system, a thorough construction schedule, and an effective communication system. The author made the case that an effective field construction representative was necessary to protect the owner's and designer's interests.

The triple constraints, which can be represented as a triangle with the three sides standing for a time, cost, and performance (which could also include quality, scope, and technical performance), are the yardstick by which success is measured.

Depending on the project, there can be secondary success reasons that supersede the primary ones. The use of the customer's name as a reference, business reputation and image, adherence to laws and regulations, strategic alignment, technological superiority, ethical conduct, and other similar variables are examples of secondary factors (Kerzner, 2022). In addition to the triple constraints, project success must consider the customer satisfaction, and business components as well. Secondary factors are also considered to be constraints and may be more important than primary constraints.

Figure 2.8: From Triple to Competing Constraints



Source: Project Management Metrics, KPIs, and Dashboards: A Guide to Measuring and Monitoring Project Performance (Kerzner, 2022)

According to (Kerzner, 2017b), the implementation of BIM is becoming more significant, and the types of factors that affect a project's successful delivery have roots in both obvious and less obvious sources, such as scope, schedule, human resources, quality, cost, and risk management. BIM has been found to have a significant impact on project success in the construction industry. BIM facilitates collaboration among stakeholders by providing a common platform for sharing information. This leads to better communication, reduced errors, and improved decision-making. Enable the project with enhanced visualization, and improved safety. BIM allows for better schedule management by providing real-time updates on project progress.

BIM has been found to reduce costs by minimizing errors, reducing rework, and improving project efficiency. A study by Zhang et al. (2019) found that BIM implementation led to a 10% reduction in construction costs.

BIM-implemented projects have improved quality by reducing errors and improving coordination among stakeholders. A study by Kim et al. (2018) found that BIM implementation led to a 30% reduction in defects during construction.

2.8 Empirical Review

J. J. (2020) Building information management (BIM) models are revolutionizing how buildings are designed and built. They may support multidisciplinary cooperation, integrate 3D design, analysis, cost estimating, and construction scheduling, and are changing how structures are designed and built.

Azhar et al. (2015) In the construction industry, BIM is a vital technology that has been generally recognized for improving project success. A facility's physical and functional attributes are represented digitally in BIM, which can be utilized to help decision-making throughout the building's life cycle. The use of BIM in construction projects has been shown to significantly improve project performance by reducing errors, improving coordination, increasing team collaboration, and enhancing communication. However, the implementation of BIM in construction projects is not without challenges.

Several studies have investigated the impact of BIM on project success. For instance, a study by Arayici et al., (2018) found that the use of BIM improves project efficiency and reduces the number of errors and rework. Another study by Maltese et al., (2017) found that BIM can improve coordination and communication among project team members, leading to better project outcomes. Similarly, a study by Kassem & Succar, (2019) revealed that BIM can enhance collaboration and information sharing among project stakeholders, leading to better project outcomes.

Olawumi & Chan (2019) stated a number of emerging nations have recently made an effort to catch up with and enhance the present level of BIM usage within the construction industry. Indeed, some of the key motivators that encourage BIM use in these construction markets are the potential benefits such as enhanced architectural visualization (Chan et al., 2019b), party collaboration (Husain et al., 2018), and efficient asset management (Ahn et al., 2016). In contrast, recent research (Amuda-Yusuf, 2018; Olanrewaju et al., 2020) similarly revealed difficulties and impediments to BIM adoption in low-income countries, despite the efforts of governments and related stakeholders in the construction sector.

The Ethiopian government has adopted the idea of collaboration and capacity-building programs to promote the inclusion of key stakeholders and enhance the general project management effectiveness of construction projects for new infrastructure (Ayalew et al., 2016). ECPMI, (2018) to apply BIM in construction projects, the Ethiopian Ministry of Construction and the Ethiopian Construction Project Management Institute launched a 5-year strategic plan in 2017. Since then, the governing body has promoted the use of BIM at various stages of the project life cycle.

Mengistu & Mahesh (2020) stated despite the booming economy and the government's initiative to implement BIM in the construction sector, professional and organizational readiness is still low. Several issues, such as poor project management efficiency, low productivity, cost overruns, delays, and disputes among key stakeholders, tend to impede the widespread diffusion of BIM in construction projects. To solve these issues, a thorough BIM implementation strategy and an analysis of the main factors influencing BIM acceptance in the present construction environment are required. This tactic will help to increase the level of BIM adoption and promote project management effectiveness for projects in the Ethiopian construction sector (Belay, Sousa, et al., 2021).

Belay et al. (2021) BIM implementation is a new subject that is now being researched in several markets throughout the world. These studies use case studies that are project- and country-specific to highlight various elements of BIM adoption. For instance, Kiani et al., (2015) investigated the Iranian potential for adopting BIM during the scheduling and planning stages. Ghazaryan, (2019) looked into how BIM was implemented differently in Armenia's building sector. Although there is a low level of BIM adoption in such nations, the analysis shows that there are opportunities to increase BIM adoption in developing nations as a whole.

Al-Ashmori et al. (2020) stated despite the benefits of BIM, its implementation in construction projects has faced several challenges. One of the main challenges is the lack of awareness and understanding of the technology among industry stakeholders. This has led to a slow adoption rate of BIM in the industry. Another challenge is the cost of implementing BIM, which can be prohibitive for some organizations. The lack of interoperability between different software systems used in construction projects is also a significant challenge.

Merschbrock & Munkvold (2015) demonstrates that interior collaborative development BIM process, hardware, and software are the top investment areas for BIM. According to (Dakhil & Alshawi, 2016), there are four categories of BIM issues: 1) technical challenges, and 2) skill and training challenges. 3) Issues with legal procedure, 4) the economy, and other factors may prevent businesses from upgrading their current systems to BIM-focused ones.

The key stakeholders identified by Chua et al., (2019) as project participants include the project manager, client, contractor, consultant, subcontractor, supplier, and manufacturer. There are numerous sets of project success criteria, but none of them will be appropriate for all of the various stakeholders involved in the construction business, claim Wai et al., (2018).

By decreasing errors, rework, and increasing project efficiency, BIM has been shown to lower costs. According to Zhang et al.'s (2019) study, BIM deployment reduced building expenses by 10%. By lowering errors and enhancing stakeholder collaboration, BIM-implemented projects have increased quality. A Kim et al. (2018) study discovered that the use of BIM reduced construction-related errors by 30%.

Project success is defined by different authors through the triangle of scope, time, and cost. BIM evolution is expected to be effective in improving project quality and performance (M. M et al., 2018); nevertheless, BIM implementation implies varied and complex risks (Ghaffarianhoseini et al., 2017). To continuously enhance BIM implementation, we need to know the critical success factors (CSFs) for BIM.

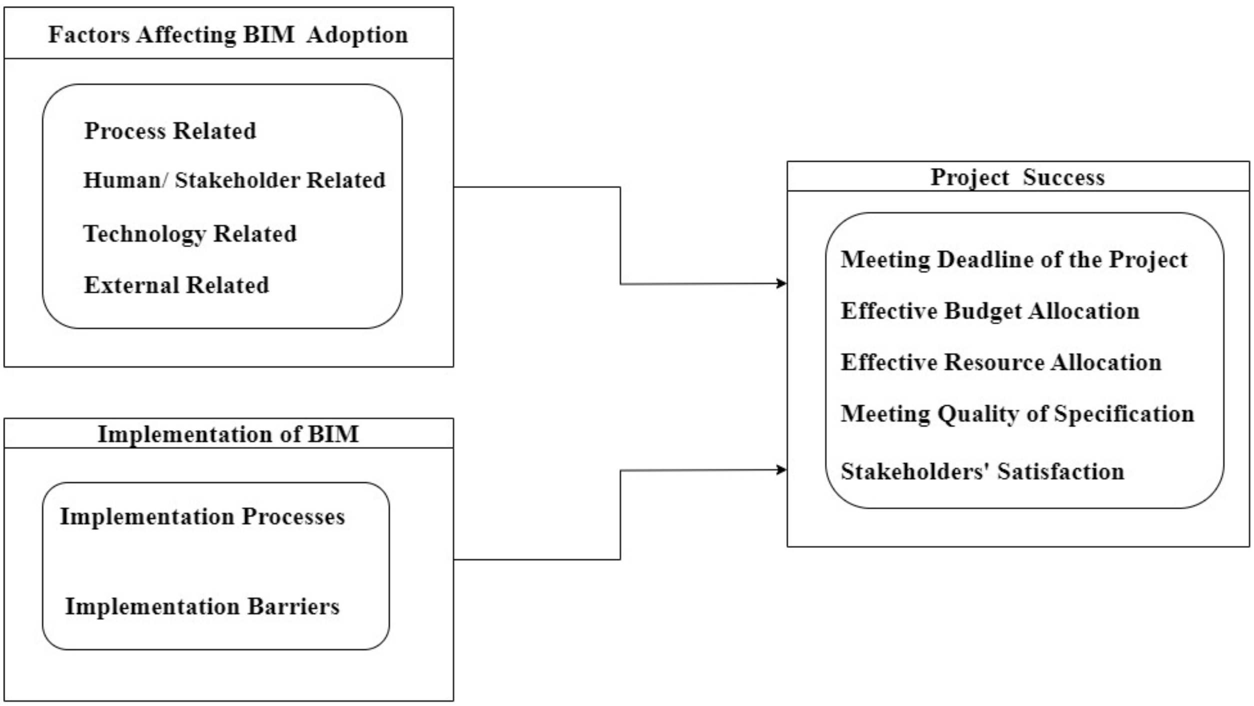
Amuda-Yusuf (2018) stated 28 CSFs were further divided into five components using factor analysis and the rotational component matrix approach. The following five factors were identified: industry stakeholders' commitment to and awareness of BIM, building adoption capability for technology; organizational support, professional collaboration synergy, and cultural orientation. The rankings of the CSFs have practical implication as it provides a basis for refining the most significant factors that industry stakeholders should focus attention on for the successful implementation of BIM.

Chan et al. (2019) identified several critical success factors for implementing BIM in the construction industry. These factors include leadership, training, collaboration, standardization, technology, data management, and contractual arrangements. Implementing these factors can help ensure successful implementation of BIM in the construction industry.

2.9 Conceptual Framework

The following conceptual framework illustrating the relationship between the dependent and independent variables is proposed based on the literatures reviewed.

Figure 2.9: The Conceptual Framework



Source: (Own developed)

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter briefly presents the methodology employed in the course of the study. The variables, independent and dependent, are identified. The research model employed is defined and the type of data with the source of data to complete this study is explained in this chapter. Data collection technique, population of the study, sampling technique, sample size, and ethical considerations are highlighted. The validity and reliability tests and the way both parameters are tested are reflected in this section.

3.2 Research Design, Variable, and Research Model

3.2.1 Research Approach/Method

The study used a mixed-methods research methodology which is suitable for addressing the research questions in depth. Mixed method research combines quantitative and qualitative approaches by incorporating both quantitative and qualitative data in a single study to utilize on the synergy and strength that exist between quantitative and qualitative research methods to comprehend a phenomenon more thoroughly than is possible using either of the methods alone (Zohrabi, 2020). The combination of qualitative and quantitative research offers greater understanding than either approach alone (Creswell & Creswell, 2020).

The Quantitative research approach involves thorough statistical examination of the obtained data (Stangor, 2021). Statistical and numerical data can be used to present objective information that comes from quantitative study (Williams, 2021). The study's initial research question is to identify the factors that influence the adoption of BIM in construction projects and exploring the implementation challenges associated with BIM is the second research question. It makes sense to use a quantitative method to explain the scenario in depth for the first and second research questions.

Stangor (2014) claims that Qualitative research is focused on observing and describing occurrences as they take place to fully capture the richness of the routine behavior, the study’s third research question is investigating the impact of BIM on project success. Therefore, it is acceptable to claim that a qualitative technique is preferable to employ while answering the third question.

3.2.2 Research Design

The researcher used both descriptive and explanatory research design for this study. Descriptive analyses help describe, show or summarize data in a constructive way such that patterns might emerge that fulfill every condition of the data that will make them easy to understand and interpret. The study underwent with the purpose of studying the correlation between the given variables which put the study under the category of explanatory research. Explanatory research design is used to assess the relationship between Building Information Modelling (BIM) and project success. In explanatory mixed method, the researcher first performs quantitative research, evaluates the findings, and then builds on the findings to further explore them through qualitative research (Creswell & Creswell, 2020). The study employed a cross-sectional survey to investigate the existence of a relationship between two or more aspects of a situation (Bryman et al., 2022) using the google formatted questionnaire and structured interview.

The study uses a descriptive analysis (i.e., mean and standard deviation), correlation test and, Relative Importance Index (RII) approaches to measure the impact of factors affecting BIM adoption in construction projects. This approach is ideal to determine the factors that affect the BIM adoption. The RII index was calculated based on the following equation (Alaghbari et al., 2019, Soekiman et al., 2011).

$$\mathbf{RII} = \frac{\sum_{i=1}^{5} W_i x X_i}{5\sum_{i=1}^{5} X_i}$$

Where Wi is the rating given to each factor by the participant ranging from 1 to 5; Xi represented the percentage of respondents scoring and reflected the order number for the respondents; i is the order score ranging from 1 to 5.

3.2.3 Variables

The study holds independent variables and a single dependent variable.

Independent Variables

- **Factors Affecting BIM Adoption:** this variable is measured through Process related, Human/Stakeholders related, Technology related, and External related factors.
- **Implementation Barriers of BIM:** insufficient knowledge of BIM technology, lack of professionals, lack of information sharing in BIM, high cost of implementation process, high cost of training and education, high initial cost of software, satisfied with the existing software, complexity of the BIM, perceived benefits of BIM are unknown.

Dependent Variables

- **Project Success**: This variable is measured through the implementation of BIM creates to enhance project success by Effective Resource allocation, Meeting Deadlines of projects, Effective Budget allocation, Meeting quality of specifications, and Stakeholders' Satisfaction.

3.3 Types and Sources of Data

To be thorough and prevent data shortage, the researcher adopts a survey research method. A survey is a research method that makes use of a questionnaire to gather data from a sample of respondents. Surveys are typically conducted to collect primary data. The information acquired directly to address the research topic under consideration is known as primary data. The traditional methods for conducting surveys involve speaking with or meeting in person with the respondents. The researcher used both primary and secondary types of data sources.

An Interview was served to fill the gap of data that was not covered by the designed questionnaire. Secondary data has also been collected from different Articles, Journals, books, websites, company policy books, etc. that have relevant information to conduct the study.

3.4 Population, Sampling Method, and Sample Size

To produce meaningful and reliable findings and draw conclusions, a researcher conducted a systematic sampling by identifying the target population of the study and the samples. Population is the total number of objects about which knowledge is sought. Sampling is the process of choosing a portion of a universe from which a conclusion or judgment about the population is drawn.

The researcher was able to determine the population size by looking into employees of the construction company who have a close relationship with the study's focus point. Structured interview questions were also created and launched for the Senior Manager, Project Manager, and BIM Execution Head, who have extensive knowledge of what, when, how, and who perform projects at Steak.

3.4.1 Population

Population is the total number of objects about which knowledge is sought. Senior managers, the entire project management staff who have close interaction with BIM execution, Architects and Site engineers of the organization who are familiar with the construction projects under consideration. The total number of the population is 200.

3.4.2 Sampling Method

Sampling is the practice of learning information about a population as a whole by looking at just a small portion of it. The sample was chosen from the target population using a non-random sampling method called purposive sampling. This is because purposive sampling is considered more appropriate when the population happens to be small and a known characteristic of it is to be studied intensively. The researcher wants to choose cases that are very instructive and identify significant people and thoroughly gather information from them which also make purposive sampling method more appropriate. Participants that are representative of the population were chosen using expert judgment and knowledge (past experience) of jobs within the construction industry.

3.4.3 Sample Size

Dunn et al., n.d.; Taherdoost, (2016) noted that the correct sample size in a study is dependent on factors such as the nature of the population to be studied, the purpose of the study, the number of variables in the study, the type of research design, the method of data analysis and the size of the accessible population. From the total population of the OVID constructions, 89 employees were taken using the purposive sampling method and required data was collected from such respondents.

3.5 Method of Data Collection

Secondary data is used to gather information from other researchers in the study's field and to support the investigation. Additionally, the necessary information was acquired from a variety of secondary sources, including books from the library, newspapers, magazines, other communication tools, online sites, other written documents, and relative research materials. Structured interviews and questionnaires with workers of the chosen organization are used to collect the primary data. The total number of respondents was 80.

Questionnaires are distributed to architects, project managers, senior managers, and site engineers, as part of the quantitative research process. Besides, a structured interview was designed and the Managing director and BIM execution head were requested to respond to the interview. A five-scale Likert scale is employed in the questionnaire to evaluate the respondents' expressed attitudes.

The questionnaire is sent through Google form and hardcopy to the respondents are divided into two sections: Section one collected the demographic characteristics of the target population i.e., the age, sex, level of education, work experience, and role at the organization. Meanwhile, the second section consists of questions which are sought to be crucial to survey the current "The implementation challenges of BIM and its role in the project success". Section two is subdivided into specific categories where research questions will be answered thoroughly.

Section Two: Main constructs

- Part A: implementation of BIM was measured with eight items: assessment and need, an invitation to tender, tender response, appointment, Mobilization, collaborative information production, information model delivery, and project close-out. Each of the items was measured on a five-point scale varying from 1 (very unlikely) to 5 (very likely).
- Part B: BIM use was measured with eight items: design authoring, cost estimation, maintenance scheduling, site analysis, 3D controls and planning, phase planning, drawing generator, 3d coordination. Each of the items was measured on a five-point scale varying from 1 (very unlikely) to 5 (very likely)

- Part C: barriers to implementing BIM were measured with nine items: insufficient knowledge of BIM technology, lack of professionals, lack of information sharing in BIM, high cost of the implementation process, high cost of training and education, the high initial cost of software, satisfied with the existing software, the complexity of the BIM, perceived benefits of BIM are unknown.
- Part D: factors affecting the adoption of BIM are divided into four categories. Each of the items was measured on a five-point scale varying from 1 (strongly disagree) to 5 (strongly agree).
    - Process related BIM barriers: lack of collaborative initiatives from the industry /lack of information sharing in BIM, lack of proven benefit/intangible business benefits, initial setup of BIM is difficult/high initial cost, difficulty in allocating and sharing BIM-related risks and costs, lack of detailed processes or workflow to apply BIM technology, lack of subcontractors who can use BIM technology, fragmented nature of the construction industry.
    - Human/ stakeholders'-related barriers: lack of client awareness and knowledge about BIM, lack of skilled personnel, resistance to change attitude, higher cost of staff training, weak education and training in universities and government centers, lack of client demand, reluctant to introduce new technology.
    - Technology-related barriers: Insufficient ICT infrastructures, the software programs are complex and are not easy to use, incompatibility and interoperability problems, high-cost of BIM software and technology, longer time required to adapt to new technologies (BIM), incompatibility and interoperability problems.
    - External factor-related barriers: lack of BIM national standards and guidelines/ lack of industry standard, legal and security issues/security of confidential data in BIM model/ownership, lack of legal framework for BIM application, lack of law enforcement by local authorities on BIM.
- Part E: impact of BIM on project success was measured with five items: resource allocation, meeting deadline of project, respecting budget, meeting quality specifications, meeting stakeholder satisfaction. Each of the items was measured on a five-point scale varying from 1 (very low) to 5 (very high).

3.6 Method of Data Analysis

The first action that will be taken is the processing operation once the questionnaires have been returned. Data editing comes first in the process. The process of editing data is looking over the gathered raw data to detect errors and omissions and fixing them as appropriate. Editing requires carefully reviewing the completed questions. Editing is done to make sure the data are accurate, consistent, as complete as is feasible, input evenly, and well-organized to facilitate coding and tabulation.

The second procedure, coding, involves labelling responses with numbers or other symbols to enable classification into a finite set of categories or classes. These courses must apply to the current research topic. Along with being exhaustive (there must be a class for each data item), they must also be mutually exclusive, which specifies that a certain response can only be recorded in the same cell in a specific category group.

The third and the final operation is tabulation. Tabulation is the process of condensing raw data for further analysis and presenting it in a concise format (i.e., in the form of statistical tables). Tabulation, in a wide sense, is the systematic grouping of data into columns and rows.

The Statistical Package for Social Sciences (SPSS) version 27 is used to analyze the survey data. The fundamental characteristics of the data in a study is described using descriptive statistics. Summaries of the sample and the measurements will be provided. They serve as the foundation for almost all quantitative study of data, along with straightforward tabulated analysis. Interpretations and any relevant comments will be made in light of the analysis' findings in order to find solution to the research problem. The study's key conclusions will be presented in the end, along with a recommendation based on the analyzed data.

3.7 Validity and Reliability

3.7.1 Validity

Convergent or divergent validity and factor analysis can both be used to establish construct validity. Convergent and divergent validity is the first technique. When an item has a high correlation with another item measuring the same construct, it is said to have convergent validity, whereas divergent validity is demonstrated by a low correlation with an item measuring a different construct. The second approach uses factor analysis to evaluate the construct validity of items or indicators.

Out of those two validation approaches, this study employs correlation which investigates the strength of relationships between the studied variables. According to (Hair, Money, et al., 2017) "measures the linear association between two metric variables" Correlations were calculated in two stages as measures of relationships between the independent (predictor) variables and (outcome variable) dependent variable.

The test also indicates the strength of a relationship between variables by a value range from -1.00 to 1.00; when 0 indicates no relationship, -1.00 indicates a negative correlation, and 1.00 indicate a perfect positive correlation (ibid). For the rest of the values used the following guideline is: small correlation for values 0.1 to 0.29, medium for 0.3 to 0.49, and large for 0.50 to 1.0 (ibid). The test is valid if the correlation value (Pearson correlation > r); on the other hand, invalid if the correlation value (Pearson correlation < r).

The sample size is n = 59, so then the number of degrees of freedom is

$$df = n-2$$

$$= 54 – 2 = 52$$

The corresponding critical correlation value *rc* for a significance level of alpha = 0.05.

$\alpha = 0.05$, for a two-tailed test is:

$$rc = 0.273$$

The Pearson correlation value of the constructs are greater than the critical correlation value (rc), so the conducted data are valid.

3.7.2 Reliability

The study's constructs' internal consistency is measured by reliability. A construct is considered reliable if the Alpha value (α) is higher than 0.70 (Hair et al., 2013, Bougie & Sekaran, 2019). A low alpha value can be caused by a small number of questions, inadequate item interrelationships, or heterogeneous constructions. The role of BIM in construction project success and implementation challenges were therefore evaluated using Cronbach's alpha through the use of OVID construction.

Cronbach’s alpha test was used to check the reliability of the instrument on the adopted questionnaires based on the internal consistency of the research instruments. For this study, the rules of thumb about Strength of Association are based on F. Hair Jr et al. (2014) categorization [(Alpha Coefficient Range,**)** **(**< 0.6= Poor**)**, **(**0.6 to < 0.7= Moderate**)**, **(**0.7 to < 0.8= Good**)** **,** **(** 0.8 to < 0.9= Very Good**)** and **(**> 0.9= Excellent**)]**.

Table 3.1: Cronbach’s Alpha Value

Variables	**Cronbach’s Alpha**	**Number of Items**	**Strength Association**
BIM Implementation	0.818	8	Very Good
BIM Use	0.922	8	Excellent
BIM Implementation Barriers	0.763	9	Good
BIM Adoption Barriers	0.937	24	Excellent
Project Success	0.822	5	Very Good

Source: Questioner Survey, 2023

From the finding of Table 3.1, the result revealed that the ‘BIM Implementation’ construct with eight items was found with an Alpha value of 0.818. Further, constructs ‘BIM Use’ and ‘BIM Implementation Barriers’ were found to have Alpha values of 0.922 and 0.763 were found reliable. Similarly, ‘BIM Adoption Barriers’ and ‘Project Success’ with item numbers 24 and 5 had an Alpha value of 0.937 and 0.822 respectively. The finding shows that the research instrument used was reliable. The overall variables have a Cronbach’s alpha coefficient of 0.831 for fifty-nine items which are more than 0.7. Thus, the data is reliable and consistent.

3.8 Ethical Consideration

The researcher made use of different data collection instruments from different sources. Utmost effort it's exerted to acknowledge materials referred & the researcher takes the responsibility to keep confidentiality of respondents' opinions & unanimity of the rest of the information. The researcher thus ensure that all participants are treated with respect and dignity, after being informed that the study is voluntary and no discrimination was triggered by failure to participate. Identification codes was assigned to the filled questionnaires, rather than participant names, to ensure that the participants received absolute confidentiality. The data gathered from respondents was used exclusively for the purposes of the study and was not be given to third parties for any other purpose. Accordingly, the researcher optimally considers all the ethical perspectives.

All respondents received the research purpose, objectives, and research questions prior to the data collection process so that they were fully informed of what was expected of their involvement. Since none of their contributions can be linked to any one contributor, it was believed that these precautions would aid in safeguarding their reputation. The information gathered from respondents was only utilized for the study's objectives and was not made available to third parties for any other use.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

The chapter is devoted to covering the presentation and interpretation of the findings of the study. The purpose of this study was to establish and to assess the role of BIM in construction project success and implementation challenges through taking OVID construction. Besides, the study focused to study the factors affecting the adoption of BIM, identify the barriers of BIM implementation, and impact of implementation of BIM on project success. The findings are presented in tables.

4.2 Questionnaire Response Rate

The percentage of people who complete a distributed survey compared to the total number of respondents is known as the survey response rate (Ramshaw, 2023). Table 4.1 below. The table presents the summary of the survey response status of this study.

Table 4.2: Survey Response Rate

Response	Total	Remark
Completed Responses	80	
Total Respondents	89	
Response Rate	90%	Excellent (Respectable)

Source: Survey, 2023

4.3 Demographic Characteristics of Respondents

Under this section, the democratic characteristics of respondents such as sex, age, educational level, position in the company and work experience related data of selected respondents are described as below.

4.3.1. Sex Distribution of Respondents

The study used the respondents' sex as a demographic element to provide a fair and equitable representation of the respondents. According to Table 4.2, 70 respondents, or 87.5%, were men, while 10 respondents, or 12.5%, were women. The findings indicate that during OVID construction, there were more male respondents than female respondents.

Table 4.2: Gender Distribution of Response

Variable	Classification	Frequency	Percent (%)
Gender	Male	70	87.5
	Female	10	12.5
	Total	80	100

Source: Questioner Survey, 2023

4.3.2. Age of Respondents

Concerning with age category of respondents, the total number of respondents is 80. Respondents who fall under the age range of 20-30 are 42 in number which holds 52.5. Thus, more than half of the entire informants at OVID construction were youngsters aged between 20 to 30 years old and energetic which facilitates the implementation of BIM in construction project and make it simple for the success of the projects. Table 4.3 displays a summary of the information for this demographic component.

Table 4.3: Age of Respondents

Variable	Classification	Frequency	Percent (%)
Age	20-30 Years	42	52.5
	31-40 Years	22	27.5
	41-50 Years	11	13.8
	Over 51 Years	5	5.3
	Total	80	100

Source: Questioner Survey, 2023

4.3.3. Educational Status of Respondents

Table 4.4, revealed the abilities of officials at the project to understand and appreciate the issues at hand, the finding shows, 45(56.3%) of respondent's educational backgrounds found a BSc/BA degree, 31(38.8%) of respondents' educational background was MSc/MA degree and 4(5%) of them have college diploma educational status. However, the response rate assured that significant numbers of the sampled informants have first-degree educational status. These findings show that most of the project managers had the highest level of education and they can understand how to implement BIM.

Table 4.4: Educational Status

Educational Level					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Diploma	4	5.0	5.0	5.0
	BSc/BA	45	56.3	56.3	61.3
	MSc/MA	31	38.8	38.8	100.0
	Total	80	100.0	100.0	

Source: Questioner Survey, 2023

4.3.4. Role at the organization

Respondents selected for this study do have diversified roles at OVID construction, as described in Table 4.5, 32(40%) have Architect role; 21(26.3%) has Project Manager; 15(18.8%) were site engineers and the remaining 12(15%) has the responsibility at senior manager at the construction. Thus, the main roles at OVID construction were Architect, Project Manager, site engineer and senior manager each can have the role to implement BIM in the construction project for its success.

Table 4.5: Role of Respondents

Role in the organization					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Senior Manager	12	15.0	15.0	15.0
	Project Manager	21	26.3	26.3	41.3
	Architect	32	40.0	40.0	81.3
	Site Engineer	15	18.8	18.8	100.0
	Total	80	100.0	100.0	

Source: Questioner Survey, 2023

4.3.5 Work Experiences of Respondents

Based on Table 4.6. 11(13.8%) of the respondent have 0-5 years of work experience, 31(38.8%) of the respondents have 5 to10 years of work experience, 16(20%) of the respondents have 10 to 15 years of work experience, and 22(27.5%) of the respondents have above 15 years of work experiences. Thus, significant numbers of the included informant have adequate and relevant work experiences and the quality of any project can be insured with workers' experiences including other variables.

Table 4.6: Work Experiences of Respondents

	Years of experience				
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	0-5	11	13.8	13.8	13.8
	5-10	31	38.8	38.8	52.5
	10-15	16	20.0	20.0	72.5
	Above 15 years	22	27.5	27.5	100.0
	Total	80	100.0	100.0	

Source: Questioner Survey, 2023

4.4. Data Analysis and Interpretation

Data editing was the first action taken after the surveys were received. The questionnaires that have been filled out are carefully examined. The process of editing data is looking over the gathered raw data to detect errors and omissions and fixing them as appropriate. Editing is done to make sure the data are accurate, consistent with other information obtained, submitted uniformly, as detailed as is practical, and well-organized to facilitate coding and tabulation.

Coding is the second operation conducted. It is a process of labelling questionnaire constructs and replies with numbers or other symbols so that they can be classified into a finite number of categories or classes. The third and final operation is tabulation. The raw data was condensed for further analysis and presenting it in a concise format (i.e., in the form of statistical tables).

It is commonly accepted that using quantitative and qualitative approaches in combination rather than separately improves knowledge of study-related difficulties. To address any gaps and weak spots between the quantitative and qualitative research, methodological triangulation, a hybrid approach, is used. To increase the breadth, depth, and consistency of methodological methods, a range of methodologies are used to understand and explore the phenomenon.

4.4.1 Descriptive analysis of variables: BIM in use at the organization

Several statements have looked at each variable on the questionnaire. The responses' mean and standard deviation values were calculated for this study, and then the statements looking at the same variable were converted into a variable index. According to (Hair, Money, et al., 2017), the term "standard deviation" refers to the range of variation of the sample distribution values from the mean. If the estimated standard deviation is high, indicating that the values in the response distribution are far from the mean, then the responses are deemed inconsistent. Conversely, if the estimated standard deviation is low, indicating that the response distribution values are closer to the mean, then the responses are considered consistent (Sclove, 2020). The threshold for standard deviation varies depending on the scale range used. In this study, we adopt the boundary for a 5-point Likert scale as defined by (ibid). Therefore, response distributions with a sigma of less than 1 are considered consistent, while those with a sigma greater than 1 are deemed inconsistent.

Building information modelling (BIM) is the process of using a shared digital representation of a built asset to speed up the design, building, and operation phases and provide a solid foundation for decision-making. This section focuses on the implementation of BIM, including where the project followed the necessary steps of BIM exchange process and the existing use of BIM. Furthermore, the implementation and use of BIM are evaluated using a Likert scale with options ranging from 1 (very unlikely) to 5 (very likely). Table 4.7 below presents the summary of variable indices and their measured value of central tendency and dispersion.

Table 4.7: Summary of variable indices

Constructs	Min.	Max.	Range	Mean	Std. Deviation
BIM Implementation	1.00	5.00	4	4.17	0.79
BIM Use	1.00	5.00	4	4.12	0.78
Implementation Challenges	1.00	5.00	4	4.36	0.86
Project Success	1.00	5.00	4	3.58	1.42

Source: Survey, 2023

4.4.2 BIM Exchange Process Implementation Steps

The study examined the BIM exchange process implementation steps also as one of the independent variables. It was measured through eight major aspects.

The total number of respondents was 80 and, the implementation of the BIM exchange process ranged from 3.20 to 4.58 mean score and, the response deviation was too narrow which ranges from 0.65 to 0.96 standard deviation. An aggregate mean of 4.17 is achieved implying that the practice of BIM implementation step is moderate. The findings are shown in Table 4.8 below.

Table 4.8: Building Information Modeling Exchange Process Implementation Steps

Questionnaire Statement	Descriptive Statistics					
	N	**Range**	**Min.**	**Max.**	**Mean**	**Std. D**
Assessment and Need	80	4	1.00	5.00	4.58	.65
Invitation to Tender	80	4	1.00	5.00	4.56	.72
Tender Response	80	4	1.00	5.00	3.46	.96
Appointment	80	4	1.00	5.00	4.46	.74
Mobilization	80	4	1.00	5.00	4.33	.79
Collaborative Information Production	80	4	1.00	5.00	3.20	.86
Information Model Delivery	80	4	1.00	5.00	4.34	.95
Project Close-out	80	4	1.00	5.00	4.45	.84
Agg. Mean			**4.17**			

Source: Questioner Survey, 2023

As revealed in the table from BIM Exchange Process Implementation Steps assessment and need, likely implemented step in the BIM process with an average response rate of (M=4.58, SD=0.65). Thus, the response rate assured that assessment and need likely implemented process during the use of BIM in the OVID construction.

The other step in BIM Exchange Process Implementation was the invitation to tender at which the program was undertaken which was practiced at a likely response rate of (M=4.56, SD=0.72). Hence, an invitation to tender was the other process that need to be practiced during the BIM Implementation process at the selected construction group.

The tender invitation marked the conclusion of one stage, while another stage required the tender response to be carried out through the BIM process, which achieved (M=3.46. SD=0.96), indicating that the scheduled response to the invited tenders was a task that is less executed during the BIM implementation process at OVID construction.

As shown in Table 4.8, the implementation of an appointment is a necessary step in the BIM process. The resulting appointment received a high (M=4.46, SD=0.74), indicating that it is the most commonly implemented step. But this still confirmed that appointing relevant parties during the BIM implementation process at the OVID construction is a crucial step in the BIM process.

The other step that was most likely to be implemented at the BIM process was mobilization which was practiced at most likely (M=4.33, SD= 0.79); thus, the mobilization of the BIM process and required tasks was the likely practice work at BIM Implementation process at the OVID constructions.

Collaborative information production is the next step, and its implementation status was likely (M=3.20, SD=0.86); the response rate, therefore, indicated that collaborative information production was less practiced work during BIM Implementation process at OVID constructions.

The other implementation step BIM exchange process was information model delivery which has a response rate of (M=4.34, SD=0.95); hence, in the OVID constructions, the information model delivery was the most used implementation step of the BIM process. The final BIM process implementation step was related to project close-out with having a (M=4.45, SD=0.84), the response implies project close-out was the main implemented work during the BIM process in the study area.

The implementation of BIM efficiently and effectively, as per (Serin, 2021), requires adherence to the 8 implementation steps outlined in the ISO 19650 procedure.

Furthermore, according to an interview with a representative from OVID construction, the construction groups placed significant emphasis on implementing the BIM process and conducting thorough evaluations of each step. This was necessary because the project involved utilizing a shared digital representation of the built asset, which was constructed by the construction group and aided in facilitating design, construction, and operation processes to establish a dependable foundation for decision-making. Consequently, the implementation and utilization of Building Information Modeling were deemed critical and anticipated in the construction industry.

4.4.3 Building Information Modeling (BIM) Use

Table 4.9 displays the varying use of Building Information Modeling among respondents. The mean score for the response rate ranges from 4.23 to 4.47, with a standard deviation of 0.69 to 0.96. To assess the current use of BIM at the OVID construction, officials were asked eight questions and rated all relevant variables based on their likelihood of use.

Table 4.9: The use of Building Information Modeling

Descriptive Statistics						
	N	**Min.**	**Max.**	**Range**	**Mean**	**Std. D**
Design Authoring (a process in which 3D software is used to develop BIM)	80	1	5	4	4.40	.78
Cost Estimation	80	1	5	4	4.39	.96
Maintenance Scheduling	80	1	5	4	3.42	.70
Site Analysis	80	1	5	4	4.47	.79
3D Control and Planning	80	1	5	4	4.26	.76
Phase Planning (4D Modelling)	80	1	5	4	3.27	.69
Drawing Generator	80	1	5	4	4.52	.71
3D Coordination (to perform clash-detection processes)	80	1	5	4	4.23	.81
		Agg. Mean		**4.12**		

Source: Questioner Survey, 2023

According to the respondents, an aggregated mean score of 4.12 and standard deviation of 0.78 is achieved implying that the BIM use in the organization is moderate. Meanwhile, the respondents believe BIM use in *Maintenance Scheduling* (M=3.42, SD=0.70) and *Phase Planning (4D Modelling)* (M=3.27, SD=0.69) are rather rare.

The response rate assured that, through using Building Information Modeling at the OVID construction, it can be possible to design authoring; estimate the cost; undertake site analysis; 3D control and planning; drawing generator and 3D coordination at the construction industry.

Song et al., (2019) stated that the application BIM for planning was used by different companies existing in the construction industry such as design institutes, construction companies, owners, government and suppliers, and the scale of each company in their category is different, and the purpose of BIM adopt is not always the same.

The study's findings aligned with those of (Sacks et al., 2019), who discovered that the efficient adoption and implementation of BIM might benefit all project stakeholders. These advantages include fewer reworks, accelerated project schedules, and cost savings via precise cost estimation.

The interviewee mentioned that the organization is in the process of using all BIM Dimensions in almost all of the construction processes. Also, leveraging the full potential of BIM to improve efficiency, accuracy, and collaboration throughout the project lifecycle.

The integration of BIM and its appropriate utilization offer numerous advantages to the construction industry. Nonetheless, several obstacles hinder the proper application of BIM in construction projects, which will be further discussed in the following section.

4.4.4 The Key Challenges in Implementing BIM in Construction Projects

The main barrier for implementing BIM was provided for selected informants taken from the OVID construction and they are required to state their agreement level 1 for strongly disagreed; 2 for disagree; 3 for neutral or undecided; 4 for agree, and 5 for strongly agree for each key challenge and their response rate was stated at minimum, maximum, mean and standard deviation descriptive statistics.

Table 4.10: Key Challenges in Implementing BIM in Construction Projects

Descriptive Statistics					
	N	**Minimum**	**Maximum**	**Mean**	**Std. D**
Insufficient knowledge of BIM technology	80	1.00	5.00	4.35	.80
Lack of professionals	80	1.00	5.00	4.55	.82
Lack of information sharing in BIM	80	1.00	5.00	4.16	.80
High cost of implementation process	80	1.00	5.00	4.54	.89
High cost of training and education	80	1.00	5.00	4.30	.81
High initial cost of software	80	1.00	5.00	4.49	.78
Satisfied with the existing software	80	1.00	5.00	4.52	.82
Complexity of the BIM	80	1.00	5.00	4.14	.95
Perceived benefits of BIM are unknown	80	1.00	5.00	4.20	1.03
Agg. Mean			**4.36**		

Source: Questioner Survey, 2023

For evaluating the main challenges seen in Implementing BIM in Construction Projects were varied, but for this particular study, nine questions were prepared, and respondents agreed on the challenges by stating their agreement level between 4.14 to 4.55 average mean value and their agreement level deviated by the standard deviation of 0.78 to 1.03 among respondents.

The first key challenge that has the highest hindering effects on implementing BIM in Construction Projects was the lack of professionals, which respondents agreed with (M=4.55, SD=0.82). Hence, the absence of required and experienced professionals was the major curbing factor for the proper implementation of BIM in construction projects.

The majority of respondents identified the high cost of implementation as the second major challenge, with a (M=4.54, SD=0.89). This indicates that the proper implementation of BIM in Construction Projects is hindered by the significant costs involved. Porwal & Hewage, (2019) also noted that implementing BIM requires substantial investment and implementation costs, making it a costly endeavor.

The models used in the construction industry were invented over time and the stick of the existing software and satisfaction by professionals was the third challenge that holds the implementation of BIM in construction projects with (M=4.52, SD=0.82). Thus, satisfaction with the existing software was the major challenge that curbs the implementation of BIM in the construction industry, similarly there is resistance to change upon receiving the BIM model as well as more time spent on the accuracy and checking the model before information extraction or updating (Love et al., 2017).

Various obstacles impeded the implementation of BIM in the construction sector, with the primary challenge being the high initial cost of the software. This issue was identified by most respondents as the fourth most significant challenge, with an average response rate of (M=4.49, SD=0.78). Consequently, the expense associated with acquiring new software emerged as another significant barrier to implementing BIM in the construction industry.

The other challenges that have higher hindering effects on the implementation of BIM were related to the insufficient knowledge of BIM technology with (M=4.35, SD=0.80), for easy implementation of BIM in construction industries, existing employees shall have sufficient knowledge of BIM technology and make the model adopted.

The high cost of training and education was the other challenge that affects the implementation of BIM, and respondents agreed (M=4.30, SD=0.81), this is because the introduction of the new system demands the provision of education and training to aware the new scheme use which requires the investment of higher cost by construction industries and impedes the easy application of the new system in to practice.

Perceived benefits of BIM are unknown was the challenge, and there is a greater agreement rate by selected respondents at (M=4.20, SD=1.03). It shows from the newly invented model, it is possible to know the expected benefits as a result employees and construction industries are obliged to hesitate to adopt the system.

The challenge relating to the lack of information sharing in BIM with an average response rate of (M=4.16, SD=0.80); is due to the construction industries and the sector's professional habit to hide information on the BIM process and experiences not easily sharing among them which bans them to apply BIM at any construction industry.

The remaining challenge for this study was related to the complexity of the BIM which takes (M=4.14, SD=0.95); thus, the complexity of the BIM was the other challenge in implementing BIM in Construction Projects.

In general, the finding stated that the challenges relating to insufficient knowledge of BIM technology, lack of professionals, lack of information sharing in BIM, high cost of the implementation process, high cost of training and education, the high initial cost of software, satisfaction with the existing software, the complexity of the BIM and perceived benefits of BIM are unknown has higher hindering effects on the implementing BIM in construction projects.

Vass (2018) identified that, even if construction professionals are aware of BIM advantages in the construction industry, there is still a lack of knowledge of the economic effects and outcomes of BIM, and there is no comprehensive list of BIM advantages and associated cost savings. In addition, according to (A. Aibinu & Venkatesh, 2019) there is a lack of skilled personnel, which leads to a lack of BIM expertise and suitable conceptions to use BIM features in the market.

There exist three main factors affecting BIM implementation in all construction industries. The first factor is a technology dimension which includes the interoperability between applications, software compatibility, authorizing and monitoring of the quality and progress of construction, design clash detection and visualization and BIM standard and protocols.

The second factor is an organizational dimension which includes BIM professionals, BIM vendors, professional training of BIM technologies, and support of senior management and clients (Eadie et al., 2019). The third factor is the attitude factor which includes an interest in learning BIM, BIM awareness, willingness to use BIM, and perceived cost of BIM technology and platform (Pikas et al., 2018). The absence of a unified BIM definition leads to confusion about the true BIM understanding by non-BIM and non-construction individuals (Hurtado & Sullivan, 2019).

In addition, Gamil & Rahman, (2019) found that, among the challenges identified, the top-ranked five challenges based on the descending are financial restrictions, lack of BIM knowledge, improper introduction of BIM concepts, lack of awareness of BIM benefits and no governmental enforcement.

Furthermore, according to an interview with a representative from OVID construction, the interviewee mentioned that BIM is a relatively new technology, and it is challenging to locate experts who are knowledgeable and experienced with it. BIM implementation can be expensive, especially for smaller construction firms that do not have the resources to pay for the required software and training. However, the interviewee emphasized that despite these challenges, they believe that BIM is essential for improving efficiency and reducing errors in construction projects.

4.5 Relative Index Analysis

Aibinu & Jagboro, (2018) state that the Relative Importance Index (RII) technique is used to characterize the relative importance of the particular causes and consequences based on their likelihood of occurring and impact on the project's success using a Likert scale of five scales. Additionally, the critical cause or influence component has a higher rating on the Index of Relative Importance (RII).

Thus, relative index analysis was selected in this study to rank the factors like process barriers, human resource/stakeholder barriers, technology barriers and external barriers according to their relative effects on project success.

The formula for determining the relative index involves multiplying the weight assigned by respondents (on a scale of one to five) by the total sample size and dividing that product by the maximum weight. This can be expressed as $RI = W/A \times N$.

According to Akadiri, (2017), five important levels are transformed from RI values: high (H) ($0.8 \leq RI \leq 1$), high-medium (H–M) ($0.6 \leq RI \leq 0.8$), medium (M) ($0.4 \leq RI \leq 0.6$), medium-low (M-L) ($0.2 \leq RI \leq 0.4$) and low (L) ($0 \leq RI \leq 0.2$).

4.5.1 The Relative Index for Process-Related to BIM Barriers

Relative index analysis was used to rank the process-related barriers on Building Information Modeling (BIM) according to their relative importance. Table 4.11 shows the ranking results for each category by using the relative index analysis using the equation.

Table 4.11: Relative Index of Process-Related to BIM Barriers

Process-Related to BIM Barriers	Total(W)	N	A	RII(W/A*N)	Rank
Lack of collaborative initiatives from the industry / lack of information sharing in BIM	267	80	5	0.6675	4th
Lack of Proven benefit /intangible business benefits	268	80	5	0.67	3rd
Initial setup of BIM is difficult / high initial cost	277	80	5	0.6925	1st
Difficulty in allocating and sharing BIM-related risks and costs	269	80	5	0.6725	2nd
Lack of detailed processes or workflow to apply BIM technology	267	80	5	0.6675	5th
Lack of subcontractors who can use BIM technology	266	80	5	0.665	6th
Fragmented nature of the construction industry	238	80	5	0.595	7th

Source: Questioner Survey, 2023

Based on these ranking results, seven major adoption barriers were highlighted to have barrier on Building Information Modeling (BIM) with a RI value between 0.595 and 0.6925. These seven barriers are with their order initial setup of BIM is difficult/high initial cost; difficulty in allocating and sharing BIM-related risks and costs; lack of proven benefit/intangible business benefits; lack of collaborative initiatives from the industry/lack of information sharing in BIM;

lack of detailed processes or workflow to apply BIM technology; lack of subcontractors who can use BIM technology and fragmented nature of the construction industry. Based on Akadiri, (2017) measurement scale the six process barriers has a high-medium (H–M) ($0.6 \leq RI \leq 0.8$) effects while the seventh barrier has medium (M) ($0.4 \leq RI \leq 0.6$) effects on Building Information Modeling (BIM). Regarding the process-related issue, financial restriction (4.671) is the most prevalent challenge according to the study of Gamil & Rahman, (2019).

4.5.2 The Relative Index of Human/ Stakeholders-Related to BIM Barriers

Relative index analysis was used to rank the human related barriers on BIM according to their relative importance. Table 4.12 shows the ranking results for each category by using the relative index analysis using the equation.

Table 4.12: Relative Index of Human/ Stakeholders-Related to BIM Barriers

Human/ Stakeholders Related to BIM Barriers	Total(W)	N	A	RII(W/A*N)	Rank
Lack of client awareness and knowledge about BIM	278	80	5	0.70	2nd
Lack of skilled personnel	277	80	5	0.69	3rd
Resistance to change attitude	234	80	5	0.59	6th
Higher cost of staff training	267	80	5	0.67	5th
Weak education and training in universities and government centers	268	80	5	0.67	4th
Lack of client demand	282	80	5	0.71	1st
Reluctant to introduce new technology	232	80	5	0.58	7th

Source: Questioner Survey, 2023

As shown at Table 4.12 above, the RII analysis human/stakeholders related factors to BIM Barriers shows; the most human/stakeholder barrier that affects BIM was a lack of client demand with RII=0.71, followed lack of client awareness and knowledge about BIM with RII=0.70, the third barrier lack of skilled personnel which has RII=0.69; the fourth barriers were weak education and training in universities and government centers and higher cost of staff training with RII=0.67; thus, as per Akadiri (2017) measurement ranks and effect rate that ranks one to five have a high-medium (H–M) (0.6 ≤ RI ≤ 0.8) impact on Building Information Modeling at the OVID constructions.

While, human/stakeholders related factors such as resistance to change attitude with RII=0.59, and reluctant to introduce new technology with RII=0.58 has medium (M) (0.4 ≤ RI ≤ 0.6) impacts for BIM at the OVID construction groups.

Gamil and Abd Rahman, (2019); Siddiqui et al., (2019), stated that the most significant factor related to human/stakeholders-related challenges is the lack of BIM knowledge (4.648) attributed to the late introduction of technology and unavailability of curricula related to BIM in higher institutions.

4.5.3 The Relative Index for Technology-Related to BIM Barriers

Relative index analysis was used to rank the technology related barriers on BIM according to their relative importance. Table 4.13 shows the ranking results for each category by using the relative index analysis using the equation.

Table 4.13: Relative Index for Technology-Related to BIM Barriers

Technology Related to BIM Barriers	Total(W)	N	A	RII(W/A*N)	Rank
Insufficient ICT infrastructures	185	80	5	0.46	5th
The software programs are complex and are not easy to use	224	80	5	0.56	2nd
High-cost of BIM software and technology	200	80	5	0.50	3rd
Longer time required to adapt to new technologies (BIM)	194	80	5	0.49	4th
Incompatibility and interoperability problems	245	80	5	0.61	1st

Source: Questioner Survey, 2023

Table 4.13 above contains, the RII analysis of technology-related factors to BIM Barriers; the most technology barrier that affects Building Information Modeling(BIM) was incompatibility and interoperability problems with RII=0.61, followed by the software programs are complex and are not easy to use with RII=0.56, the third barrier is the high cost of BIM software and technology with RII=0.50; longer time required to adapt to new technologies (BIM) with RII=0.49 and insufficient ICT infrastructures with RII=0.46.

According to Akadiri (2017), measurement ranks only first among the five technology barriers that have a high-medium (H–M) ($0.6 \leq RI \leq 0.8$) impact on Building Information Modeling at the OVID construction group; however, the ranks second to six has medium (M) ($0.4 \leq RI \leq 0.6$) impacts for Building Information Modeling at the OVID construction groups.

But, according to Gamil and Abd Rahman (2019); Ho et al., (2019b) study, it is indicated that the most important factor related to technology is the high cost of technology (4.510), and this is justified due to the financial limitations.

4.5.4 The Relative Index of External Factors-Related to BIM Barriers

Table 4.14: Relative Index of External Factors-Related to BIM Barriers

External Factors Related to BIM Barriers	Total(W)	N	A	RII(W/A*N)	Rank
Lack of BIM national standards and guidelines/ lack of industry standard	300	80	5	0.75	1st
Legal and security Issues/security of confidential data in BIM model/ownership	267	80	5	0.67	3rd
Lack of legal framework for BIM application	277	80	5	0.69	2nd
Lack of law enforcement by local authorities on BIM	263	80	5	0.66	4th

Source: Questioner Survey, 2023

The relative index of external factors-related to BIM Barriers result was shown in Table 4.14 above, the most external barrier that affects Building Information Modeling(BIM) the first barrier was a BIM national standards and guidelines/lack of industry standard with RII=0.75, the second was a lack of legal framework for BIM application of with RII=0.69, the third barrier is legal and security issues/security of confidential data in BIM model/ownership which has RII=0.67; the fourth barrier is a lack of law enforcement by local authorities on BIM with RII=0.66.

According to Akadiri (2017), measurement ranks the four barriers of external factors that have high-medium (H–M) ($0.6 \leq RI \leq 0.8$) impact on Building Information Modeling at the OVID construction group.

According to (Chan et al., 2019; Muluken & Prof. Dr. Ing Hans, 2020) study, indicates that the most important factor related to external factors are a lack of BIM national standards and guidelines/lack of industry standards and a lack of law enforcement by local authorities, this is justified due to the lack of policies and standards at the national level.

4.6 The Impact of BIM Implementation in Project Success

The study examined the impact of BIM implementation in project success. It was measured through five major constraints/ aspects.

The total number of respondents was 80 and, the impact of BIM implementation in project success ranged from 3.35 to 4.27 mean score and, the response deviation ranges from 0.82 to 1.72 standard deviation. The findings are shown in Table 4.15 below.

Table 4.15: The Impacts of BIM implementation in Project Success

Descriptive Statistics						
	N	**Min**	**Max**	**Range**	**Mean**	**Std. D**
Resource Allocation	80	1.00	5.00	4	4.27	.82
Meeting Deadline of Project	80	1.00	5.00	4	3.47	1.57
Respecting Budget	80	1.00	5.00	4	3.35	1.72
Meeting quality specifications	80	1.00	5.00	4	3.35	1.52
Meeting Stakeholder Satisfaction	80	1.00	5.00	4	3.45	1.47
	Agg. Mean		**3.58**			

Source: Questioner Survey, 2023

As shown in Table 4.15 above, for project success, resource allocation has the highest impact with a 4.2 mean score and a response deviations was 0.82 standard deviation; meeting the deadline of the project has an average response rate of 3.47 mean score and 1.57 standard deviation; meeting the stakeholder satisfaction with 3.45 mean values and 1.47 standard deviation; meeting quality specifications and respecting budget with an equal mean score of 3.35 and diversified response deviation of 1.52 and 1.72 standard deviation respectively.

The project's success in terms of resource allocation, meeting the deadline of the project, meeting stakeholder satisfaction, meeting quality specifications and respecting the budget was maintained at medium with a 3.58 aggregate mean and 1.42 standard deviation, these, BIM implementation has a moderate impact on project success at the OVID construction group.

A study by Zhang et al. (2019); Kim et al. (2018) indicates that BIM implementation led to a reduction in construction costs, improved quality (reduction in defects), improved schedule and meeting stakeholders' satisfaction.

During the interview, it was stated that the adoption of BIM has resulted in several benefits on the outcome of projects. These include the ability to identify delays at an early stage, leading to improved scheduling. Additionally, BIM has helped to minimize errors, resulting in cost savings. The implementation of BIM has also led to increased project efficiency and improved overall quality.

4.7 Correlation Analysis

To calculate the degree of relationship between two or more variables, correlation analysis examines the joint variation of the two or more variables. The correlation is a number that the value of 'r' ranges from -1 to +1, measuring the strength of the relationship between two variables. Positive correlations indicate positive associations, whereas negative correlations imply inverse or adverse associations. There is no relationship between the two variables if 'r' has a value of zero.

Assumptions of the Correlations

1. The two variables (X, Y) are scaled data. These variables should be neither ordinal nor nominal.
2. There is no distinction between the two variables, i.e., no consideration for explanatory or response variable.
3. Linear relationship exists between the two variables.
4. Both variables must be normally distributed.

4.7.1 Assumption Testing

Assumptions one and two about data (measurement scale and type) are theoretical and are important to be taken into consideration while choosing the parametric correlation analysis.

4.7.1.1 Testing for Linearity

According to (J. P. & Abdel-Salam, n.d., 2019) the linearity assumption states that the relationship between each pair of correlated variables is linear. This assumption can be tested by looking at the bivariate scatter plots of the variables to be used in correlation analysis.

Based on the response rate obtained from chosen informants, the bivariate scatter plots of the variables were displayed below. Several factors, including processes, human/stakeholders, technology, and external related factors, hindered the adoption of Building Information Modelling (BIM) in construction projects.

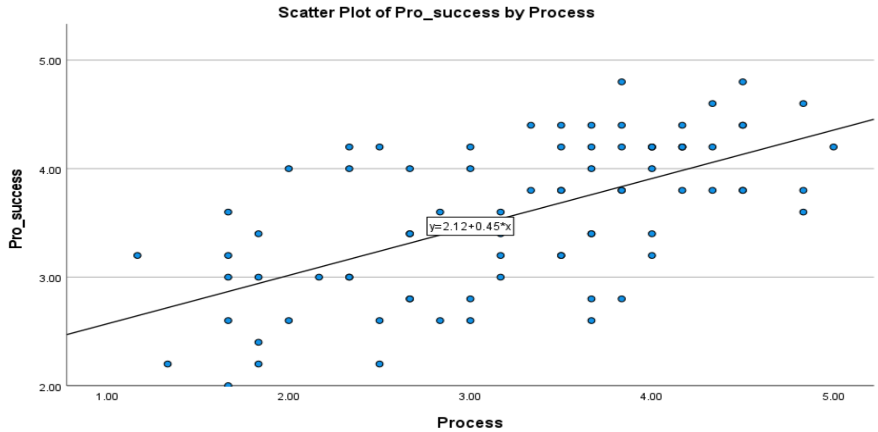


Figure 4.2: Linearity Test of Process-related barriers and Project success

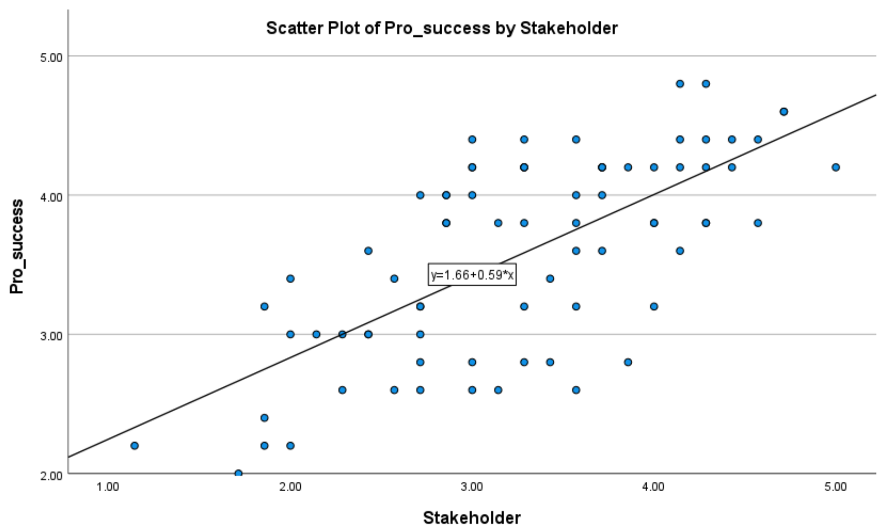


Figure 4.2: Linearity Test of Human/Stakeholders'-related barriers and Project success

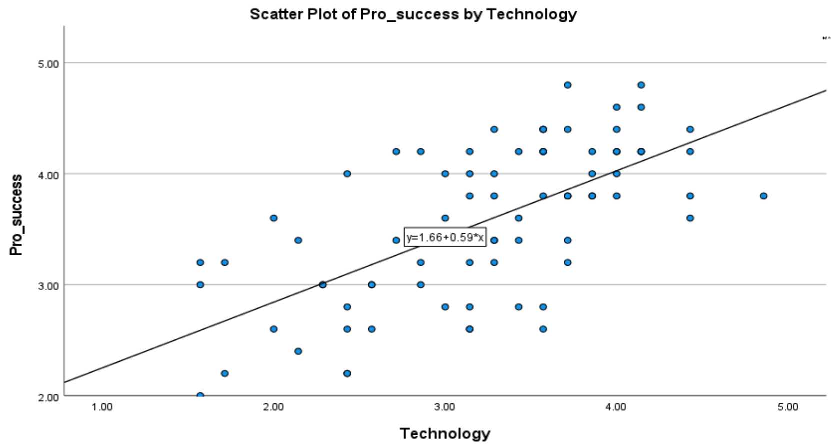


Figure 4.3: Linearity Test of Technology-related barriers and Project success

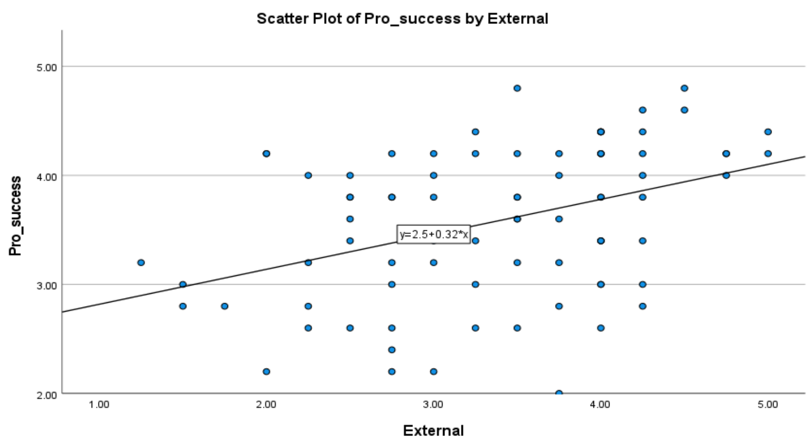


Figure 4.4: Linearity Test of External factor-related barriers and Project success

The scatter plot shows that the plot has settled on the linear line and that residual values were not frequently observed by the aforementioned figure. Therefore, there were no significant violations of assumptions in this investigation.

4.7.1.2 Testing for Normally Distribution

To determine the normal distribution of the data and to assess the statistical significance of Pearson's correlation coefficient, the Shapiro-Wilk test was considered. It also takes skewness, and kurtosis values under consideration. If the value of the Shapiro-Wilk test is greater than 0.05, the data is distributed normally. If it is below 0.05, the data significantly deviate from a normal distribution. Hair et al. (2015); Bryne (2015) argued that data is considered to be normal if skewness is between -1 to +1 and kurtosis is between -3 to +3. Table 4.16 shows the normality test for the variables.

Table 4.16: Summary of Normality Testing

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Process	.122	80	.005	.962	80	.018
Stakeholder	.062	80	.200*	.987	80	.622
Technology	.109	80	.019	.968	80	.043
External	.138	80	.001	.967	80	.037

Source: Survey, 2023

All of the Shapiro-Wilk test results from the preceding table are larger than 0.05, indicating that the data is distributed normally. Additionally, all variable values fall within the expected range of skewness and kurtosis values. Since every assumption regarding individual relationships has been verified, the study can be analyzed using correlation analysis.

A high degree of correlation between the two variables is indicated by a 'r' value that is closer to +1 or -1. Table 4.17 shows the points in order to interpret output of correlation analysis.

Table 4.17: Measuring parameters of Pearson Correlation

Measured Parameter	Value	Description
Strength (r)	Strong	0.7-1
	Moderate	0.3-0.7
	Weak	Less than 0.3
Nature	Positive	Greater than 0
	Negative	Less than 0
Significance	Significant	P-value < 0.05
	Insignificant	P-value > 0.05

Source: Kotrlik, et al., (2011)

The result of the analysis of correlation is presented in table 4.18 and the interpretation of the analysis is as follows:

- Person product correlation of human/stakeholder's factors was found to be strongly negative and statistically negative ($r = -0.790$; $P < 0.05$). This indicates that the human resource/stakeholder barrier significantly impacts project success.
- Person product correlation of external factors was found to be moderately negative and statistically negative ($r = -0.402$; $P < 0.05$). This suggests that external barriers have moderate but negative impacts on project success in the study area.
- Person product correlation of process related factors was found to be strongly negative and statistically negative ($r = -0.856$; $P < 0.05$), indicating that process-related barriers have negative impacts on construction projects' success.
- Finally, person product correlation of technology related factors was found to be moderately negative and statistically negative ($r = -0.722$; $P < 0.05$), suggesting that technology-related barriers substantially and negatively impact construction projects' success.

Overall, the correlation analysis shows that there is a strongly negative and substantial relationship between technology-related factors, process-related factors, and human resource/stakeholder barriers and project success in construction projects. However, the external barrier has only a moderate but still negative association with its effects on project success in construction projects.

Table 4.18: Result of Correlation Analysis

Correlations

		Human	**External**	**Process**	**Technology**	**Success**
Human	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	80				
External	Pearson Correlation	.399**	1			
	Sig. (2-tailed)	.000				
	N	80	80			
Process	Pearson Correlation	.777**	.386**	1		
	Sig. (2-tailed)	.000	.000			
	N	80	80	80		
Technology	Pearson Correlation	.742**	.201	.839**	1	
	Sig. (2-tailed)	.000	.075	.000		
	N	80	80	80	80	
Success	Pearson Correlation	-.790**	-.402**	-.856**	-.722**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	80	80	80	80	80

*. Correlation is significant at the 0.05 level (2-tailed),

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Questioner Survey, 2023

CHAPTER FIVE: Summary of Findings, Conclusions, and Recommendations

5.1 Introduction

This chapter presents discussion summary on the key data findings, the conclusions drawn from the findings highlighted and recommendations forwarded for responsible organs.

The conclusions and recommendations drawn were focused on addressing the objectives of the study.

5.2 Summary of Finding

The study required to examine Building Information Modeling (BIM) implementation challenges and practice in project success at OVID construction groups. It assessed the BIM implementation barriers and adoption challenges and their impact on project success. The analysis made using statistical tools also showed this fact. According to an analysis using Pearson association analysis, the use and role of BIM had a linear, one to one relationship with the project's success. Tables 5-1, 5-2 respectively, present the summary of the descriptive analysis, and the correlation analysis.

Table 5.1: Summary of Descriptive Analysis

Constructs	Minimum	Maximum	Mean	Std. Deviation
BIM Implementation	1.00	5.00	4.17	0.79
BIM Use	1.00	5.00	4.12	0.78
Implementation Challenges	1.00	5.00	4.36	0.86
Project Success	1.00	5.00	3.58	1.42

Source: Survey, 2023

At OVID construction there are about eight BIM exchange process implementation steps that needs to be implemented which includes an assessment and need, invitation to tender, appointment, mobilization, information model delivery and project close-out and there is narrower response deviation among respondents on the implementation of such steps. Tender response and collaborative information production are the two steps that are implemented less likely in the organization.

The study found that BIM can facilitate design authoring, cost estimation, maintenance scheduling, site analysis, 3D controls and planning, phase planning, drawing generation and 3D coordination in the construction industry. However, the study also revealed several challenges to implementing BIM effectively. These include a shortage of professionals with expertise in BIM technology; high initial costs associated with software acquisition; high costs associated with implementation processes; insufficient knowledge of BIM technology; satisfaction with existing software; lack of information sharing within BIM systems; high costs associated with training and education; complexity of the BIM system; and unknown perceived benefits of using BIM in construction projects.

Table 5.2: Summary of Correlation Analysis

		Human	**External**	**Process**	**Technology**
Project Success	Pearson Correlation	-.790**	-.402**	-.856**	-.722**
	Sig. (2-tailed)	.000	.000	.000	.000

Source: Survey,2023

5.3 Conclusions of the Study

The research aim of this study primarily was to identify the BIM implementation processes applied in the organization. The finding of the research showed that BIM implementation processes have not been fully implemented, there is room for improvement in the BIM implementation processes at OVID construction. The organization may need to focus on enhancing its tender response and collaborative information production processes to fully realize the benefits of BIM. It also showed the importance of the organization following all implementation steps to ensure a successful BIM implementation.

The aspects of BIM use derived from reviewed literature have received an aggregate mean score of 4.37. Additionally, top management has confirmed that the organization is implementing BIM in multiple areas. By incorporating Building Information Modeling in OVID construction, it becomes feasible to engage in design authoring, cost estimation, site analysis, 3D controls and planning, drawing generation and 3D coordination within the construction industry. The finding of the study implies that the use of BIM is becoming increasingly popular in the organization and incorporating BIM into their construction project processes can benefit from improved efficiency and accuracy in various aspects of their projects.

The second objective of the study was to identify the key challenges in BIM implementation, derived from reviewed literature have received an aggregate mean score of 4.36. Additionally, top management has confirmed that the main challenges the organization faces during BIM implementation are relating to insufficient knowledge of BIM technology, lack of professionals, lack of information sharing in BIM, high cost of the implementation process, high cost of training and education, the high initial cost of software, satisfaction with the existing software, the complexity of the BIM and perceived benefits of BIM are unknown has higher hindering effects on the implementing BIM in construction projects. The finding of the study implies that the primary obstacles to implementing BIM at OVID construction are related to technology, organization, and attitudes.

The third objective of the study was to identify the factors affecting the adoption of BIM. To determine their impact on project success, the various factors such as process barriers, human /stakeholder barriers, technology barriers, and external barriers were evaluated and ranked accordingly. Process-related top three barriers include the initial setup of BIM being difficult/high initial cost with RII=0.69, difficulty in allocating and sharing BIM-related risks and costs with RII=0.673, and lack of proven benefit/intangible business benefits with RII=0.67.

The top three human/stakeholder-related barrier that affects Building Information Modeling were lack of client demand with RII=0.71, lack of client awareness and knowledge about BIM with RII=0.70, and lack of skilled personnel which has RII=0.69. The RII analysis of top technology-related factors to BIM implementation includes incompatibility and interoperability problems with RII=0.61; the software programs are complex and are not easy to use with RII=0.56, the third barrier is the high cost of BIM software and technology with RII=0.50.

The top external-related barrier that affects Building Information Modeling (BIM) was the lack of BIM national standards and guidelines/lack of industry standards with RII=0.75; lack of legal framework for BIM application with RII=0.69; legal and security issues/security of confidential data in BIM model/ownership with RII=0.67. From the study, it can be concluded that the factors that affect the adoption of BIM in the organization are related to cost, technology, legal and regulatory requirements, and client demand.

The last objective of the study was to investigate the role of BIM in project success. project's success in terms of resource allocation, meeting the deadline of the project, meeting stakeholder satisfaction, meeting quality specifications and respecting the budget was maintained at aggregate mean score of 3.58 and BIM implementation has a moderate impact on project success at OVID construction.

Under the findings, the human/stakeholders-related barriers, technology-related barriers, process-related barriers, and external factor-related barriers correlated with the project success as per the analysis made on the Pearson correlation analysis. The correlation analysis test indicated that there is a negative and substantial correlation between technology-related factors, process-related factors and human/stakeholder barriers and project success; while there is a moderate and negative association between external barrier and their effects on project success in construction projects.

5.4 Recommendation of the Study

It is recommended that:

- OVID construction should assume the full implementation of Building Information Modeling (BIM) in all of their projects. They should get themselves out of the traditional way of handling projects as it is not convenient to manage a project in a better way.

- Top management should develop a comprehensive strategy that outlining the goals, objectives, and timelines for BIM adoption also working with external stakeholders to promote BIM adoption.

- To effectively implement BIM, organizational decision-makers must provide support to their staff by offering short-term training. Additionally, each individual within the organization should strive to improve their BIM competencies.

- To integrate BIM in OVID construction projects along with the existing process to increase awareness of professionals towards BIM.

5.5 Suggested Areas for Further Research

As this study is bounded by a single company and is limited by geographical boundaries, future studies of the practice of Building Information Model (BIM) towards project success could include:

- Evaluate project success from the client's and the consultant's perspectives so that impacts of the Building Information Model (BIM) on project outcomes provide an adequate solution to the client's problem and win-win advantages both to the organization and the client in terms of quality of product/services offered, greater output volume, quicker delivery, and provide tangible benefits such as gaining profits.

- BIM and its role in construction project success should be studied on a wide scale to examine the impact of BIM on project management processes, including scheduling, cost estimation, risk management, sustainability, and communication.

- Exploring how BIM can be integrated into architectural, engineering, and construction education to prepare students for future careers in the industry.

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Annex I

Questionnaire for Senior managers, Project Managers and Office Engineer

Hermela G/egziabher
Email: - her21gegziabher@gmail.com
Addis Ababa

Dear Sir/Madam

RE: REQUEST FOR PARTICIPATION IN A RESEARCH STUDY

I am attending a post graduate program in Project Management at Addis Ababa University School of Commerce (AAUSC). As partial fulfillment for the degree, I am conducting research study on “Role of Building Information Modeling (BIM) on project success and its implementation challenges.” Therefore, I would appreciate it if you could spare a few minutes of your time to answer the following questions regarding the role of Building Information Modeling (BIM) on project success and its implementation challenges in your project works.

To meet the study's goal, I respectfully urge that you answer all of the questions in the questionnaire. All the information provided will be purely used for academic purposes and your identity will be treated with the utmost confidentiality. Your assistance will be highly appreciated.

Thank you in advance!

Yours faithfully,

Hermela G/egziabher

Mobile Number: 0929-362412

INSTRUCTION:

i. Do not write your name on the questionnaire.
ii. Please read each question carefully.
iii. Kindly answer all the questions by ticking or filling in the spaces provided.

SECTION ONE: BACKGROUND INFORMATION

1. Sex: Male ☐ Female ☐

2. Age:

   i. 20 - 30years ☐ ii. 31- 40 years ☐

   iii. 41 – 50 years ☐ v. Over 51 years ☐

3. Level of Education

   i. Certificate ☐ ii. Diploma ☐ v) Other ______________

   iii. BSc/BA ☐ iv. MSc/MA ☐

4. What is your role in the organization?

   i. Senior Manager ☐ ii. Project Manager ☐ iii. Architect ☐

   iv. Site Engineer ☐ v. Other ______________

5. Work Experience in the organization

   i. 0 - 5 years ☐ ii. 5 – 10 years ☐

   iii. 10 – 15 years ☐ iv. Above 15 years ☐

SECTION TWO: BUILDING INFORMATION MODELING (BIM) IN USE AT THE ORGANAZATION

Building Information Modeling (BIM) *is use of a shared digital representation of a built asset to facilitate design, construction and operation processes to form a reliable basis for decisions. Please mark with a Tick in the applicable box with regard to the current Building Information Model used in your organization (Please read the above definition).*

A. Implementation of BIM

1. Has your project followed the necessary steps of BIM exchange process? Please Tick

BIM Execution Process workflow	Very unlikely	Unlikely	Neutral	Likely	Very likely
	1	2	3	4	5
Assessment and Need					
Invitation to Tender					
Tender Response					
Appointment					
Mobilization					
Collaborative Information Production					
Information Model Delivery					
Project Close-out					

2. In what area of the project are you currently using BIM?

BIM Use	**Very unlikely**	**Unlikely**	**Neutral**	**Likely**	**Very likely**
	1	2	3	4	5
Design Authoring (a process in which 3D software is used to develop BIM)					
Cost Estimation					
Maintenance Scheduling					
Site Analysis					
3D Control and Planning					
Phase Planning (4D Modelling)					
Drawing Generator					
3D Coordination (to perform clash-detection processes)					

3. In your opinion what do you think is the main barrier for implementing BIM? Please Tick on the appropriate one

Barriers for Implementing BIM	**Strongly Disagree**	**Disagree**	**Neither Agree or Disagree**	**Agree**	**Strongly Agree**
	1	2	3	4	5
Insufficient knowledge of BIM technology					
Lack of professionals					
Lack of information sharing in BIM					
High cost of implementation process					
High cost of training and education					
High initial cost of software					
Satisfied with the existing software					
Complexity of the BIM					
Perceived benefits of BIM are unknown					

Other Factors (If there is any you recommend)

____

____

____

B. Factors Affecting the Adoption of BIM

How would you rate the following factors affecting the adoption of Building Information Modelling (BIM) in your organization? Please Tick on the appropriate one

Process Related to BIM Barriers	**Strongly Disagree**	**Disagree**	**Neither Agree or Disagree**	**Agree**	**Strongly Agree**
	1	2	3	4	5
Lack of collaborative initiatives from the industry / lack of information sharing in BIM					
Lack of Proven benefit/intangible business benefits					
Initial setup of BIM is difficult / high initial cost					
Difficulty in allocating and sharing BIM-related risks and costs					
Lack of detailed processes or workflow to apply BIM technology					
Lack of subcontractors who can use BIM technology					
Fragmented nature of the construction industry					
Human/Stakeholders Related to BIM Barriers	**Strongly Disagree**	**Disagree**	**Neither Agree or Disagree**	**Agree**	**Strongly Agree**
	1	2	3	4	5
Lack of client awareness and knowledge about BIM					
Lack of skilled personnel					
Resistance to change attitude					
Higher cost of staff training					

Weak education and training in universities and government centers					
Lack of client demand					
Reluctant to introduce new technology					

Technology Related to BIM Barriers	**Strongly Disagree**	**Disagree**	**Neither Agree or Disagree**	**Agree**	**Strongly Agree**
	1	2	3	4	5
Insufficient ICT infrastructures					
The software programs are complex and are not easy to use.					
Incompatibility and interoperability problems					
High-cost of BIM software and technology					
Longer time required to adapt to new technologies (BIM)					
Incompatibility and interoperability problems					

External Factors Related to BIM Barriers	**Strongly Disagree**	**Disagree**	**Neither Agree or Disagree**	**Agree**	**Strongly Agree**
	1	2	3	4	5
Lack of BIM national standards and guidelines/ lack of industry standard					
Legal and security Issues/ security of confidential data in BIM model/ownership					
Lack of legal framework for BIM application					
Lack of law enforcement by local authorities on BIM					

C. Impact of BIM Implementation in Project Success

How would you rate the impact of BIM implementation to the general project success in the following areas? Please Tick on the appropriate one

Impact of BIM on Project Success	Very Low	Low	Moderate	High	Very High
	1	2	3	4	5
Resource Allocation					
Meeting Deadline of Project					
Respecting Budget					
Meeting quality specifications					
Meeting Stakeholder Satisfaction					

Annex II

Addis Ababa University
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SEEK WISDOM, ELEVATE YOUR INTELLECT AND SERVE HUMANITY !

Structured Interview for Senior Managers

1) What are the nature and types of projects handled by the organization?
2) What are the areas your company currently implementing building information modelling?
3) What are the activities your company following to implement building information modelling?
4) What are the major factors affecting the adoption of BIM in your company?
5) What are the main barriers to the implementation of BIM in your company?
6) What are the opportunities of using Building Information Modelling (BIM)?
7) How do you measure the impact of BIM implementation on the project success?
8) Are there any other issues concerning implementing BIM that have not been covered in the interview and that you wish to bring to our attention?