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COLLEGE OF BUSINESS AND ECONOMICS

MASTER OF BUSINESS ADMINISTRATION

ASSESSMENT OF BUILDING INFORMATION MODELING (BIM) IMPLEMENTATION PRACTICE IN ETHIOPIAN ENGINEERING CORPORATION

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February 2025

DECLARATION

I hereby declare that this thesis, entitled ' Assessment of Building Information Modeling (BIM) Implementation Practice In Ethiopian Engineering Corporation,' submitted to the College of Business and Economics, Department of Business Administration, is my original work conducted under the guidance of my advisor. This work has not been previously submitted or presented to this or any other university or institution.

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CERTIFICATION

This is to certify that this thesis entitled "Assessment of Building Information Modeling (BIM) Implementation Practice in Ethiopian Engineering Corporation," submitted in partial fulfillment of the requirements to award masters of business administration to the College of Business and Economics, Addis Ababa University undertaken by Abraham Yoseph is an authentic work and appropriate for submission.

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TABLE OF CONTENTS

DECLARATION i
CERTIFICATION ii
ACKNOWLEDGEMENTS iii
TABLE OF CONTENTS iv
ACRONYMS vii
LIST OF TABLES viii
LIST OF FIGURES ix
ABSTRACT x
CHAPTER 1 1
INTRODUCTION 1
1.1 Background 1
1.2 Statement of the Problem 3
1.3 The Objectives of the Study 4
1.3.1 Major objective 4
1.3.2 Specific Objectives 4
1.4 Scope 5
1.5 Significance 5
1.6 Limitations 5
CHAPTER 2 6
LITERATURE REVIEW 6
2.1 Background of BIM 6
2.2 History of BIM 6
2.3 PROJECTION BY Implementation of BIM 8
2.4 Application of BIM in other Country’s 9
2.5 Measuring BIM Maturity 10
2.6 Measuring PRODUCTIVITY IN Construction Business 11
2.7 BIM Implementation Practices and Challenges in Organizations 12
2.8 About EEC Company 13

2.9 Research Gap 14
CHAPTER 3 15
MATERIAL AND METHODS 15
3.1 Research Design 15
3.2 Source of Data 16
3.3 Study Area 17
3.4 Study Population 17
3.5 Sampling Techniques and Sample Size Determination 18
3.5.1 Sampling Techniques 18
3.5.2 Sample Size Determinations 19
3.6 Developing BIM Maturity Matrix 20
3.6.1 Defining the Stages of BIM Implementation and Integration 20
3.6.2 Assessment Criteria Identifying Specific Dimensions for Evaluation 20
3.6.3 Scoring System: Quantifying the Implementation Levels 21
3.7 Developing Construction Performance Matrix 21
3.8 Data Collection Methods 24
3.8.1 Questionnaire 24
3.9 Method of Data Analysis and Representation 25
3.9.1 Qualitative 25
3.9.2 Quantitative 25
3.10 ETHICAL CONSIDERATIONS 25
CHAPTER 4 26
DATA PRESENTATION, ANALYSIS AND DISCUSSION 26
4.1 Background 26
4.2 Demographic Profile of Respondents 26
4.3 Reliability Test 28
4.4 Key Performance Indicator Descriptive Results across Sectors 29
4.5 Descriptive Results on BIM Maturity across Sectors 32
4.6 Interpretation of ANOVA KPI Results in EEC Sectors 36
4.7 BIM Maturity anova Results Interpretation 38

CHAPTER 5 40
SUMMARY, CONCLUSION AND RECOMMENDATION 40
5.1 BACKGROUND 40
5.2 SUMMARY 41
5.3 Conclusion 43
5.4 RECOMMENDATION 44
5.5 AREAS FOR FURTHER RESEARCH 45
REFERENCE 46
APPENDIX 49
QUESTIONNAIRE AND ANALYSIS RESULTS 49

ACRONYMS

AEC	Architectural, Engineering and Construction
BIM	Building Information Modeling
BEP	BIM execution plan
BIM	Building Information Modeling
CAD	Computer Aided Design
DM	Design Management
CDE	Common Data Environment
ECPMI	Ethiopian Construction Project Management Institute
EEC	Ethiopian Engineering Corporation
EIR	Employer Information Requirement
ETB	Ethiopian Birr
IFC	Industry Foundation Classes
GDP	Growth Domestic Production
GTP	Growth Transformation Plan
IBDE	Integrated Building Design Environment
IFC	Industry Foundation Class
SPSS	Statistical package for social science

LIST OF TABLES

Table 2.1 Prospect by BIM Implementations by Distinguished Authors 8

Table 2.2 Dimensions and Indicators (Y. Chen, 2013)... 11

Table 2.3 Key Performance Indicator Dimensions.. 12

Table 2.4 The implementation framework (Jung and Joo, 2011)... 13

Table 3.1 Study Population at Ethiopian Engineering Corporation (EEC, 2024) 18

Table 3.2 proportions of sample with in EEC.. 19

Table 3.3 Key Performance Matrix 23

Table 4.1 Demographic Profile of Respondents.. 27

Table 4.2 Results of Cranach alpha 28

LIST OF FIGURES

Figure 2.1 BIM Dimensions (EPCMI, 2019).. 7

Figure 2.2 BIM Evolution (Chan, 2014)... 10

Figure 4.1 Descriptive Results for Key Performance Indicator (SPSS output V.26)................... 30

Figure 4.2 Descriptive Results for BIM maturity (SPSS output V26) 33

Figure 4.3 Descriptive Results of Anova KPI Results in EEC sectors (SPSS output V26)......... 36

Figure 4.4 BIM maturity anova results interpretation (SPSS output V26)................................... 38

ABSTRACT

The study explores the use of Building Information Modeling (BIM) in EEC specifically issues with its application and advantages that can obtained from its utilization. The study engaged concerned BIM trained staffs for survey across different sectors within corporation which needs to achieved such key indicators as BIM maturity, staff numbers technology implementation assessment, project delivery approaches, and organizational performance. The research revealed that, despite information technology infrastructure usage and documentation capability strengths characterized by EEC as the company asset appreciated, most of hardware infrastructures are inefficiencies and outdated technology. Besides, the company lacks of training for employee and has no mitigation risk management on basis of new technology adoption in addition to absence of leadership development noted. Key sectorial conclusions discovered are the management strengths in quality and time schedule but the absence of control of cost and safety procedure, required effective systems for controlling data, required leadership and financial control. The study has also addresses the necessity for specifically targeted interventions to fill up BIM implementation gaps through formal training and development of the workforce, investment in digital technology, and improved reward and leadership systems. Finally, the author suggest that, a proper reaction towards the acceptance of BIM toward training and developing the workforce, investing in infrastructure, and managing risks will give rise to optimal project efficiency and extensive implementation in EEC.

Keywords: BIM Implementation, Performance Indicator, Descriptive Statistics, EEC Sectors

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The world construction industry has now revolutionized on an enormous scale as buildings and infrastructure designed, built and operated in fundamentally new ways. One of the most important technologies driving the transformation is Building Information Modeling (BIM). BIM is an intelligent digital solution that facilitates a group of teams to communicate more effectively through sharing a realistic virtual model of a project. The model holds all regarding a building's design; materials, structure, and function in such a way that various teams can share and reach decisions back (Eastman et al., 2011). Additionally, BIM is integrating with new technologies like the Internet of Things (IoT), Artificial Intelligence (AI), Virtual and Augmented Reality (VR/AR), robotics, and automation and thus enhancing construction efficiency, safety, and sustainability (Jung et al., 2020).

Although all the developed countries have almost implemented digital construction technologies, no single step has taken in this regard by Ethiopian professionals. The Ethiopian government appreciates the need for digitalization and has outlined policy programs like the Digital Ethiopia Strategy (2024), Growth and the Ten-Year National Development Plan (2019) to advance digital uptake across all sectors, including construction. All this despite the above, the implementation of BIM in Ethiopia is below expectation. Conventional methods remain the widespread approaches of the majority of construction companies due to such constraints as limited exposure to high technology, extremely high implementation costs, inadequate expertise, and resistance (ECPMI, 2019).

The global Architecture, Engineering, and Construction (AEC) industry, companies have moved away from traditional approaches to modern design, which involved hand drawings, revision clouds, and disintegrated communication. The use of such early practices is bound to lead to errors, miscommunication, delays, and overruns in expenses (Azhar et al., 2011). One of the primary issues with such methodologies is that, information does not move easily from one phase of a project to another, resulting in loss and inefficiencies (Abdul et al., 2005). In contrast, BIM application provides project management straightforward since it allow from 3D to multiple dimension models that covers all design, construction, and maintenance requirements. It enables increased visualization, clash detection, cost estimation, and environmental analysis, leading to increased coordination, reduced rework, and improved construction quality (Duell et al., 2013). There needs to be high technology, effective processes, capable people, and effective government policies for BIM to operate at its peak level (Chen et al., 2016).

Despite its many advantages, BIM implementation has still affected by many challenges. Some of the greatest obstacles include incompatibility of software, difficulties related to managing extremely large amounts of data, lack of clear industry standards, and legal uncertainties (Lu et al., 2021; Zhang et al., 2020). To measure the efficiency of BIM implementation, business organizations use Key Performance Indicators (KPIs) to track time saving, cost reduction and overall project efficiency gain (Hosseini et al., 2020). However, for broad implementation of BIM, business companies shall invest in efficient training, good implementation policies, and collaborative culture. Unfortunately, the majority of business organizations are confronted with limited budgets, inefficient procedures, and resistance to change from traditional to virtual practices (Azhar et al., 2011).

The research conducted in Ethiopian Engineering Corporation (EEC), which is one of the leading government companies with experience in undertaking mega construction and design study projects throughout Ethiopia. With EEC being part of the strongest services in Ethiopia's construction sector, its strength largely determines how the industry must to proceed in the future. However, little work is available that accounts for the integration and implementation of BIM and other technologies in EEC. It is imperative to know the way BIM has currently utilized at EEC and what disadvantages and benefits it poses so that the company could directed toward better project management and overall effectiveness. Hence, the current study has aimed to assess BIM implementation among EEC sectors, analyzing how it has used in project planning, execution, and management. The research will also assess organizational keenness, main barriers to implementation, and the impact of BIM on project performance. Additionally, this study assessed BIM Maturity Matrix (BIMM) and BIM-specific KPIs presenting a systematic method of measuring and improving BIM implementation in company. These findings will support EEC managements and professional staffs who have experience with BIM and industry stakeholders in making informed decisions about digital transformation on BIM in construction.

By conducting descriptive case analysis in real-world data, this research has a potential to fill the awareness gap on BIM implementation in EEC and offer practical solutions to overcome its challenges. Finally, the study output may contribute to building a more advanced, technology-driven construction industry that aligns with Ethiopia's vision for sustainable development and economic growth.

1.2 STATEMENT OF THE PROBLEM

The Architecture, Engineering, and Construction (AEC) industry has long affected by shortcomings such as fragmented collaboration, poor coordination, less communication, unwell performing buildings, excessive energy consumption, and unsustainable construction processes (Latham, 1994; Egan, 1998). Design deficiencies, project delays, reduced productivity, reduced building quality, and reduced stakeholder experiences are also the deriving potential on project performance.

In the area of human capital, the willingness of the work force to adopt new technologies like Building Information Modeling (BIM) remains a broad with untapped horizon (Smith, 2009). While BIM holds vast possibilities for changing the construction industry, its use by the Ethiopian Engineering Corporation (EEC) has undermined by many challenges. The appearance of limited access to digital materials, inappropriate inclusive policies, and absence of localized studies limit implementation and delay incorporation into organizational processes are observed in project progress activities. Currently, EEC has n transitioned period to implement digital tools like BIM. However, among the employer the unequal access projects information and unclear office guidelines have not only slowed down the implementation process but also provided a challenge to quantify BIM maturity based on performance. Besides, the non-availability of detailed case studies applicable for implementation in EEC also delays developing proper BIM implementation strategies applicable to the EEC work environment.

In contrast, the majority of the studies conducted on BIM by distinguished authors have focused on well-developed countries, while its application in developing countries like Ethiopia has not well understood. A study based empirical evidence in BIM specific to Key Performance Indicators (KPIs) which play a central character in measuring project success and making BIM-supported processes improve progressively though its limited as acquire demand end users (Bryde et al., 2013).

Therefore, the current research intends to assess the captioned challenges that are very important to enhance EEC's and other sectors as competitive advantage for planning, execution, and management with BIM implementation. Through focusing on these compulsory areas, the study tries to provide an integrated view of assessment for BIM implementation. This will in turn, translate to improved efficiency and more project deliverables, thereby putting EEC on track as a business innovation leader.

Research Questions

- In what extent BIM implement in Ethiopian Engineering Corporation (EEC)?
- What are the key challenges and barriers affecting the implementation and effective utilization of BIM in EEC's projects?
- How BIM application addresses project efficiency and collaboration within EEC?

1.3 THE OBJECTIVES OF THE STUDY

1.3.1 Major objective

The research aims to assess the current state of Building Information Modeling (BIM) implementation in the Ethiopian Engineering Corporation (EEC) by examining its level of implementation and integration within sectors of EEC. It seeks to identify key challenges delaying BIM implementation, including technological, organizational, and regulatory barriers.

1.3.2 Specific Objectives

The specific objectives of the study are describes below

- To Assess the current BIM implementation and application integration in EEC company among sectors

- To describe and identify key challenges obstructing BIM implementation in EEC.
- To Evaluate BIM implementation on sectors efficiency with performance in EEC

1.4 SCOPE

The scope of the study mainly focused on the Construction Industry in Ethiopia specifically on evaluating the potential for enhancing construction business productivity by employing an integrated Building Information Modeling (BIM) Technology. The research has confined to an assessment of how the implementation and utilization of BIM technology can challenge, as well as enhance productivity within the company of EEC.

1.5 SIGNIFICANCE

The research has centered on addressing major problems in Ethiopia's expanding construction sector particularly in EEC, including infrastructure deficits, cost volatility, quality deficiencies, and delays in projects. Conventional means of information sharing, such as the use of drawings, have resulted in inefficiencies and loss of data. It aims to identify to the gap between traditional methods and new technology, assisting in improving productivity and project quality. Through involving EEC stakeholders through surveys, interviews, and focus groups, the research has aimed to ensure collaboration and lead to better project outcomes, increased efficiency, and continued long-term performance for the development of the construction sector.

1.6 LIMITATIONS

The study has constrained by participant willingness and availability to interviewed, which may have a result in bias. The descriptive quantitative analysis is dependent on response range and quantity in surveys, affecting generalizability of results. The depth of insight of participants may range, affecting richness of result. Misunderstanding of a question may also affect data accuracy. In addition, the researcher's personal biases may disrupt study design, data interpretation, and conclusions.

CHAPTER 2

LITERATURE REVIEW

2.1 BACKGROUND OF BIM

Prior to the introduction of BIM as a terminology, researchers had extensively examined building product models. Basher et al. (2017) placed basis in preceding the formalization of BIM. Liu et al. (2011) offered a dual perspective on BIM, describing it as both a modeling and application tool. The modeling aspect defines BIM as Building Information Modeling that utilizing three-dimensional digital technology to combine construction project data, graphical engineering models, physical and functional properties, and project life cycle information. Conversely, from an application standpoint, BIM represents a digital model supporting diverse construction project operations, offering dynamic inclusion of project information throughout the life cycle to provide specific demands (Liu, 2011).

Moreover, it is critical to recognize that BIM is not only software; it is a combination of process and software. As articulated by Hardin B. (2009), BIM entails not just the use of three-dimensional intelligent models but also entails considerable alterations in workflow and project delivery processes, indicating its comprehensive impact beyond software utilization within the construction domain. In Accordance to the ECPMI (2019) statement, Building Information Modeling (BIM) goes beyond electronic documents by involving the comprehensive utilization, exchange, and reuse of information. BIM extends more than a three-dimensional modeling or digitized paper files and effecting BIM leads to reduced risks with maintains design reliability, streamlines quality control, enhances communication clarity, and it offers accessibility to advanced analytical tools.

2.2 HISTORY OF BIM

Laiserin, cited in Eastman et al.'s (2008) Handbook on BIM, gives a ordinary perspective of the evolution of BIM history that illustrates how terms evolved from "Building Product Models" in the USA to "Product Information Models" in Europe, illustrating how the language of the technology evolved. Laiserin (2002) played a major role in making the term BIM popular, although Phil Bernstein of Autodesk (Succar, 2009) first utilized it. This followed the concept of a product model, a fundamental concept upon which BIM technology has founded. It combines consensus data structures with the capacity to express comprehensive engineering data on determinate artifacts, a concept upheld by Watson (2010).

Ibrahim M. and Ahmad T. (2020) contend that, the origin of BIM dated to the 1960's and 1960's when computer-aided design (CAD) was first applied. Such an innovation was Ivan Sutherland developing CAD software in 1963, where Sketchpad was the graphical interface. Subsequently, in the 1960's, French Aerospace Company developed CAD technology from two dimensions (2D) to three dimensions (3D). Autodesk was a name that everyone at home had heard of in the IT world in the 1960's with their software AutoCAD. The era witnessed evolution from three-dimensional (3D) modeling to the 4D model, which was of monumental importance to stakeholders, especially in the AEC sector, as it supported scheduling and resource planning well in line with time. The subsequent development, the five-dimensional (5D) model, was intended for cost estimation, providing convenient assistance to quantity surveyors and estimators in justifying project cost estimates.

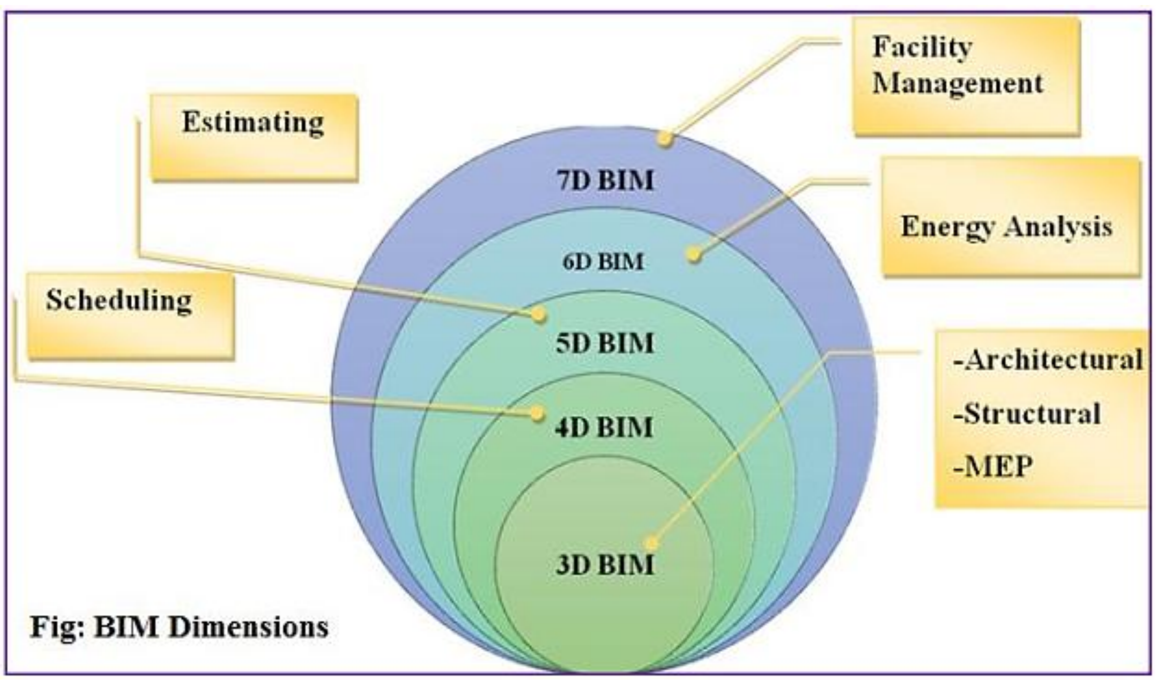

Figure 2.1 BIM Dimensions (EPCMI, 2019)

The evolution continued with the inclusion of the six-dimensional (6D) model, emphasizing sustainability considerations, and the seven-dimensional (7D) model, emphasizing facilities management. These 'nD' models were used for specific functionalities. Beveridge (2012) discovered subsequent versions such as eight-dimensional (8D) for integrated project delivery and maintainability, nine-dimensional (9D) for acoustics (auditability), ten-dimensional 10D for security, and eleven-dimensional 11D for heat-related considerations. The overall evolution demonstrates a systematic expansion of BIM functionality to cover different industry needs.

2.3 PROJECTION BY IMPLEMENTATION OF BIM

The use of Building Information Modeling (BIM) contributes positively to the value addition of construction and project management, resulting in increased productivity and reduced risk in the lifecycle of the project (Eastman et al., 2011). BIM as a novel socio-technical system enables enhanced collaboration and communication by the team players, resulting in enhanced project performance, reduced rework, and enhanced predictability of project outcome and asset maintenance (Azhar et al., 2011). As per ECPMI (2019) definition, Project clients who are initiating the role of adopting BIM and gaining many benefits through the adoption of BIM. Here as shown table below are some of benefits suggested by distinguished authors.

Table 2.1 Prospect by BIM Implementations by Distinguished Authors

Eastman et al., 2011	Provides multi-dimensional visual representations and timely information related to construction projects, aiding in better decision-making
	Facilitates the testing of models and quick generation of options to optimize time, cost, processes, and risk management
	Helps in detecting design faults, such as clashes, leading to fewer design changes and rework
	Facilitates better project coordination by enabling early-stage collaboration among project participants
	Enhances third-party and public engagement by improving communication and soliciting community support during project planning
	Improves the quality-cost ratio through better analysis and simulations, supporting informed decision-making
	Enhances marketing efforts through improved client communication and service delivery

Azhar et al., 2011	Improves site safety management and operational security by identifying equipment sufficiency early in the process
	Enhances financial risk management by reducing variations and delays, thereby minimizing financial claims
	Contributes to improved capital investment and life cycle cost management by enhancing cost predictability
	Enhances project schedule management by providing better scheduling and sequencing tools

2.4 APPLICATION OF BIM IN OTHER COUNTRY'S

Munir M. (2020) citing Chan (2014) draws attention to the expanding recognition and usage of in a few of the developed nations such as Germany, France, Brazil, Austria, Finland, Denmark, Norway, and Sweden. Research indicates that the Western European sector has experienced approximately 36% incorporation of, echoing its growing establishment within that region's contractor base. Additionally, nations like Japan, South Korea, and Austria/New Zealand are also experiencing a second stage of maturity of adoption with three to five years of experience in the technology.

The mentioned speedy advancement of is being witnessed in South Korea, as contractors manifested a 65% uptake level within the year 2012. Singapore, which has been dynamic in championing since 1997, set up a national implementation roadmap in 2011, leveraging for different aspects of construction like building plan approvals and fire safety certifications. From the year 2015, Singapore's government mandated in public sector projects that are larger than 5000 square meter. China also built a system under a five-year government plan that lasted from 2011 to 2015. Hong Kong is also experiencing rapid implementation.

In the US, the General Services Administration (GSA) integrated spatial programs into final concept submission requirements, making the country a mature and innovative best practice market. The action led to a drastic rise in implementation in North America, increasing from 28% to 71% between 2007 and 2012, surpassing architects' implementation levels. The UK, in a tender to lead the way in implementation within Europe, enforced its use within public sector projects from 2016, yet further boosted global expansion initiatives.

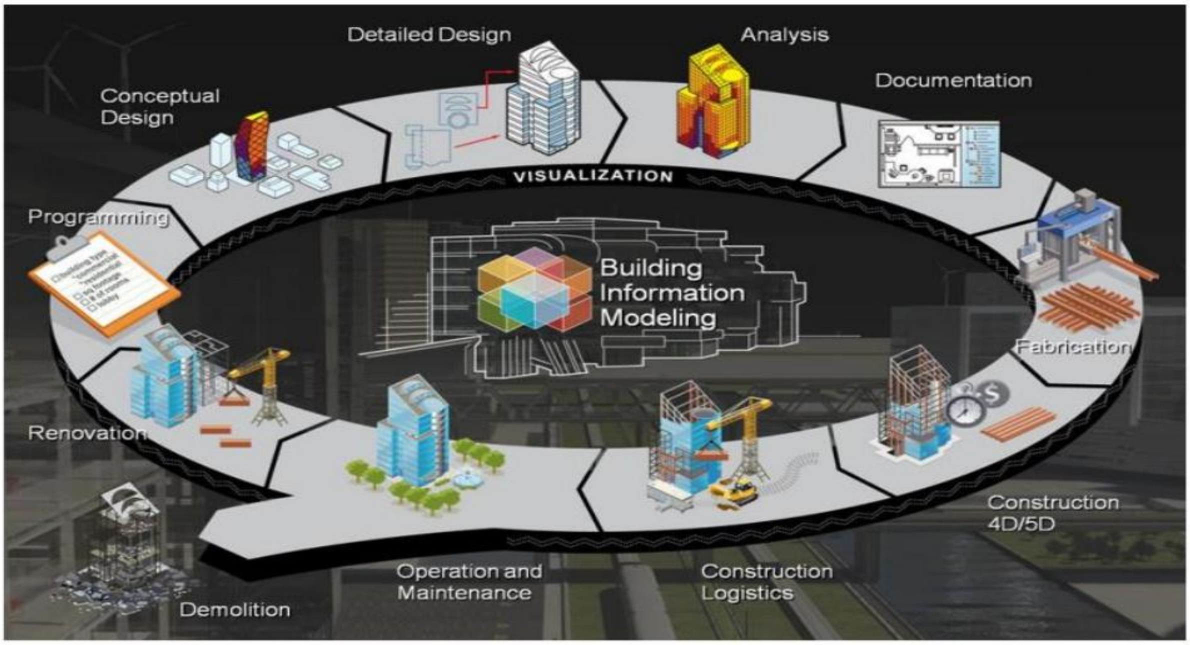

Figure 2.2 BIM Evolution (Chan, 2014)

2.5 MEASURING BIM MATURITY

David (2018) expressed that, study of Building Information Modeling Maturity (BIMM) has prompted by a desire to establish a standardized framework for measuring and following the maturity of Building Information Modeling (BIM). Chen et al. (2016) conducted a study to investigate into BIMM and identify indicators and factors that offer a full understanding of maturity. Chen's research categorizes BIMM into dimensions such as Technology, Information, Process, and People. Subsequently, Succar et al. (2013) expanded upon Chen's work by incorporating Policy as an additional factor within the framework.

The authors listed on table 2.2 have evident from research that Building Information Modeling (BIM) serves as an effective platform for transforming construction practices and documentation to enhance collaboration (James and Meadati, 2008). In practical applications of project, distinguished authors case study has proven that effective project collaboration depends more on individual participants than collaborative organizational structure (Dossick and Neff, 2010). The results underscore its function as a tool for collaboration that promotes output. To encourage information sharing and good teamwork sprit among employee, the necessity of addressing concerns such as software interoperability inside systems and improving project team members' on leadership is essential on BIM maturity.

Table 2.2 Dimensions and Indicators (Y. Chen, 2013)

Dimension	Indicator
Technology (Y. Chen, 2013); (Succar, 2010); (Y. Jung & M. Joo, 2011)	Software Applications
	Interoperability
	Hardware Equipment
	Hardware Upgrade
Information (Y. Chen, Dib, & Cox, 2014);(Computer Integrated Construction, 2011); (National Institute of Building	Information Delivery Method (IDM)
	Information Assurance
	Data Richness
	Real-Time Data
	Information Accuracy
	Graphics
	Geospatial Capability
	Work Flow
	Documentation and Modeling Standards (DMS)
Process (Giel & Issa, 2013); (Gu & London, 2010);(Mom, Tsai, & Hsieh, 2011)	Process & Tech Innovation (PTI)
	Strategic Planning
	Lifecycle Process
	Change Management
	Risk Management
	Specification
People (Y. Chen, 2013);(Computer Integrated Construction, 2013);(Gu &	Senior Leadership
	Role,Reward System
	Competency Profile
	Training Program

2.6 MEASURING PRODUCTIVITY IN CONSTRUCTION BUSINESS

In business of the construction industry, Key Performance Indicators (KPIs) are used for quantifiable actions to measure the performance of an organization, employee, or activity in terms of goal achievement and delivering desired performance (Marr, 2012). Additionally, the author describes that, KPIs provide a clear framework for measuring performance, which allows companies to connect strategic and operational goals with real performance. Regardless of technological innovation and progress, the construction companies continue to struggle with long-standing performance issues like delay, cost overruns, and quality defect (Enshassi et al. 2012). Therefore, implementation strict performance measurement practices in construction projects can significantly enhance overall industry performance.

Table 2.3 Key Performance Indicator Dimensions

Key Performance Indicators (KPIs)	Reasons by Authors
Performance	Provide a clear and objective means of assessing whether an organization is meeting its goals. (Kaplan and Norton, 1996).
Benchmarking	Enable organizations to compare their performance against industry standards or competitors, identifying areas for improvement. (Marr, 2012)
Strategic Planning	Businesses can make informed decisions, set strategic priorities, and allocate resources more effectively. (David, 2015).
Accountability	Establish clear expectations and accountability for employees and teams, fostering a performance-driven culture. (Kaplan and Norton, 1996).

2.7 BIM IMPLEMENTATION PRACTICES AND CHALLENGES IN ORGANIZATIONS

Implementing of Building Information Modeling (BIM) in organizations includes assumption processes and overcoming challenges in order to use digital technologies for managing projects and design. Such important processes include establishing set objectives that are aimed at organizational objectives, investing in training employees about software capabilities, and facilitating collaboration among stakeholders on digital shared platforms (Azhar et al., 2011). Challenges include high software and IT infrastructure costs, resistance to change by employees, and managing complex data with software interoperability issues (Dawood & Sikka, 2013). Legal and contractual matters involving intellectual property and liability also have to address to enable easy implementation (Eastman et al., 2011). Jung and Joo (2011) also proposed an implementation framework as shown in Table 2.4.

Table 2.4 The implementation framework (Jung and Joo, 2011)

Technical	Perspective	Construction Business Function		
Data	Industry	Research	Quality	Estimating
Relation	Organization	General Admin.	Cost control	Design
Standards	Project	Finance	Contracting	Sales
Utilization	Sectors	Human resource	Materials	Planning

2.8 ABOUT EEC COMPANY

The Ethiopian Engineering Corporation (EEC) was established following the union of three well-known companies: Water Works Design and Supervision Enterprise (WWDSE), Construction Design Share Company (CDSC), and Transport Construction Design Share Company (TCDSC), which collectively have played significant roles in planning, researching, designing, and supervising Water and Hydropower, Building and Transport sector projects since 1998, 1977, and 1987 respectively. EEC is a fully integrated engineering consulting and construction firm, structured as six specialist business units covering Water and Energy, Building and Urban development, Transport, Geomechanics, Construction, and Underground Works. The corporation's broad range of services has augmented by two high-technology centers: one housing advanced laboratory and research facilities, and the second in surveying, geospatial, and civil informatics.

EEC maintains excellence and sustainability with attention to knowledge creation and delivery of sustainable engineering solutions not only delivery of sustainable engineering solutions not only in Ethiopia but also the whole of Africa. Organizational framework is uniquely built to cater diverse client requirements with a broad range of engineering services in main segments such as Water and Energy, Transport, Building and Urban development, Geotechnical Investigation, Geotechnical Engineering, Underground Construction, supported by specialized Research, Laboratory, Training, Surveying, Geospatial, and Civil Informatics centers. This integrated strategy puts EEC in the optimum position to deal with evolving client requirements while sticking to engineering superiority and sustainability. Services of the company range very wide covering Water Supply Engineering, Environmental Engineering, Dam and Hydraulic

Engineering, Hydropower Development, and Renewable Energy Sources Development, and others with special expertise in groundwater exploration, hydrogeological mapping, and geophysical investigations.

Additionally, EEC provides consultancy services in Renewable Energy and Hydropower Development in the shape of micro-mini hydropower schemes and diversification into renewable energy schemes such as geothermal, wind, solar, and bio-fuel energy. State-of-the-art scientific equipment like drone surveys, GPS technology, and computer-aided design programs are used in the company's surveys, while geotechnical and geophysical investigation services employ state-of-the-art equipment to conduct hydrogeological and geophysical investigations. This general structure highlights EEC's commitment to delivering innovative and sustainable engineering solutions to a broad range of industries and project types.

2.9 RESEARCH GAP

A Literature review has also placed on center stage some of the gaps between BIM performance measures and maturity by renowned scholars. The most obvious gap in research is the absence of research on BIM at local levels, primarily in developing countries like Ethiopia. There is also a need for empirical research to examine the implications of BIM implementations and digital transformation strategies in various industries. It is necessary to research the specific issues, successes, and adjustments in relation to the construction industry context in order to develop effective and robust strategies according to the unique needs of the country.
On the aspects of human capital, training, and long-term impacts, there seems to be a gap in research evidence regarding the status of digital literacy, the capability for using BIM and other digital technologies of the workforce across various construction industries. Efficiency of training programs in equipping the workers with necessary skills for these technologies is another area that calls for further research. Finally, there is a lack of longitudinal research into the long-term effects of BIM and digital transformation upon the project outcomes and overall organizational performance.

CHAPTER 3

MATERIAL AND METHODS

3.1 RESEARCH DESIGN

Descriptive cross-sectional study design has employed in the study to analyze captioned specific objectives on set of BIM maturity with key performance indicator between sectors of EEC organization. Cross-sectional study design is of very significant importance in various sectors like, Transport, urban building, Construction, Water and Energy, Research and Laboratory Center, Geotechnical, and Survey. In addition, Cross-sectional studies help to assess various projects within well-known geographical locations by taking a complete image of present conditions and making comparisons between various areas at a particular time (Zuleika, P., & Legiran, 2022. The method is cost-friendly and timesaving, which is perfect for researcher conducted on organizations with limited budgets and facilitates timely decision-making. The research utilized a mixed-methods approach that involved both qualitative research methods. Qualitative methods allow researchers to explore and learn more about the complexities within a phenomenon (Smith, 2009).

The mixed methods approach to research adds to, rather than replaces, quantitative and qualitative methods, which are still important and useful (Johnson & Onwuegbuzie, 2004). Researchers using mixed methods try to use the best parts of both approaches while avoiding their weaknesses. The strengths and weaknesses of these methods can change depending on the context, how researchers study the topic.

Qualitative research described as a flexible approach that happens in a natural setting, allowing the researcher to gain detailed insights from being closely involved in the real experiences (Creswell, 1994). A key feature of qualitative research is studying social events from the participant's perspective. Williams (2007) states that, Qualitative research operates within a post-structural framework. It includes five main types: case study, which involves in-depth analysis of one or more cases; ethnography, which provides a detailed examination of people and cultures; phenomenology, which focuses on individuals' lived experiences; grounded theory, which develops theories from collected data; and content analysis, which analyzes textual or visual content. These approaches rely on inductive reasoning, allowing theories and patterns to emerge from the data. Besides, it is based on inductive reasoning, where observations lead to questions and explanations. Unlike quantitative research, where the researcher remains detached, qualitative research involves a close relationship between the observer and the data Leedy, P., and Ormrod, J. (2001).

Thus, in light of the mixed-method approach to research, both qualitative and quantitative approaches are necessary to enrich research methodologies (Apuke 2017). Qualitative data has acquired by in-depth interviews of focused group discussions, thematic analyses, and perspectives from key professionals, Managerial experts, and practitioners within the EEC organizations as preliminary for developing quantitative methods. Triangulation of these approaches allowed the researchers to achieve comprehensive information on the study subject, in-depth and breadth. Quantitative methods, with the facilitation of SPSS, R-soft, and Sigma Plot tools, gave a clear, scientific view of the respondents' opinions through structured questionnaires and statistical analysis.

3.2 SOURCE OF DATA

The study gathered data from both primary and secondary sources. Primary data were directly obtained from respondents through questionnaires and interviews. These methods involved interacting with individuals to gather firsthand information relevant to the study's objectives. On the other hand, secondary data were collect by reviewing related literature, as well as other published and unpublished materials that provided additional context and background information for the research (Bryman, 2016). The mentioned approach enabled the study to draw upon existing knowledge and insights while also capturing fresh perspectives and responses from the participants directly involved.

3.3 STUDY AREA

The author has chosen Ethiopian Engineering Corporation, which is located in Addis Ababa, Ethiopia, and particularly found in Bole Sub City, Woreda 08, along the Megenagna-Bole Road around Gerji. The Selection criteria were on basis of centrality to the study and relevance to it. A unique condition for sectors merging can permit the direct accessing to observation and analysis of this area by advantage of the nature of the creation, formed through a merge of three elite agencies, which include the WWDSE or Water Works Design and Supervision Enterprise, CDSC or Construction Design Share Company, and the Transport Construction Design Share Company (TCDSC). Collectively, these organizations have performed major involvements in the planning, design, and supervision of projects in the water and hydropower, building and transport sectors since their establishment in 1998, 1977, and 1987, respectively.

EEC has six-professional business units, one construction sector integrated engineering consulting, and Construction Company founded in 2024. Its professional business units include Water and Energy, Building and Urban Development, Transport, Geotechnical, and Underground Works. Two more centers that are advanced were established to extend the broad service portfolio of the corporation, one house laboratory and research facilities, while the other houses surveying, geospatial and civil informatics specializations (EEC strategy plan, 2024).

3.4 STUDY POPULATION

The total population of professionals in the Ethiopian Engineering Corporation (EEC), encompassing the head office, six sectors, and construction unit, which constitutes the study's total population, has 50 staff as shown table below. Detailed information on the staff arrangement and the organizational structure of EEC can be found in Annex I. The annex provides an in-depth look at the distribution of employees across various departments and the hierarchical framework within the corporation.

Table 3.1 Study Population at Ethiopian Engineering Corporation (EEC, 2024)

Department EEC	BIM Trained Staff	Target BIM Professionals
Corporate Head Office	13	5
Water and Energy Sector	14	8
Transport Sector	14	5
Building and urban plan Sector	9	5
Geotechnical and Investigation Sector	11	5
Research, Laboratory and Training Center	12	5
Surveying and Civil Informatics Centre	8	4
Construction Sector	21	13
Grand Total	102	50

3.5 SAMPLING TECHNIQUES AND SAMPLE SIZE DETERMINATION

3.5.1 Sampling Techniques

A Non - probability purposive sampling techniques were used for this case study. The author applies a purposive type of probability sampling to accomplish the intention of this study effectively. Non-probability purposive sampling has applied in cases where research focuses on an in-depth understanding of an issue, phenomenon, or population rather than generalization of findings to a whole population (Etikan et al. 2016). Again, the purposive sampling method has greatly applied in research when the research involves in-depth case studies of particular organizations, events, as well as individuals that provide rich, contextualized insights, such as investigating a specific company's organizational culture. As argued by Yin (2018), in the case of case study research, it becomes relevant to select the cases strategically so that they can light up the research questions. Purposive sampling ensures that the selected cases or individuals are not chosen randomly but through targeted selection based on predetermined criteria, aimed at blending with the set objectives of the research for better depth and good quality of the findings.

Hence, collecting data from the entire stratified population solely has impossible, costly, and time-consuming due to the extensive range of projects, from small-scale to mega projects that spread across the country. Against the mentioned constraints, the purposive sampling technique has chosen in comply with stratified sampling based on availability time and resources. The methods allowed selecting relevant and reliable information since it focused on specific groups or professionals in the organization.

The top managers, supporting staffs, design engineers, architects, construction staff, researchers, quality control staff, project managers, contract administration staff, site supervisors, electro-mechanical engineers, information technology staff, human resources personnel, facility managers, BIM modelers, innovation design centers, laboratory control managers and finance officers are the respondents sampled for this study.

3.5.2 Sample Size Determinations

The sample size determination for EEC case study of population is based on disproportional purposive groups mentioned in section 3.4. The sectors of known figures of professionals has used for this research accordingly. The research focuses concerned groups who have technical background and direct relation on digital transformation technology with BIM adaptive potential.

Table 3.2 proportions of sample with in EEC

Department EEC	Proportion of the study population	Percent
Corporate Head Office	5	10%
Water and Energy Sector	8	16%
Transport Sector	5	10%
Building and urban plan Sector	5	10%
Geotechnical and Investigation	5	10%
Research, Laboratory and Training Center	5	10%
Surveying and Civil Informatics Centre	4	8%
Construction Sector	13	26%
Total	50	100%

3.6 DEVELOPING BIM MATURITY MATRIX

The BIM maturity is a method whereby the extent and effectiveness of the implementation of BIM at either the organization or project level appraised. It serves to identify the existing capability, underlines further areas for improvement, and informs strategic development. Maturity levels refer to specific stages in the adoption of BIM, indicating how far and integrated BIM practices have been within the organization.

Over time, the development of a BIM maturity matrix has developed and matured to identify and include several key factors. One such study The Development of a Multifunctional BIM Maturity Model. Liang et al. (2016) recognizes four factors as by Chen and Succar (2016) adds a fifth, being protocol. Khosrowshahi et al 2016 acknowledged the critical factors to actualize BIM as technology, process, and people. In accordance to the authors Liang et al. (2016), the managerial aspects of BIM and found product, application approach, and work environment, besides technology, information, process, and people, as the key factors for BIM maturity. Process factor observed as the most important factor in the managerial context of BIM within their study.

3.6.1 Defining the Stages of BIM Implementation and Integration

Drawn from Eastman et al (2008), maturity levels for BIM adoption provide a systematic mechanism to quantify progress and integration of BIM applications in organizations. The levels of maturity are a systematic framework and give an impression of the aptitude and ability of an organization in the useful application of BIM technologies. They enable stakeholders to quantify the evolution of BIM uptake from the initial stages of awareness to more sophisticated stages of integration and optimization, thereby facilitating better project management and collaboration. Each stage is a unique stage of development, from basic awareness and initial use to full integration and optimization.

3.6.2 Assessment Criteria Identifying Specific Dimensions for Evaluation

Assessment criteria are the certain factors or dimensions put into consideration while assessing the BIM maturity of an organization. Succar (2012) describes these as the fundamental factors or dimensions that used in the correct measurement of an organization's BIM maturity. Most of BIMM criteria have carrying out a complete assessment across various aspects of BIM implementation at the organization. These include Strategy and Leadership, Processes and Standards, Technology and Infrastructure, People and Culture, Data and Information Management, Project Delivery, and Lifecycle. Since the captioned factors address many dimensions, criteria review is comprehensive and covers all the extensive usages of BIM in a multi-stage implementation process.

3.6.3 Scoring System: Quantifying the Implementation Levels

The scoring system is a procedure used for giving a numerical value for assessing maturity of BIM adoption in an organization, and it provides the BIM maturity status of an organization in numerical value. It converts qualitative assessments into quantitative scores that give the ability to compare and analyze easily in various dimensions of BIM implementation Eastman et al (2008). It has typically based on a numerical scale; for example, from one to five, where each number represents a different maturity level. For instance, a rating of one may be defined as the initial or ad hoc use of BIM, while rating 5 stands for optimized and fully integrated BIM in all organizational processes and phases of the projects. These types of scores will better reflect an organization's progress to achieve BIM maturity and will assist in making proper strategic decisions with regard to going further to improve the BIM capabilities.

3.7 DEVELOPING CONSTRUCTION PERFORMANCE MATRIX

Measurement defines the process through which the magnitude of actions effectively and efficiently performed has quantified. For instance, such a system has to facilitate comprehensive assessments, draw understanding that can be used, and outline problems so that judgments about predefined criteria are possible, as identified by (Neely, 2005). These processes significantly developed with the presence of KPIs. The Public Record Office Victoria, 2010 provides that KPIs are quantitative and qualitative measures that used to denote the performances of an organization concerning the efforts toward the goals. These indicators are then reduced to specific targets for both departments and individuals and are reviewed periodically to keep it in tune with the objectives.

In the UK, the working groups on KPIs have recognized ten key parameters for benchmarking projects, as highlighted by Takin and Akintoye, 2002 in response to Egan's report, 1998. These summarized in the Rethinking Construction model, construction cost, construction time, predictability of cost and time, client satisfaction with the product and service, defects, productivity, profitability, and safety. Result-oriented thinking is encouraged by indicators including construction cost and time, defects, client satisfaction, profitability, and productivity. On the contrary, process-oriented thinking has related to the predictability of design cost and time, construction cost and time, and safety.

Construction performance measurement refers to the measurement of productivity based on several dimensions including safety, cost, time, quality, environment, communication, functionality, and satisfying clients. According to Yeung et al. (2013), there is consistency between these studies in the documentation of KPIs that include measurements for cost, time, safety, and satisfaction as well as predictability of these factors. For instance, in 2002, another study acknowledged the following factors contributing to productivity risk, status of the project, effectiveness of decision-making, production, effectiveness of cost, customer commitment, stakeholder involvement, and management of project (Pillai et al 2002). All these performance indicators have maintained in recent literature, showing the strong consistency of factors considered important to construction productivity.

In 1999, the UK working group formalized the concept of KPIs within the construction industry. A model that had proposed in the 1998 Egan Report titled "Rethinking Construction." These Headline KPIs were a way to measure and drive improvement within the industry; they have undergone continuous revision in keeping with on-going development of the same, annually (Swan, 2004). Table below shows the general KPI matrix adopted with some update developed by David 2018, highlighting the key factors, indicators, and attributes necessary for the construction performance evaluation. Hence, the author used as a major contribution to the field, with detailed assessment of ways in which productivity can improve within Ethiopian Engineering Corporation case study.

Table 3.3 Key Performance Matrix

<table>
<tr><th>Factors</th><th>Indicators</th><th>Attributes</th><th>References</th></tr>
<tr><td rowspan="8">KPI

(Result oriented)</td><td>Cost Goal</td><td>Meet target budget</td><td rowspan="3">(Mincks & Johnston, 2003), (Nitithamyong & Skibniewski, 2006), (Gattorna & Walters, 1996),</td></tr>
<tr><td>Schedule</td><td>Meet schedule goal</td></tr>
<tr><td rowspan="2">Quality</td><td>Meet quality specification</td></tr>
<tr><td>Total number of Change Orders, Cost and Punch items</td><td>(Cox et al., 2003)</td></tr>
<tr><td>Safety</td><td>Meet safety goal</td><td>(Nitithamyong 2006)</td></tr>
<tr><td rowspan="2">Customer Satisfaction</td><td>Improve customers’ satisfaction</td><td>(Mincks & Johnston, 2003)</td></tr>
<tr><td>Decrease total number of legal claims and litigations, Increase number of repeat customers</td><td>(Ng et al., 2002)</td></tr>
<tr><td rowspan="16">KPI

(Process oriented)</td><td rowspan="2">Communication Management</td><td>Timely and appropriate generation, collection, distribution, storage, retrieval, and disposition of project information)</td><td>(PMI, 2008)</td></tr>
<tr><td>Communication Frequency, Effectiveness, Method, tools</td><td>(Ng et al., 2002), (Naoum, 2003)</td></tr>
<tr><td rowspan="2">Resource Management</td><td>Material Management</td><td>(Cox et al., 2003),</td></tr>
<tr><td>Subcontractor Management</td><td>(Mincks & Johnston, 2003)</td></tr>
<tr><td rowspan="2">Cost Management</td><td>Earlier detection and design error of problems</td><td>(Nitithamyong & Skibniewski, 2006)</td></tr>
<tr><td>Effective Cost Management (Definition: Planning, estimating, budgeting, and controlling costs)</td><td>(PMI, 2008), (P. S. P. Wong & Cheung, 2005),</td></tr>
<tr><td>Schedule Control</td><td>Total number of RFI during preconstruction</td><td>(Naoum, 2003)</td></tr>
<tr><td rowspan="2">Quality</td><td>Total number of RFI during construction</td><td>(PMI, 2008)</td></tr>
<tr><td>Joint Solutions</td><td>(Cox, 2009)</td></tr>
<tr><td>Safety Management</td><td>Effective Safety Management (Plan, implementation, evaluation, and management)</td><td>(P. S. P. Wong & Cheung, 2005)</td></tr>
<tr><td rowspan="4">Management Human Resource</td><td>Effective Leadership</td><td>(Cox, 2009)</td></tr>
<tr><td>Effective coordination of stakeholders</td><td>(PMI, 2008)</td></tr>
<tr><td>Improve decision-making process</td><td>(Ng et al., 2002)</td></tr>
<tr><td>Scope Clarification</td><td>(PMI, 2008)</td></tr>
</table>

3.8 DATA COLLECTION METHODS

In this case study, the methods include a literature review to study existing studies, reports, and documentation on the implementation of BIM in the construction sector of Ethiopia. Second, a survey has developed and collected which administered to the Ethiopian Engineering Corporation stakeholders in order to get information about understanding BIM adoption, challenges, and perceived benefits among the concerned target group. Structured interviews and focus group discussions with key stakeholders, including professional members from EEC practitioners, conducted further explore their experiences and perspectives.

The interviews were sequential in nature to ensure that there was comprehensive data collection and analyses. The first phase included the general purpose of the interview that stated to the respondents to understand the practices and perceptions concerning the application of BIM in the construction business. During the second stage, semi-structured questions with open and closed-ended formats drafted to elicit relevant and detailed responses that aligned with the research objectives. In the third stage, framing of specific case study questions has done regarding the evaluation of BIM maturity and KPIs within the organization. Finally, in the fourth stage, targeting design, construction supervision, and business sectors has done with a view to understanding what their roles have been in BIM implementation and integration.

3.8.1 Questionnaire

The research survey was starts with the collection of the basic demographic data of the respondents that will give background information on them. The level of awareness and understanding of the concept of digital transformation, inclusive of BIM, among stakeholders, and their perception in respect of importance and impact on project outcomes. The questionnaire identifies some of the perceived issues and challenges to successful implementation, including organizational willingness, resource constraints, technological issues, and outright resistance to change. It also ascertains the outlook on digital transformation into the future at EEC, hence gathering both desired outcomes and opportunities in relation to enhanced integration. The survey proceeds to map the perceptions of stakeholders regarding how effective the current strategies of implementation are in terms of project efficiency, improving collaboration, and general impacts on performance. Finally, there is an opportunity for the respondents to give any open-ended feedback, comments, suggestions, or concerns with regard to digital transformation and its implementation.

3.9 METHOD OF DATA ANALYSIS AND REPRESENTATION

3.9.1 Qualitative

The process involved cross-referencing interview responses with questionnaire data to ensure consistency and comprehensiveness, as suggested by Creswell and Plano Clark (2018). This approach provided a strong foundation for triangulating findings and validating data collected from multiple sources, aligning with the recommendations of Yin (2018) for strong case study research. Key themes and patterns identified through a detailed review, enabling a thorough understanding of the underlying issues and insights, consistent with Braun and Clarke’s (2006) thematic analysis framework. The concept note that guided this process emphasized the importance of integrating qualitative and quantitative methods, as highlighted by Bryman (2006), to capture a holistic view of the challenges, practices, and perceptions surrounding BIM implementation in Ethiopia’s construction industry.

3.9.2 Quantitative

The interviews cross-referenced with the results from the questionnaire has done as suggested by Creswell and Plano Clark (2018), to make sure that information would be consistent and complete. This allowed creating a reliable basis for triangulating findings and allowing validation of data against data acquired through different sources, following the recommendations for good case study research by Yin (2018). Detailed review of data acceptable for the identification of key subjects and patterns that highlighted an in-depth understanding of the underlying issues and insights, as suggested framework by (Braun and Clarke's 2006).

3.10 ETHICAL CONSIDERATIONS

Ethical considerations form an integral part of this study, with several basic principles revolving around it. Confidentiality and privacy of the feedback of participants is the foremost consideration. This involves maintenance of confidentiality and identity of subjects taking part in the study.

CHAPTER 4

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 BACKGROUND

The chapter focuses analysis and interpretation of data that collected for study titled and the objectives outlined in the preceding chapters. The main objective of this analysis was to investigate the important factors that would influence the implementation of BIM within an organization for efficiency, effective collaboration, and decision-making.

Again, the key factors influencing the willingness for BIM adoption and its impacts on performance analyzed through descriptive statistical techniques. It covers demographic data regarding employee status, education, professional experience, proficiency in BIM, and project delivery methods to pinpoint systemic challenges and enablers related to BIM implementation. Besides the study, measurements of the fit of organizational culture, technological capacity, and project management practices regarding BIM principles.

4.2 DEMOGRAPHIC PROFILE OF RESPONDENTS

The authors were distribute questionnaires, and from given out to 50 employees in the study; the response rate is 100%. The critical dimensions the analysis includes targeted EEC employee demographics, educational background, professional experience, BIM exposure, key performance indicator and the usage of project delivery methods. The above variables show an overview of disposition and obstacles regarding adopting BIM and attain the chances towards optimized BIM implementation in the EEC organization. Moreover, this section provides the base for understanding the dynamics of BIM adoption in the Ethiopian Engineering Corporation, pointing out areas that need improvement and providing strategic opportunities toward better technological integration and operational efficiency. The demographic results has shown in the table below, derived from the SPSS V.26 output, and give an overview of the characteristics of the respondents and their relevance to the study objectives.

Table 4.1 Demographic Profile of Respondents

Variables		Frequency	Percent
Age	Above 50	5	10
	42-49	10	20
	34-41	14	28
	26-33	18	36
	18-25	3	6
Total		*50*	*100*
Gender	Female	19	38
	Male	31	62
Total		*50*	*100*
Highest Education	Master Degree	26	52
	First Degree	24	48
Total		*50*	*100*
Work Experience	Above 16 Years	9	18
	9 – 15 Years	13	26
	4 – 8 Years	16	32
	1 – 3 Years	12	24
Total		*50*	*100*
Worked with BIM in Years	15 Years < Y	1	2
	8 < Y ≤ 15 Years	14	28
	3 < Y ≤ 8 Years	3	6
	1 < Y ≤ 3 Years	25	50
	None	7	14
Total		*50*	*100*
Project Delivery - BIM	Integrated Project Delivery (IPD)	9	18
	Design-Build (DB)	15	30
	Construction Management (CM) Agency	7	14
	Construction Management (CM) at Risk	7	14
	Design-Bid-Build (DBB)	12	24
Total		*50*	*100*

Source: SPSS output V.26

As Results in Table 4.1 have shown that, the demographic characteristics of the respondents expressed as young, with 64% falling within the 26-41 age bracket, while only 10% are above 50 that indicates dynamic and adaptable environment has avail in EEC, but may be challenging in intergenerational knowledge transfer. The male employee are more compare to female at 62%, showing a gender difference typical in the construction and engineering sectors. Hence, the result shows a diversified management position needs to provide a greater sense of inclusions and multiple viewpoints within the organization.

In terms of education, 52% of the participants reported having a Master's degree level, thus highly educated and therefore well equipped for the adoption of complex systems such as BIM. Work experience information discloses that a majority of the employees fall in the 4-8-year bracket at 32%, followed by the 9-15-year bracket with 26%. Consequently, there are fewer senior employees with over 16 years of experience at 18%. This distribution reflects a mid-level workforce, which would want more experience in mentorship for effective technology adoption.

BIM is a relatively new experience for the employees as indicates where 50% of the respondents have between 1 and 3 years of experience, and 14% have no BIM experience. Only 2% have worked with BIM for more than 15 years. In general, the target on BIM implementation for effective training and up skilling acquires many initiatives. Regarding project delivery methods, 30% use Design-Build, 24% Design-Bid-Build, while Integrated Project Delivery stands at 18%, showing the emergence of adoption of collaborative strategies in line with BIM principles.

4.3 RELIABILITY TEST

Reliability indicates how consistency and dependability on particular concept measures and is considered to be the quality of the measure for the overall quality of the measure. Sekaran, 2016 argues that, Cronbach's Alpha coefficients have calculated in testing for reliability for items of each construct, as shown in Table 4.2. Sekaran and Bougie, 2016 provide that, a value of Cronbach's Alpha score below 0.60 is poor, around 0.70 is acceptable, and while above 0.80 rated as good. The reliability analysis in the study result shows high reliability of all constructs, which is the strength of the measurement instrument.

Table 4.2 Results of Cranach alpha

Variables	Number of Items	Cranach’s Alpha Value
BIM Maturity	20	.932
Key Performance Indicator	25	.945

Source: SPSS output V.26

The reliability analysis of the questionnaire shows high internal consistency of the variables under measurement. The 20-item BIM Maturity scale was found to have a Cronbach's Alpha of 0.932, which is an indicator of excellent reliability. This shows that the items in this construct are strongly correlated and always measure to what extent BIM implementation maturity exists. Similarly, the 25-item Key Performance Indicator (KPI) scale recorded a Cronbach's Alpha of 0.945, also showing excellent reliability. These results confirm the questionnaire as a strong and reliable instrument for assessing the practice implementation of BIM and its impact on project performance in the Ethiopian Engineering Corporation (EEC). These high reliability coefficients make the measuring instrument reliable for decision-making and subsequent analysis.

4.4 KEY PERFORMANCE INDICATOR DESCRIPTIVE RESULTS ACROSS SECTORS

Descriptive statistical analysis provides valuable insights into respondents' perceptions of BIM Maturity, Key Performance Indicators (KPIs), within the company. Using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), respondents indicated their level of agreement with various statements.

The author adopt mean and standard deviation used for this research analysis to explain the relationship of BIM maturity and key performance indicator among sectors and their impacts on implementation. For instance, the average level of agreement was determined as the mean for every dimension. In this case, a higher value means stronger agreements while a lower one means greater disagreements. In addition, according to SPSS V.26, the standard deviation has taken to be a measure of distribution in response. When the standard deviation is high, the respondents have wide differences in opinion, whereas small standard deviation represents lesser variation in the opinions of the respondents (Hair et al., 2004).

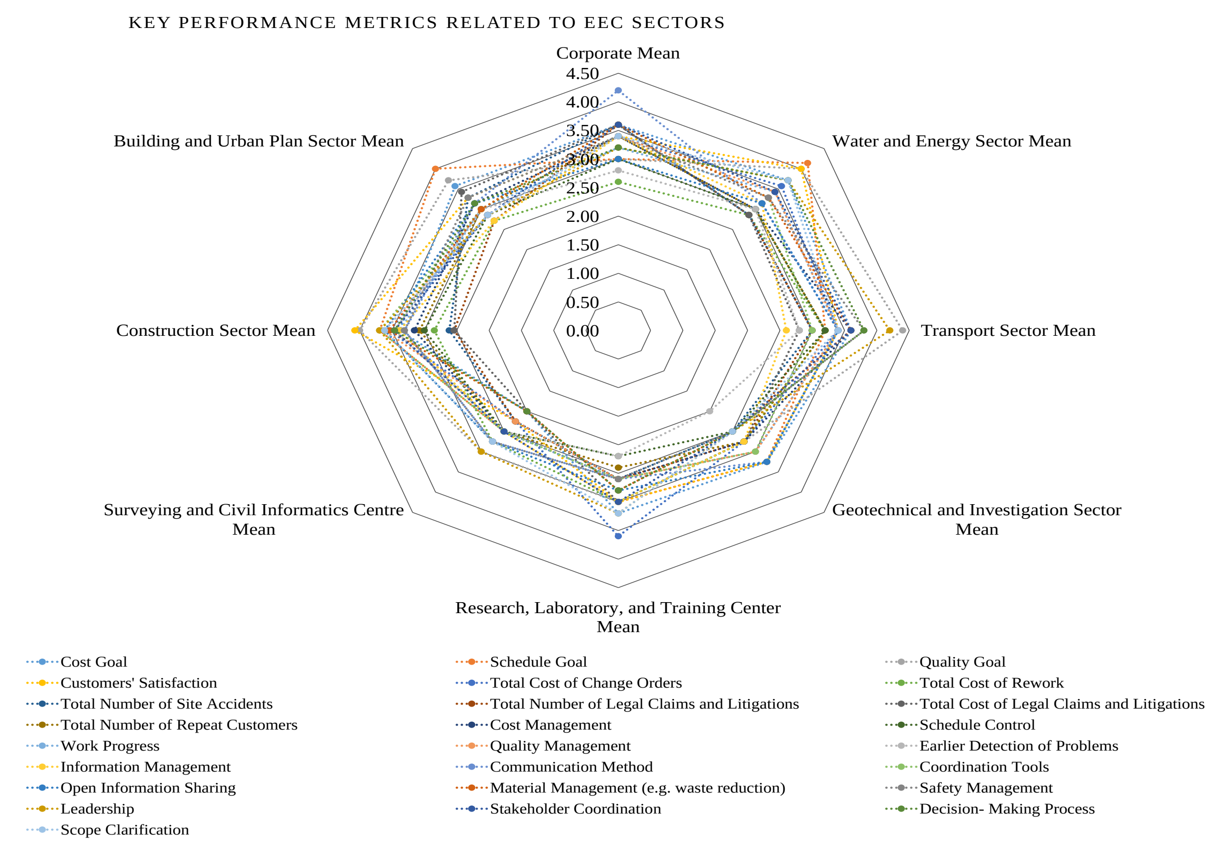

Figure 4.1 Descriptive Results for Key Performance Indicator (SPSS output V.26)

The survey findings presented in the paper indicate that EEC does well in certain key performance indicators with in sectors and it has challenged by others infrastructure provision that needed attention to improve project delivery and overall performance. Similarly, the sector-wise performance of BIM-related KPIs highlights those areas that require improvement in cost management, schedule management, safety, and risk mitigation. The results and discussion have shown below.

The Water and Energy Sector has good standing in cost management (mean = 3.71) and leadership (mean = 3.71), in which it reflects a strong financial control and leadership practices. However, the sector's performance in accident reduction was value of (mean = 2.25) and schedule management (mean = 3.00). Both results have highlight areas where further attention is required to meet safety standards and project timelines (Kerzner, 2017). In addition, relatively high standard deviation in cost goal, 1.34, signals inconsistency in financial performance; while some projects meet cost targets, others do not, indicating the need for better tracking and reporting of finances in BIM implementation (Ding et al., 2020).

The Transport Sector also achieves remarkably well in schedule goals (mean = 4.14) and quality goals (mean = 4.40), replicating effective in project time as well as quality management (Hwang et al., 2017). However, the aforementioned challenges remain in cost management (mean = 3.00) and safety management (mean = 3.29), which are central for successful BIM integration in large-scale infrastructure projects (Cheng et al., 2014). Actually, the low standard deviation in quality goal (0.00) shows a uniform approach to quality management, indicating that quality standards are consistently encountered as discussed (Kassem et al., 2017).

The Geotechnical and Investigation Sector achieves well in cost goals (mean = 3.60) and work progress (mean = 3.40) as like of water and energy sectors, but faces a problem in information management (mean = 2.60) and early detection of problems (mean = 2.80). The result indicates that early detection of problems and better management of data with BIM are the two major reasons for the successful completion of a project (Azhar, 2011). The high standard deviation in cost target of 1.34 depicts that the projects have variation in cost management; hence, the need for better cost estimating techniques and consistency in financial performance is required (Eastman et al., 2011)

The mean for the Research, Laboratory, and Training Center regarding communication is very high (mean = 4.20), which is important for the successful implementation of BIM since effective communication is considered a critical success factor (Wong et al., 2013). At the same time, some challenges have been identified, such as providing leadership (mean = 2.86) and managing legal costs (mean = 2.75), in which further development is required for effective project management to lower legal risks (Kim et al., 2015). The leadership is less dispersed; it is 0.49, which indicates that there is some consistency in the leadership style but perhaps not good enough to ensure BIM adoption (Khosrowshahi and Arayici, 2012).

The Surveying and Civil Informatics Centre shows strengths in coordination tools (mean = 3.69) and cost goals (mean = 3.60), indicating effective use of technology for project coordination and financial management (Hammad et al., 2011). However, challenges in customer retention (mean = 2.50) and risk management (mean = 2.75) suggest that strategies to improve customer satisfaction and mitigate project risks need strengthening (Azhar et al., 2015). Variations in some KPIs from project to project indicate inconsistency in results, and that requires standardized practices and better project execution.

The Construction Sector has well in schedule goals, with a mean of 4.00 and quality goals with a mean of 4.00. Whereas, risk management with a mean of 2.75 and reward systems with a mean of 2.50 are indicators for construction sector as considering most problematic issues. Hence requiring enhancement of risk mitigation mechanisms, and employees' incentives provision is acquired as previous authors have described, for instance, (Liu et al., 2016). The moderate standard deviation across the KPIs indicates mixed evidence of successful versus challenged projects that need further scrutiny and enhancement.

At the end, Building and Urban Planning Sector had strong performance for communication with a mean of 3.31 and information management with a mean of 3.38, showing that communication and data management are very important regarding BIM success, supporting the concept done previously by Elbeltagi et al., 2014. However, issues within reward systems value of mean = 2.50, and quality management mean = 2.86, emphasize the need for further strategies in order to motivate employees and enhance quality control within the sector.

4.5 DESCRIPTIVE RESULTS ON BIM MATURITY ACROSS SECTORS

The descriptive statistics provide a valuable insight into Building Information Modeling Maturity (BIMM) across various areas of the Ethiopian Engineering Corporation (EEC). The Corporate Sector, Water and Energy Sector, Transport Sector, Geotechnical and Investigation Sector, Research, Laboratory, and Training Center, and Construction, and Building Sector are all studied with specific reference to the most significant BIM maturity characteristics such as software applications, hardware equipment, means of information delivery, and strategic planning. The results display various levels of BIM maturity in industries with strengths and weaker points in each industry. All the descriptive SPSS table findings displayed in appendix I.

On a descriptive performance scale, the top-scoring characteristic for the Corporate Sector is Process and Technology Innovation (Mean = 4.00, Rank = 1), indicating the sector's ability to use innovative processes and technologies as per BIM standards. These are in line with those of previous writers, for instance, with Succar's (2009) BIM Maturity Model, and its emphasis on process innovation as a primary driving force for the attainment of higher levels of BIM maturity. Standard Operating Process (Mean = 3.80) and Information Assurance (Mean = 3.80) are also indicative of the industry's development in formalized workflows and safe data handling, which are key to advanced BIM implementation. Yet poor Reward System (Mean = 2.60) indicates one needs to inspire and stimulate workers, an aspect key to efficient BIM practice (Sebastian and van Berlo, 2010).

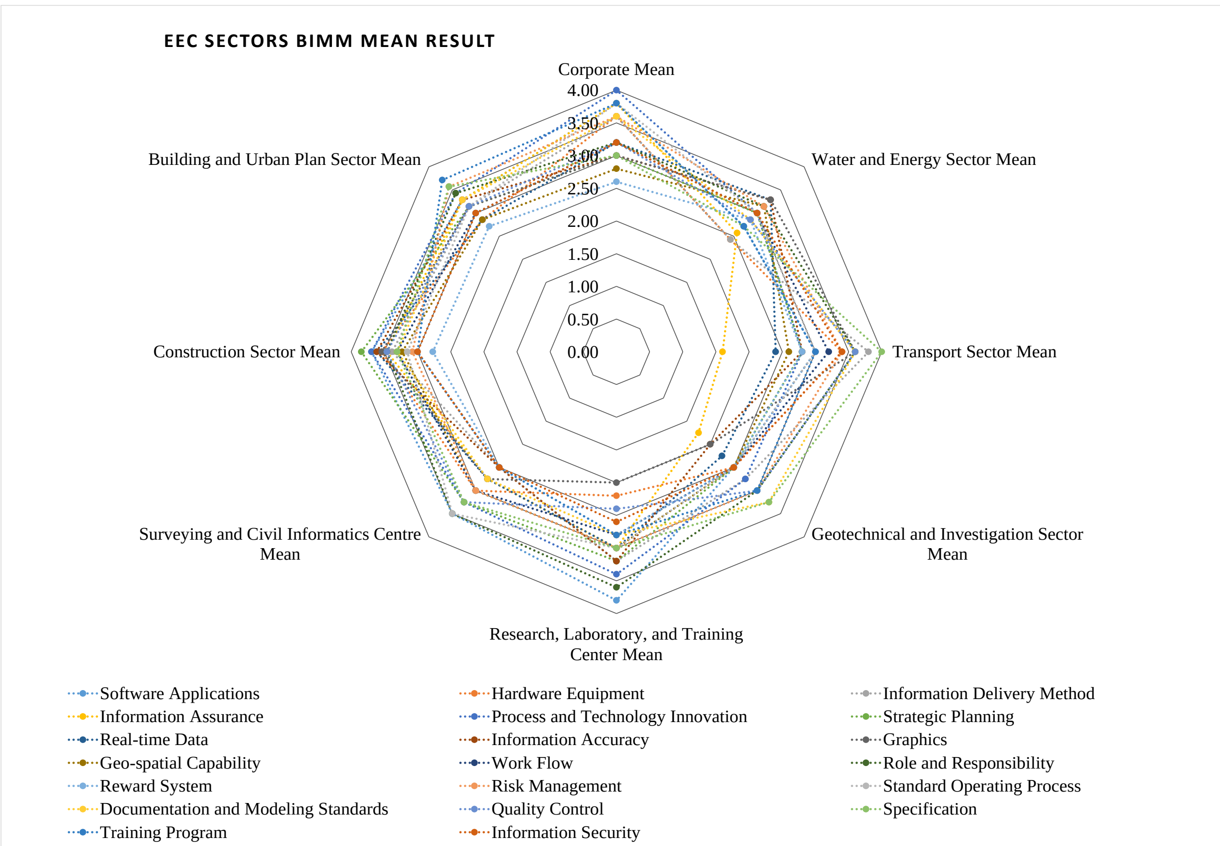

Figure 4.2 Descriptive Results for BIM maturity (SPSS output V26)

The Water and Energy Sector shows strengths in Real-time Data, Information Accuracy, and Graphics (Mean = 3.29, Rank = 1), which highlight the sector’s potential for influence BIM capabilities in managing dynamic and accurate information. However, the sector struggles with Hardware Equipment (Mean = 2.43, Rank = 19) and Information Assurance (Mean = 2.57, Rank = 18), suggesting limitations in infrastructure and data security. According to Volk et al. (2014), strong IT infrastructure and secure data management are foundational for achieving higher BIM maturity levels. Addressing these gaps will be critical for the sector's progress.

In the Transport Sector, Specification scores the highest (Mean = 4.00, Rank = 1), indicating strong commitment to BIM standards for design and construction documentation. This is in line with ISO 19650, which has made it clear that there is a need for information management within the BIM environment. Other attributes such as Documentation and Modeling Standards, Role, and Responsibility are also rated well, thus enabling the sector to follow Level 2 maturity practices in BIM. However, Real-time Data, (Mean = 2.40, Rank = 19) scored below level, an indication of improving data integration that is accessible and important for running BIM collaboratively as explained by Eastman et al., 2011.

The Geotechnical and Investigation Sector has strengths in Documentation and Modeling Standards and Specification, (Mean = 3.25, Rank = 1). That would support the assumed that, there is more implementation of standardized processes for the documentation of BIM, and such is expected for interoperability and collaboration. The sector is very weak in Information Assurance (mean = 1.75 and ranking = 20) that showing a high level of insecurity about data and how such information could be reliable. With increased BIM maturity, data accuracy is becoming more crucial to minimize errors and ensure better project outcomes (Redmond et al., 2012).

The Research, Laboratory, and Training Center is strongest in Software Applications (Mean = 3.80, Rank = 1), showing effective utilization of the BIM tools in modeling and analysis. This agrees with the findings of Azhar (2011), which known software proficiency as one of the key enablers of higher BIM maturity levels. It runs a good Role and Responsibility Clarity, with a mean of 3.60, an essential attribute at Level 2 BIM implementation. Improvement attributes are Graphics, (mean=2.00, Rank=20), since effective visualization tools are necessary in communicating BIM information to wide stakeholders.

The Surveying and Civil Informatics Centre result proves strong overall performance with an average score of 3.50. The output shows that the sector has high level of maturity in areas of software applications, hardware, and information security. However, in areas such as reward systems (Mean = 2.50, Rank = 16) and risk management (Mean = 2.75, Rank = 12), needs attention where the sector's performance is lower. The author suggested that, these areas could benefit from further development to enhance overall efficiency. The standard deviation of 1.00 shows that human respondents have pointed out a moderate range, showing that there is some variability in perceptions or practices within the sector. This supports the assertion by Cochran et al. (2017) that effective organizational performance requires consistent performance in key areas such as risk management and reward systems.

The Construction Sector on the other hand excels in areas such as software applications (Mean = 3.80, Rank = 1) and strategic planning (Mean = 3.85, Rank = 1). The respondent’s feedback are important for successful BIM integration. The standard deviation revealed of 0.75 indicates that, there is a high level of consistency in how these practices implemented across the sector. However, in similar to the Surveying and Civil Informatics Centre, the reward system (Mean = 2.50, Rank = 16) and information assurance (Mean = 2.75, Rank = 12) are KPI areas where the sector needs to improve in order to achieve the goals of BIM through KPI. The overall respondents agreed with Zhou et al. (2019) who suggested that, integrating advanced technologies requires a well-supported infrastructure for implementation and incentive mechanisms to adoptive long-term success in EEC sectors.

The Building and Urban Planning Sector is strong in real-time data, with a (Mean = 3.43 and Rank = 5) and process and technology innovation with a (Mean = 3.43 and Rank = 5). Both these facts prove that it actively invests in advanced technologies. However, the reward system is ranked 17th with a mean of 2.86, while risk management is ranked 10th with a mean score of 3.14, which both indicate that incentives and risks are relatively serious challenges that delay the best practices of BIM adoption and performance. Li et al. (2020) describe that urban planning sectors have to shift their attention to focus on technological advancement aspects with human capital involvement in reward systems and risk management for better deliver the project's outcome.

4.6 INTERPRETATION OF ANOVA KPI RESULTS IN EEC SECTORS

ANOVA analysis results indicate that there exist significant differences among departments in the Ethiopian Engineering Corporation (EEC) in some key performance indicators (KPIs). Of the parameters analyzed, Quality Goal ($p = 0.001$, $F = 4.459$) and Customer Satisfaction ($p = 0.040$, $F = 2.358$) have statistically significant differences between the departments. This suggests that though there are some departments with optimal quality levels and enhanced customers' relationships, others can fail to achieve the same levels of performance. Love et al. (2000) posit that variability in quality performance across construction-related organizations is often attributed to variation in project management practices, adoption of technology, and competency among workers. Simultaneously, Thomas and Flynn (2011) mention that customer satisfaction in engineering firms is considerably influenced by communication effectiveness, process effectiveness, and leadership behavior within different units of an organization. The considerable amount of variation in quality goals is supported by research conducted by Davis et al. (2016), who found organizations with well-governed quality management systems perform better than those with less structured strategies did.

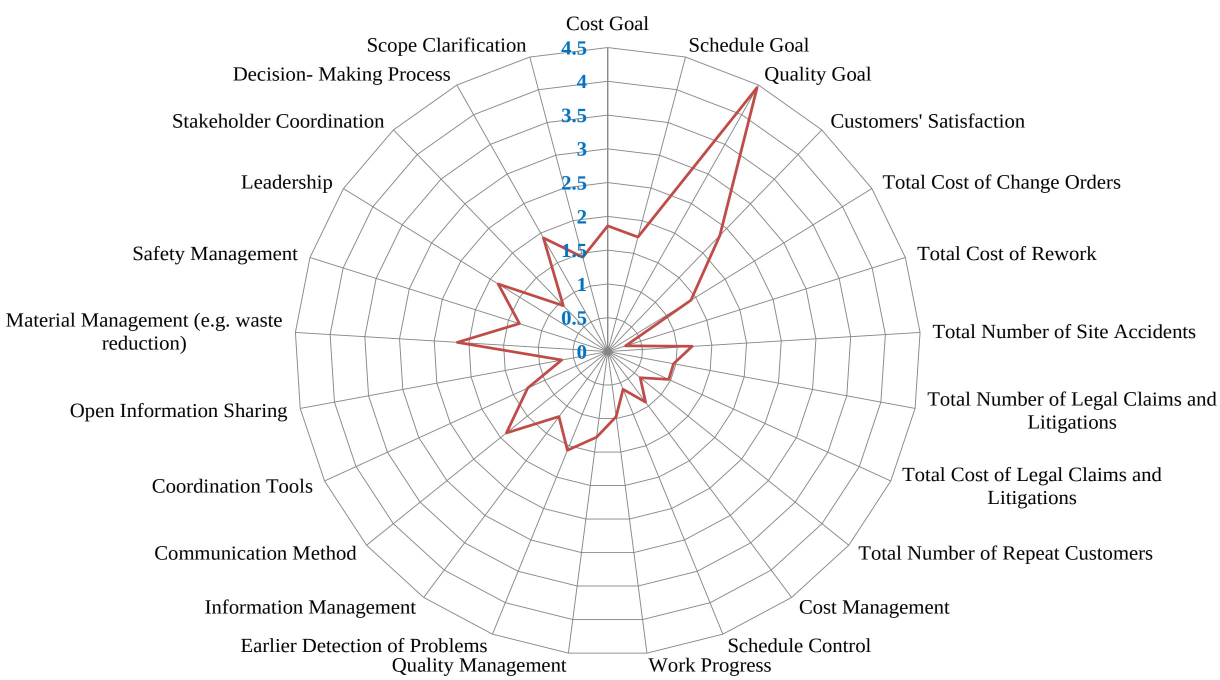

Figure 4.3 Descriptive Results of Anova KPI Results in EEC sectors (SPSS output V26)

On the other hand, some of the KPIs, including Cost Goal (p = 0.101, F = 1.860), Schedule Goal (p = 0.123, F = 1.750), and Total Cost of Change Orders (p = 0.224, F = 1.417), do not have statistically significant differences between the departments. This indicates cost and schedule management practice is relatively homogeneous within EEC. However, even without statistical significance, there could be minimal differences in performance that would be worth examining with qualitative assessments. Literature to date by Olawale and Sun (2010) establishes that cost and schedule control within engineering firms depends more on extraneous conditions such as resource availability, contract policies, and financial management rather than department-specific competencies.

Analysis also indicates that Leadership (p = 0.100, F = 1.864), Decision-Making Process (p = 0.091, F = 1.919), Communication Method (p = 0.095, F = 1.891), and Material Management (p = 0.057, F = 2.166) are marginally significant, indicating potential departmental differences that are not statistically significant at the 95% confidence level but may be significant at a slightly lower confidence level. The observations also align with Müller and Turner (2010), who share the opinion that leadership styles and decision models have an important influence on project success rates and effectiveness. In the same note, Williams (2003) points out that communication and information exchange systems are vital in minimizing rework as well as improving material management, especially in big construction and engineering companies.

On the other hand, Total Cost of Rework (p = 0.962, F = 0.271), Total Number of Site Accidents (p = 0.315, F = 1.218), and Safety Management (p = 0.258, F = 1.335) do not differ significantly across departments. This would suggest a uniform method of safety and error management across EEC, perhaps as a result of standardized safety protocols and regulatory compliance requirements. This finding aligns with the work of Zou et al. (2008), who determined that firms with comprehensive safety policies experience minimal variation in workplace accident rates across different operating units.

Considering the findings, post-hoc tests should be undertaken by EEC to identify what precise departments make up the extreme Quality Goal and Customer Satisfaction variation. Targeted enhancements in decision-making effectiveness, communication styles, material management, and leadership will help improve the general organizational performance. Departments performing at a better level in such activities should act as role models to those where implementation is in vain.

4.7 BIM MATURITY ANOVA RESULTS INTERPRETATION

The ANOVA test shows differences between the technological and organizational variables of various offices, with information assurance being the only variable that has differences ($F = 2.754$, $p = .019$). This implication is that certain departments have more effective ways of ensuring data security and reliability, while others lag behind. This is in line with Zhao et al. (2020), who emphasized the determinative role of information assurance in project management and technology integration. Weaker assurance processes in departments will most likely be ineffective in their data accuracy, which may result in delays in projects and ill-informed decision-making.

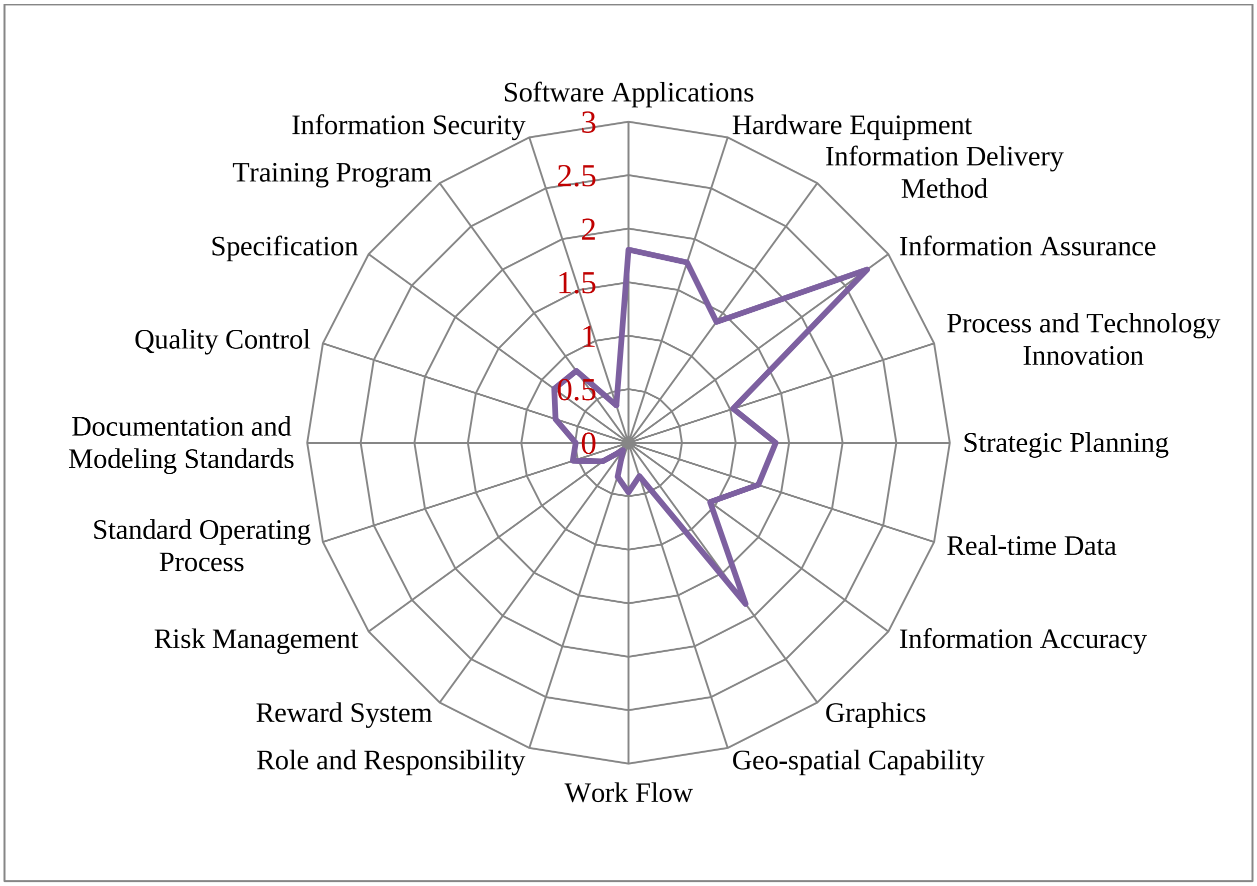

Figure 4.4 BIM maturity anova results interpretation (SPSS output V26)

On the other hand, software packages (F = 1.805, p =.112) and hardware equipment (F = 1.770, p =.119) are moderately different among offices but are not statistically significant. This shows that while variations in technology utilization and availability do exist, overall impact on performance is not the same. Giel & Issa (2016) also reported such findings, noting that absence of standardized software and hardware deployments can have low operational efficiency in construction and engineering firms. Another noteworthy result is the lack of substantial differences in strategic planning (F = 1.374, p =.241) and process and technology innovation (F = 1.028, p =.426). It indicates that these factors are fairly homogenous between offices, yet there can be some room for improvement. Azhar et al. (2015) argue that strategic planning is the secret to successful technology adoption, particularly in the AEC industry. Therefore, although the statistical results do not show dramatic swings, departments should aim for enhanced alignment in strategic decision-making.

For workflow (F = 0.465, p =.854) and role and responsibility clarity (F = 0.333, p =.934), the results suggest minimal differences across offices. This may indicate that organizational structures are well defined, though previous literature, e.g., Davies & Harty (2013), highlights that new technology integration often requires role adjustment and workflow changes.

The findings here suggest that more qualitative research may be needed to see whether employees perceive inefficiencies that quantitative data does not capture. Somewhat unexpected, reward systems (F = 0.087, p =.999) and risk management (F = 0.299, p =.950) are not significantly different between offices. This outcome is in consensus with literature where Luthans and Youssef (2007) believe that reward systems can reduce variation but are unlikely to raise motivation unless rewards tied to performance on a performance contingency basis are issued. Similarly, Hopkin (2018) discusses how consistent risk management work can usher organizational stability but designed risk reduction for some projects is still a necessity. Finally, quality control (F = 0.715, p =.660) and compliance with specifications (F = 0.858, p =.547) also have small variations, which point to the fact that procedural and regulatory compliance is guaranteed to the same extent in departments. However, as Eastman et al. (2011) highlight in their BIM implementation study, continuous enhancement of quality control processes can significantly enhance the outcome of projects.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 BACKGROUND

The study has investigates how far the Ethiopian Engineering Corporation has involved in using Building Information Modeling. BIM maturity also assessed and how Key Performance Indication relates to BIM success and came up with a strategic map. BIM has increasingly seen and regarded as an instrumental tool in ensuring efficiency and productivity within the jurisdiction of construction and engineering activities. Understanding how well EEC is using BIM and what factors influence its success has been key in helping the organization perform better.

The research on BIM includes software and hardware usage on sharing information and strategies of planning. Again, it investigated how the maturity of BIM relates to, and performance. By analyzing the interrelation of these factors, the research provides valuable insights into how EEC can further improve its operations by maximize BIM application and substitute a culture of collaboration and innovation.

The research points out the problems that obstruct the common application of BIM at EEC, and at the same time provide useful solutions for the problems. It provides ideas on how EEC can fill gaps in processes, enhance skills among its personnel, and embed the latest technologies in its work. This section discusses the main findings of the study, mentioned why these results are important. The stage for conclusions, recommendations, and challenges from the research work will also be prepared in this context. At end, it has focused the key areas of further research that should support EEC's continued endeavors towards improving on BIM application to improve its performance generally.

5.2 SUMMARY

The research has focused on the challenges and potential benefits of implementing Building Information Modeling (BIM) at the Ethiopian Engineering Corporation (EEC). It examined the challenges and potential advantages accrued to the implementation of BIM at the Ethiopian Engineering Corporation. It searched for barriers such as technology, organization, and skill-related problems, and benefits such as enhanced project efficiency and collaboration. The research provided perceptions into recommendations that would help EEC and any other similar organization those are found in developing countries and enhance their operations with the incorporation of BIM.

In this regard, the study focused on EEC, at Addis Ababa, Ethiopia. In this research effort, 50 questionnaires were distributed among the employee and fortunately all responded from target groups. The research studied workforce demographics, education, professional experience, BIM exposure, KPIs, organizational culture, and project delivery methods, among other aspects. The workforce was very young, with 64% of the respondents between 26 and 41 years old, while only 10% were over 50 years old. The workforce was predominantly male, 62%, a feature common in most construction sectors. Diversity improvement can create an inclusive environment and facilitate diverse thinking within the organization. A total of 50% of the respondents had a Master's degree, while the majority had 4-15 years of experience. Several employees had very limited experience with BIM, including 50% with 1-3 years and 14% with none, which was indicative of training needs. The most common project delivery methods now in use include Design-Build and Design-Bid-Build, but interest in Integrated Project Delivery is growing. Reliability analysis showed very strong consistency across the constructs with high reliability of BIM Maturity (Cronbach's Alpha = 0.932), KPIs (0.945).

Main findings about BIM maturity across EEC sectors displayed strengths and weaknesses. Water and Energy Sector and Transport Sector has well achieved from the point of view of documentation but creating data integration problems, Geotechnical Sector has good value in terms of documentation and there was issues traced on present relating to security of data. Research Center on the other hand has traced very well though not so bright in the graph visualization and software was an exception. The Surveying Centre had a sound performance but needed to improve its rewards and manage risks. The Surveying and Civil Informatics Centre, Construction Sector, and Building and Urban Planning Sector excel in areas such as software applications, strategic planning, and innovation. However, all these sectors face challenges in reward systems, risk management, and employee incentives, and so they need further improvements to achieve consistency, efficiency, and overall performance. Finally, BIM Improvements were needed in all sectors in terms of infrastructure, data security, and human capital.

The assessment also showed strengths and challenges in BIM implementation and KPIs across sectors. The Water and Energy Sector topped in cost management and leadership but faced challenges in accident reduction and schedule management. Also Transport Sector leading with the best performing schedule and quality management while challenges are identified relating to cost management, and safety; Geotechnical sector top in performing in cost goals within work executed with weak indications over the performed data management and problem timely detection. On the other hand, the Research Center outperformed in communication by reflecting weaknesses in the characteristics of leadership and legal cost management. In addition, the other sectors reflected strengths on coordination and schedule, but weakness points given as customer retention and risk management. The strengths are project coordination, quality standards, and communication of the Surveying and Civil Informatics Centre, Construction Sector, and Building and Urban Planning Sector. Besides, the three have weaknesses: risk management, employee incentives, and quality control. This shows there is a need to focus on unified practice, motivation strategies, and putting in place mechanisms that would maximize risk mitigation for sustained project success.

5.3 CONCLUSION

The research described and measured the BIM Maturity Matrix and its associated KPIs among sectors within EEC. The results found that, there was a great difference in the levels of maturity of BIM across the sectors. For instance, The Water and Energy Sector were very good at real-time data but faced problems with outdated hardware and a lack of security in data. The Transport Sector was good in documentation but had integration issues in data. The Geotechnical Sector was performing better concerning documentation, but it was way behind regarding data security provisions. The software utilization and coordination once again seemed strong in the Research and Surveying Centers, while risk management, leadership, and visualization tools were the gaps found on research analysis. The Surveying Centre demonstrated a good show, but needed further improvement regarding rewards and risk management. The strong points for the Surveying and Civil Informatics Centre, Construction Sector, and Building and Urban Planning Sector were software applications, strategies, and innovation, respectively. However, all sectors performed poorly in reward systems, risk management, and employee incentives; thus, there is a need for improvement in consistency and efficiency to raise the overall performance level. These results showed where all sectors strengths and weaknesses are below requirement of BIM implementation that outlining the need for improved technological infrastructure, reliable data security measures, and human capital development to enhance BIM maturity across the organization.

Furthermore, the study explored how organizational factors influenced EEC's BIM maturity interactively. It emphasized the fact that, sources of most variations involved workforce demographics, professional experiences, and organizational support. The majority workforces are young staff and most of them have limited exposure to BIM technology adoption. Therefore, the author reported that the employee across the sectors have a few years' experience in handling the system. In fact, strong associations existed between BIM maturity and KPIs, These clearly supported that education; training, leadership, and technological infrastructure are all critical enablers toward the adoption of BIM. Targeted intervention thus became essential to bridge such gaps and develop BIM maturity in all spheres of the organization.

In General conclusion, the research study provides critical insights from the analysis output into BIM maturity and performance at EEC. The results indicated EEC sectors specific challenges, limited workforce exposure to BIM, and a lack of sufficient support mechanisms within an organization that delays optimal BIM adoption. The strategic investment in technologies and people's training, combined with the organization's culture, has contributed significantly to filling those gaps within EEC and generally improving BIM maturity with associated performance improvements. Thus, the overall findings provided valuable lessons to EEC organizations and other similar firms in developing countries, particularly in Ethiopia, in terms of acting as a roadmap toward the successful surmounting of the barriers to critical factors for benefits ensuing from BIM implementation in projects and organizations.

5.4 RECOMMENDATION

Based on the study’s findings, the following recommendations are proposed to enhance BIM maturity and organizational performance at EEC.

- The EEC organization should update the technological infrastructure by providing reliable hardware, full-bodied data security measures, and unified data integration across sectors. This will result in enhanced BIM adoption, improved operational performance, and reduction of sector-specific challenges like outdated hardware and data security concerns.

- Consider a young workforce that has relatively less experience in BIM, so EEC should concentrate on training and development programs for BIM technical skills building, software usage documentation, and risk management, thereby having full control over BIM, which may help employees to support the growth of the organization.

- Performance-based reward systems should established in line with EEC organizational goals and incentives to promote innovation and improvement in employee motivation. Besides, leadership capabilities are to be developed, while risk management frameworks should be strengthened to duly execute the projects and reduce potential risks.

- EEC should adopt a continuous monitoring system in measuring BIM maturity and KPIs, so that it is timely to change and improve on time. For the industry-wise collaboration across sectors like surveying, construction, and building and urban planning through workshops and joint projects, this will enhance BIM adoption and improve performances.

5.5 AREAS FOR FURTHER RESEARCH

Based on the findings and limitations of this study, potential areas for further research have identified as shown below.

- The study also identified the strengths and weaknesses in the BIM implementing assessment of EEC sectors and assumed that such challenges as data security, risk management, and visualization require further research. Further research could be done in these areas to observe how training and professional development have improved BIM skills and the performance of employees over time because of the limited experience of many workers in BIM.
- The growing interest in Integrated Project Delivery in EEC provides an excellent opportunity for future research studies on how this model can contribute to furthering collaboration, efficiency, and implementation of BIM for organizations with similar characteristics. Equally important is performing research on those new technological solutions necessary for several of the challenges, like hardware limitations, data integration, and security issues.
- It has expected that future studies could targeted toward comparative analysis that would look into problems and successes of BIM implementation in various organizations and regions for wider insights into best practices that can replicated under similar contexts. A longitudinal study could also determine long-term impacts on organizational performance, cost efficiency, project timelines, and stakeholder satisfaction following BIM adoption.

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APPENDIX

QUESTIONNAIRE AND ANALYSIS RESULTS

ADDIS ABABA UNIVERSITY

EEC - Research Survey on BIM Assessment,

This study is being conducted for assessment of Ethiopian Engineering Corporation's (EEC) for implementation of BIM technology. To ensure the success of this research, we kindly request your support and cooperation in responding to the questionnaire. Please provide honest and accurate answers to the questions. The information you provide will be used only for research purposes and will be treated as confidential. The findings from this questionnaire will be reported in an aggregated manner, and your privacy as a respondent will be maintained.

Thank you in advance for your kind cooperation.

General Information: Questions for Initial Qualitative Analysis

1. What are the top benefits of Building Information Modeling (BIM) in your perspective?
2. How do you measure productivity in your organization/ corporate/sector/center?
3. Does your corporate/sector/center utilize Building Information Modeling (BIM)? If so, what software do you use? What does BIM mean to you and your projects?
4. If your corporate/sector/center uses BIM, what are the benefits? For each benefit listed, can you explain how BIM contributes to these advantages?
5. If your corporate/sector/center uses BIM, has it improved productivity on your projects. If yes, how?

A1 - Demographic Questionnaire

Nr	Question	Select Thick	Options
1	Your Current Office/Center		○ Corporate Head Office
			○ Water and Energy Sector
			○ Transport Sector
			○ Building and Urban Planning Sector
			○ Geotechnical and Investigation Sector
			○ Research, Laboratory, and Training Center
			○ Surveying and Civil Informatics Centre
			○ Construction Sector
2	Gender		○ Male
			○ Female
3	Age in Years		○ 18-25
			○ 26-33
			○ 34-41
			○ 42-49
			○ Above 50
4	Your Current Position/Title		○ Top Management / CEO, DCEO, Manager / Level 1
			○ Core Process / Director / Sector Resource Manager / Level 2
			○ Sub Process / Team Leader / Project Manager / Resident Engineer / Level 3
			○ Senior / Expert / Level 4
			○ Staff / Level 5
			○ Other Specify
5	Highest Degree		○ Diploma
			○ First Degree
			○ Master Degree
			○ PhD and Above
6	Total Years of Work Experience		○ 1 – 3 Years
			○ 4 – 8 Years
			○ 9 – 15 Years
			○ Above 16 Years

Nr	Question	Select Thick	Options
7	Please specify your level of confidence in your expertise in construction management.		○ None
			○ Low
			○ Medium
			○ High
			○ Expert
8	Please indicate your confidence in your expertise in BIM.		○ None
			○ Low
			○ Medium
			○ High
			○ Expert
9	Please indicate how long you have worked with BIM (Y)		○ Never
			○ $1 < Y \leq 3$ Years
			○ $3 < Y \leq 8$ Years
			○ $8 < Y \leq 15$ Years
			○ 15 Years < Y
10	Please indicate the building types for the majority of those BIM-assisted projects (select all that apply)		○ Commercial, Residential, Institutional
			○ Dam, Irrigation, Water Supply
			○ Road, Transportation, Bridges, Retaining Structures
			○ Tunnel, Conduit, Underground Structures
			○ Foundations, Hydrogeology, Urban Drainage Works
			○ Other (please specify): _____
11	Please indicate the project delivery methods used for the majority of those BIM-assisted projects (select all that apply)		○ Design-Bid-Build (DBB)
			○ Construction Management (CM) at Risk
			○ Construction Management (CM) Agency
			○ Design-Build (DB)
			○ Integrated Project Delivery (IPD)
			○ Other (please specify): ______
12	Please indicate all stakeholders who used BIM in the majority of your BIM-assisted projects (select all that apply)		○ Client/Financer
			○ Architect/Engineer
			○ General Contractor
			○ Construction Manager
			○ Subcontractor (please specify): ______
			○ Sub Consultant (please specify): _____
			○ Software Vendor (please specify): ___
			○ Other (please specify): _______

13	Please indicate the value (V) for the majority of those BIM-assisted projects		○ 0 < V ≤ 1 million ETB
			○ 1 million < V ≤ 50 million ETB
			○ 50 million < V ≤ 200 million ETB
			○ 201 million < V ≤ 500 million ETB
			○ 500 million < V
			○ I do not know
14	BIM Implementation: BIM is effectively implemented and supported within EEC.		○ Strongly disagree
			○ Disagree
			○ Neutral
			○ Agree
			○ Strongly Agree

A 2 - BIM Maturity Evaluation

The Building Information Modeling Maturity (BIMM) matrix is a framework used to evaluate the extent and effectiveness of BIM implementation within an organization or project. It helps identify current capabilities, highlight areas for improvement, and guide strategic development.

Nr	Question	Select Thick	Options
1	Please specify your level of confidence in your expertise in construction management.		○ None
			○ Low
			○ Medium
			○ High
			○ Expert
2	Please indicate your confidence in your expertise in BIM.		○ None
			○ Low
			○ Medium
			○ High
			○ Expert
3	Please indicate your confidence in your expertise in BIM.		○ None
			○ Low
			○ Medium
			○ High
			○ Expert
4	Please indicate how long (Y) you have worked with BIM.		○ Never
			○ 1 < Y ≤ 3 Years
			○ 3 < Y ≤ 8 Years

			○ 8 < Y ≤ 15 Years
			○ 15 Years < Y
5	Please indicate the overall BIM Maturity level for the majority of BIM-assisted projects in which you have been involved, considering all previous items.		○ Extremely Immature
			○ Immature
			○ Neutral
			○ Very Mature
			○ Extremely Mature

Nr	Question	Items	None (1)	Low (2)	Medium (3)	High (4)	Expert (5)
1	Please rate the following items with respect to their relevance in measuring BIM Maturity.	Software Applications					
		Hardware Equipment					
		Information Delivery Method					
		Information Assurance					
		Process and Technology Innovation					
2	Please rate the following items with respect to their relevance in measuring BIM Maturity.	Strategic Planning					
		Real-time Data					
		Information Accuracy					
		Graphics					
		Geo-spatial Capability					
3	How would you rate the overall maturity of your organization in implementing BIM practices, considering the following aspects?	Work Flow					
		Role and Responsibility					
		Reward System					
		Risk Management					
		Standard Operating Process					
4	To what extent do you believe your organization has matured in implementing BIM practices in the following areas?	Documentation and Modeling Standards					
		Quality Control					
		Specification					
		Training Program					
		Information Security					

A 3 – Key Performance Indicator

Key Performance measurement is the process of quantifying how efficiently and effectively actions are carried out. For such a system to be a valuable management tool, it should enable thorough evaluation, provide actionable insights, and identify issues, allowing for judgments based on predefined criteria

Nr	Question	Items	None (1)	Low (2)	Medium (3)	High (4)	Expert (5)
1	Please Please rate the following items with respect to their relevance in measuring the project success in management, Design, contracts, and construction	Cost Goal					
		Schedule Goal					
		Quality Goal					
		Customers' Satisfaction					
		Total Cost of Change Orders					
2	How How effectively does your organization track and measure the following Key Performance Indicators (KPIs) in its projects ?	Total Cost of Rework					
		Total Number of Site Accidents					
		Total Number of Legal Claims and Litigations					
		Total Cost of Legal Claims and Litigations					
		Total Number of Repeat Customers					
3	How well does your organization perform in monitoring and controlling the following Key Performance Indicators (KPIs) ?	Cost Management					
		Schedule Control					
		Work Progress					
		Quality Management					
		Earlier Detection of Problems					
4	Based on Information and Communication , Please rate the following items with respect to their relevance in measuring the performance of management.	Information Management					
		Communication Method					
		Coordination Tools					
		Open Information Sharing					
		Material Management (e.g. waste reduction)					
5	On basis of Management related Process and Decision, Please rate the following items with respect to their relevance.	Safety Management					
		Leadership					
		Stakeholder Coordination					
		Decision- Making Process					
		Scope Clarification					

APPENDIX 4: ANALYSIS RESULT OUTPUT

BIM Maturity - The Descriptive Statistics

Sectors – BIM Maturity	Corporate			Water and Energy Sector			Transport Sector			Geotechnical and Investigation Sector			Research, Laboratory, and Training Center		
	Mean	Rank	Std. Dev.	Mean	Rank	Std. Dev.	Mean	Rank	Std. Dev.	Mean	Rank	Std. Dev.	Mean	Rank	Std. Dev.
Software Applications	3.80	2	0.45	2.71	15	1.25	3.00	11	0.00	2.50	9	1.00	3.80	1	1.10
Hardware Equipment	3.60	6	0.89	2.43	19	1.27	3.40	7	0.89	2.50	9	1.00	2.20	19	1.64
Information Delivery Method	3.60	6	0.89	2.43	19	1.13	3.80	2	0.84	2.75	7	0.50	3.20	4	1.30
Information Assurance	3.80	2	0.45	2.57	18	1.51	1.60	20	1.34	1.75	20	1.50	3.00	7	1.41
Process and Technology Innovation	4.00	1	0.71	3.00	7	1.53	2.80	14	0.45	2.75	7	1.50	3.40	3	1.14
Strategic Planning	3.00	15	0.71	3.00	7	1.41	2.80	14	0.84	2.50	9	1.29	3.20	4	1.30
Real-time Data	3.20	10	1.10	3.29	1	1.25	2.40	19	0.55	2.25	17	1.26	3.00	7	1.22
Information Accuracy	3.00	15	0.71	3.29	1	1.38	2.80	14	0.84	2.00	18	2.00	3.20	4	1.64
Graphics	3.00	15	0.71	3.29	1	1.25	3.60	3	1.14	2.00	18	1.41	2.00	20	1.22
Geo-spatial Capability	2.80	19	1.10	3.14	4	1.21	2.60	18	1.14	2.50	9	1.00	3.00	7	1.41
Work Flow	3.20	10	0.45	3.00	7	1.15	3.20	10	0.84	2.50	9	0.58	2.80	13	1.10

Role and Responsibility	3.20	10	1.10	3.14	4	1.21	3.60	3	0.55	3.00	3	0.82	3.60	2	0.55
Reward System	2.60	20	1.14	2.86	12	1.35	2.80	14	0.84	2.50	9	0.58	2.80	13	0.84
Risk Management	3.60	6	1.14	3.14	4	1.57	3.40	7	1.14	3.00	3	0.82	3.00	7	1.22
Standard Operating Process	3.80	2	0.84	3.00	7	1.41	3.00	11	1.58	2.50	9	1.29	3.00	7	1.00
Documentation and Modeling Standards	3.60	6	1.52	2.86	12	1.35	3.60	3	1.14	3.25	1	1.50	2.80	13	0.84
Quality Control	3.20	10	1.30	2.86	12	1.07	3.60	3	0.55	3.00	3	0.82	2.40	18	0.55
Specification	3.00	15	0.71	2.71	15	1.25	4.00	1	0.71	3.25	1	0.50	3.00	7	0.00
Training Program	3.80	2	1.30	2.71	15	1.25	3.00	11	1.22	3.00	3	1.41	2.80	13	1.10
Information Security	3.20	10	1.10	3.00	7	1.41	3.40	7	0.89	2.50	9	1.29	2.60	17	0.55

Sectors – BIM Maturity	Surveying and Civil Informatics Centre			Construction Sector			Building and Urban Plan Sector			Total		
	Mean	Rank	Std. Deviation	Mean	Rank	Std. Deviation	Mean	Rank	Std. Deviation	Mean	N	Std. Deviation
Software Applications	3.50	1	1.00	3.69	2	0.75	3.29	6	0.95	3.34	50	0.94
Hardware Equipment	3.00	8	0.82	3.54	6	0.66	2.86	17	1.07	3.02	50	1.08
Information Delivery Method	2.50	16	1.29	3.38	11	0.96	3.14	10	0.90	3.14	50	1.03
Information Assurance	2.75	12	1.26	3.46	8	0.52	3.29	6	1.11	2.92	50	1.24

Process and Technology Innovation	3.25	4	0.96	3.69	2	0.48	3.43	5	1.27	3.36	50	1.03
Strategic Planning	3.25	4	0.50	3.85	1	0.55	3.14	12	0.90	3.22	50	0.97
Real-time Data	2.75	12	0.96	3.62	4	0.77	2.86	17	1.35	3.06	50	1.08
Information Accuracy	2.50	16	1.00	3.62	4	0.77	3.29	6	1.80	3.12	50	1.27
Graphics	2.75	12	1.26	3.54	6	0.78	3.14	12	1.21	3.06	50	1.15
Geo-spatial Capability	3.00	8	0.82	3.23	15	0.83	2.86	17	1.46	2.96	50	1.07
Work Flow	3.00	8	0.82	3.31	12	1.03	3.00	15	0.58	3.06	50	0.87
Role and Responsibility	3.50	1	0.58	3.46	10	0.88	3.43	4	0.79	3.38	50	0.83
Reward System	2.50	16	0.58	2.77	20	1.30	2.71	20	0.76	2.72	50	0.99
Risk Management	3.00	8	0.82	3.08	17	1.19	3.57	2	0.53	3.22	50	1.07
Standard Operating Process	3.50	1	0.58	3.15	16	0.99	3.14	12	0.90	3.14	50	1.07
Documentation and Modeling Standards	2.75	12	0.50	3.31	14	1.03	3.29	6	0.76	3.20	50	1.07
Quality Control	3.25	4	1.26	3.46	8	1.13	3.14	10	1.35	3.16	50	1.06
Specification	3.25	4	1.26	3.31	12	1.11	3.57	2	1.27	3.26	50	1.01
Training Program	2.50	16	1.29	3.00	19	1.29	3.71	1	0.49	3.08	50	1.18
Information Security	2.50	16	1.00	3.00	18	1.22	3.00	15	1.41	2.94	50	1.13

Office/ Sector	Corporate			Water and Energy Sector			Transport Sector			Geotechnical and Investigation Sector				Research, Laboratory, and Training Center		
	Mean	Rank	Std. Dev	Mean	Rank	Std. Devi	Mean	Rank	Std. Dev	Mean	Rank	N	Std. Dev	Mean	Rank	Std. Dev
Cost Goal	3.60	2	0.55	3.71	4	0.49	3.60	5	1.34	3.25	1	4	0.50	3.20	2	0.84
Schedule Goal	3.00	20	0.71	4.14	1	0.38	3.20	16	1.64	3.25	1	4	1.26	3.00	5	1.22
Quality Goal	3.00	20	1.00	4.00	2	0.00	4.40	1	0.89	2.75	9	4	0.96	3.00	5	0.71
Customers' Satisfaction	3.40	9	0.89	4.00	3	0.58	3.40	9	0.55	3.25	1	4	1.26	3.00	5	0.71
Total Cost of Change Orders	3.40	9	0.89	3.57	8	0.53	3.40	9	1.14	2.75	9	4	0.96	3.60	1	0.55
Total Cost of Rework	2.60	25	0.55	2.86	22	0.90	3.20	16	0.84	2.75	9	4	0.96	3.00	5	1.00
Total Number of Site Accidents	3.60	2	0.55	2.86	22	1.35	3.00	20	1.22	2.50	17	4	1.00	2.60	15	0.55
Total Number of Legal Claims and Litigations	3.60	2	0.55	2.86	22	0.90	3.00	20	1.00	2.75	9	4	1.26	2.60	15	0.55
Total Cost of Legal Claims and Litigations	3.60	2	0.55	2.86	22	1.35	2.80	23	0.84	2.75	9	4	1.71	3.00	5	1.41
Total Number of Repeat Customers	3.40	9	0.55	3.00	18	0.82	3.20	16	1.48	2.75	9	4	0.96	2.40	23	1.14
Cost Management	3.40	9	0.55	3.00	20	0.58	3.60	5	0.89	2.75	9	4	0.96	2.60	15	0.89
Schedule Control	3.00	20	0.7	3.00	18	0.58	3.20	16	1.10	2.50	17	4	0.58	2.20	24	0.84

			1													
Work Progress	3.20	17	0.45	3.43	9	0.79	3.40	9	0.55	3.00	6	4	0.82	2.60	15	0.55
Quality Management	3.40	9	1.14	3.43	9	0.79	3.40	9	1.14	3.00	6	4	0.82	2.60	15	0.55
Earlier Detection of Problems	2.80	24	0.84	3.00	20	0.82	2.80	23	0.84	2.00	25	4	1.41	2.20	24	0.45
Information Management	3.40	9	0.89	3.14	15	0.69	2.60	25	0.89	2.75	9	4	0.50	3.00	5	1.00
Communication Method	4.20	1	0.45	3.14	15	0.69	3.40	9	0.55	3.25	1	4	0.50	2.60	15	0.89
Coordination Tools	3.60	2	0.55	3.29	13	0.76	3.00	20	0.71	3.00	6	4	1.15	2.60	15	0.55
Open Information Sharing	3.00	20	0.71	3.14	15	1.07	3.40	9	1.14	3.25	1	4	0.50	2.80	12	0.45
Material Management (e.g. waste reduction)	3.60	2	0.89	3.29	12	0.76	3.60	5	0.55	2.50	17	4	0.58	2.80	12	0.45
Safety Management	3.40	9	0.55	3.29	13	0.49	3.80	3	0.45	2.50	17	4	1.00	2.60	15	0.55
Leadership	3.20	17	0.45	3.71	4	0.49	4.20	2	0.84	2.50	17	4	1.29	3.20	2	0.84
Stakeholder Coordination	3.60	2	0.55	3.43	9	0.53	3.60	5	1.14	2.50	17	4	1.00	3.00	5	0.71
Decision-Making Process	3.20	17	0.84	3.71	4	0.49	3.80	3	1.10	2.50	17	4	1.00	2.80	12	0.45
Scope Clarification	3.40	9	0.55	3.71	7	0.49	3.40	9	0.55	2.50	17	4	0.58	3.20	2	0.84

Office/Center	Surveying and Civil Informatics Centre				Construction Sector		Building and Urban Plan Sector			Total		
	Mean	Rank	N	Std. Deviation	Mean	Std. Deviation	Mean	Rank	Std. Deviation	Mean	N	Std. Deviation
Cost Goal	2.00	22	4	0.82	3.38	0.87	3.57	3	0.98	3.36	50	0.90
Schedule Goal	2.50	8	4	0.58	3.69	0.85	4.00	1	1.15	3.48	50	1.05
Quality Goal	3.00	1	4	0.82	4.00	0.58	3.71	2	0.49	3.62	50	0.83
Customers' Satisfaction	2.25	17	4	1.26	4.08	0.76	3.29	5	1.38	3.50	50	1.02
Total Cost of Change Orders	2.25	17	4	0.96	3.54	0.97	2.86	17	1.21	3.26	50	0.96
Total Cost of Rework	2.75	3	4	0.50	2.85	0.80	2.71	23	0.76	2.84	50	0.77
Total Number of Site Accidents	2.25	17	4	0.50	2.62	0.87	3.29	5	0.76	2.84	50	0.93
Total Number of Legal Claims and Litigations	2.25	17	4	0.96	2.54	0.88	2.71	23	1.11	2.76	50	0.92
Total Cost of Legal Claims and Litigations	2.00	22	4	0.82	2.54	1.13	3.43	4	1.27	2.86	50	1.18
Total Number of Repeat Customers	2.50	8	4	0.58	3.08	1.04	3.00	12	0.82	2.96	50	0.95
Cost Management	2.50	8	4	0.58	3.15	1.07	3.14	9	0.90	3.06	50	0.87
Schedule Control	2.50	8	4	1.29	3.00	1.22	2.86	20	1.07	2.84	50	0.98
Work Progress	2.50	8	4	1.29	3.38	1.04	3.00	12	0.82	3.14	50	0.86
Quality Management	2.25	17	4	0.50	3.62	1.12	2.86	17	1.35	3.18	50	1.04
Earlier Detection of Problems	2.50	8	4	0.58	3.46	1.13	3.00	12	1.15	2.88	50	1.02

Information Management	2.50	8	4	0.58	3.38	0.77	2.71	23	0.95	3.02	50	0.82
Communication Method	2.75	3	4	0.96	3.31	0.95	3.14	8	0.69	3.24	50	0.82
Coordination Tools	2.50	8	4	1.00	3.69	1.18	3.00	12	1.15	3.20	50	0.99
Open Information Sharing	2.75	3	4	0.96	3.62	1.12	3.14	9	0.90	3.22	50	0.93
Material Management (e.g. waste reduction)	2.00	22	4	0.00	3.54	1.13	3.00	12	1.15	3.16	50	0.96
Safety Management	2.75	3	4	0.96	3.31	1.11	3.29	5	0.95	3.18	50	0.87
Leadership	3.00	1	4	0.82	3.69	0.85	2.86	17	1.46	3.38	50	0.99
Stakeholder Coordination	2.50	8	4	1.00	3.46	1.33	2.86	20	1.46	3.20	50	1.09
Decision- Making Process	2.00	22	4	0.82	3.46	1.33	3.14	9	0.90	3.20	50	1.05
Scope Clarification	2.75	3	4	0.50	3.62	1.19	2.86	20	1.07	3.28	50	0.90

KEY PERFORMANCE RESULT

A 5 - BIMM Maturity ANOVA Results Table

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
Software Applications * Office/Center	Between Groups	(Combined)	9.994	7	1.428	1.805	.112
	Within Groups		33.226	42	.791		
	Total		43.220	49			
Hardware Equipment * Office/Center	Between Groups	(Combined)	12.978	7	1.854	1.770	.119
	Within Groups		44.002	42	1.048		
	Total		56.980	49			
Information Delivery Method * Office/Center	Between Groups	(Combined)	9.822	7	1.403	1.396	.232
	Within Groups		42.198	42	1.005		
	Total		52.020	49			
Information Assurance * Office/Center	Between Groups	(Combined)	23.806	7	3.401	2.754	.019
	Within Groups		51.874	42	1.235		
	Total		75.680	49			
Process and Technology Innovation * Office/Center	Between Groups	(Combined)	7.536	7	1.077	1.028	.426
	Within Groups		43.984	42	1.047		
	Total		51.520	49			
Strategic Planning * Office/Center	Between Groups	(Combined)	8.681	7	1.240	1.374	.241
	Within Groups		37.899	42	.902		
	Total		46.580	49			
Real-time Data * Office/Center	Between Groups	(Combined)	9.957	7	1.422	1.275	.286
	Within Groups		46.863	42	1.116		
	Total		56.820	49			
Information Accuracy * Office/Center	Between Groups	(Combined)	10.746	7	1.535	.941	.486
	Within Groups		68.534	42	1.632		

	Total		79.280	49			
Graphics * Office/Center	Between Groups	(Combined)	15.354	7	2.193	1.862	.100
	Within Groups		49.466	42	1.178		
	Total		64.820	49			
Geo-spatial Capability * Office/Center	Between Groups	(Combined)	2.898	7	.414	.328	.937
	Within Groups		53.022	42	1.262		
	Total		55.920	49			
Work Flow * Office/Center	Between Groups	(Combined)	2.651	7	.379	.465	.854
	Within Groups		34.169	42	.814		
	Total		36.820	49			
Role and Responsibility * Office/Center	Between Groups	(Combined)	1.778	7	.254	.333	.934
	Within Groups		32.002	42	.762		
	Total		33.780	49			
Reward System * Office/Center	Between Groups	(Combined)	.687	7	.098	.087	.999
	Within Groups		47.393	42	1.128		
	Total		48.080	49			
Risk Management * Office/Center	Between Groups	(Combined)	2.685	7	.384	.299	.950
	Within Groups		53.895	42	1.283		
	Total		56.580	49			
Standard Operating Process * Office/Center	Between Groups	(Combined)	4.671	7	.667	.546	.795
	Within Groups		51.349	42	1.223		
	Total		56.020	49			
Documentation and Modeling Standards * Office/Center	Between Groups	(Combined)	4.245	7	.606	.492	.835
	Within Groups		51.755	42	1.232		
	Total		56.000	49			
Quality Control * Office/Center	Between Groups	(Combined)	5.825	7	.832	.715	.660
	Within Groups		48.895	42	1.164		

	Total		54.720	49			
Specification * Office/Center	Between Groups	(Combined)	6.208	7	.887	.858	.547
	Within Groups		43.412	42	1.034		
	Total		49.620	49			
Training Program * Office/Center	Between Groups	(Combined)	8.223	7	1.175	.830	.569
	Within Groups		59.457	42	1.416		
	Total		67.680	49			
Information Security * Office/Center	Between Groups	(Combined)	3.620	7	.517	.367	.916
	Within Groups		59.200	42	1.410		
	Total		62.820	49			

A 6 - Key Performance Indicator ANOVA results Table

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
Cost Goal * Office/Center	Between Groups	(Combined)	9.350	7	1.336	1.860	.101
	Within Groups		30.170	42	.718		
	Total		39.520	49			
Schedule Goal * Office/Center	Between Groups	(Combined)	12.304	7	1.758	1.750	.123
	Within Groups		42.176	42	1.004		
	Total		54.480	49			
Quality Goal * Office/Center	Between Groups	(Combined)	14.401	7	2.057	4.459	.001
	Within Groups		19.379	42	.461		
	Total		33.780	49			
Customers' Satisfaction * Office/Center	Between Groups	(Combined)	14.248	7	2.035	2.358	.040
	Within Groups		36.252	42	.863		
	Total		50.500	49			
Total Cost of Change Orders * Office/Center	Between Groups	(Combined)	8.718	7	1.245	1.417	.224
	Within Groups		36.902	42	.879		
	Total		45.620	49			
Total Cost of Rework * Office/Center	Between Groups	(Combined)	1.242	7	.177	.271	.962
	Within Groups		27.478	42	.654		
	Total		28.720	49			
Total Number of Site Accidents * Office/Center	Between Groups	(Combined)	7.207	7	1.030	1.218	.315
	Within Groups		35.513	42	.846		
	Total		42.720	49			
Total Number of Legal Claims and Litigations *	Between Groups	(Combined)	5.704	7	.815	.966	.468
	Within Groups		35.416	42	.843		

Office/Center	Total		41.120	49			
Total Cost of Legal Claims and Litigations * Office/Center	Between Groups	(Combined)	9.468	7	1.353	.970	.465
	Within Groups		58.552	42	1.394		
	Total		68.020	49			
Total Number of Repeat Customers * Office/Center	Between Groups	(Combined)	4.047	7	.578	.609	.745
	Within Groups		39.873	42	.949		
	Total		43.920	49			
Cost Management * Office/Center	Between Groups	(Combined)	4.921	7	.703	.926	.497
	Within Groups		31.899	42	.760		
	Total		36.820	49			
Schedule Control * Office/Center	Between Groups	(Combined)	4.263	7	.609	.602	.750
	Within Groups		42.457	42	1.011		
	Total		46.720	49			
Work Progress * Office/Center	Between Groups	(Combined)	5.029	7	.718	.974	.463
	Within Groups		30.991	42	.738		
	Total		36.020	49			
Quality Management * Office/Center	Between Groups	(Combined)	9.382	7	1.340	1.279	.284
	Within Groups		43.998	42	1.048		
	Total		53.380	49			
Earlier Detection of Problems * Office/Center	Between Groups	(Combined)	10.649	7	1.521	1.573	.170
	Within Groups		40.631	42	.967		
	Total		51.280	49			
Information Management * Office/Center	Between Groups	(Combined)	5.467	7	.781	1.192	.328
	Within Groups		27.513	42	.655		
	Total		32.980	49			
Communication Method * Office/Center	Between Groups	(Combined)	7.936	7	1.134	1.891	.095
	Within Groups		25.184	42	.600		

	Total		33.120	49			
Coordination Tools * Office/Center	Between Groups	(Combined)	8.402	7	1.200	1.273	.287
	Within Groups		39.598	42	.943		
	Total		48.000	49			
Open Information Sharing * Office/Center	Between Groups	(Combined)	4.289	7	.613	.672	.694
	Within Groups		38.291	42	.912		
	Total		42.580	49			
Material Management (e.g. waste reduction) * Office/Center	Between Groups	(Combined)	11.861	7	1.694	2.166	.057
	Within Groups		32.859	42	.782		
	Total		44.720	49			
Safety Management * Office/Center	Between Groups	(Combined)	6.804	7	.972	1.335	.258
	Within Groups		30.576	42	.728		
	Total		37.380	49			
Leadership * Office/Center	Between Groups	(Combined)	11.325	7	1.618	1.864	.100
	Within Groups		36.455	42	.868		
	Total		47.780	49			
Stakeholder Coordination * Office/Center	Between Groups	(Combined)	7.798	7	1.114	.932	.492
	Within Groups		50.202	42	1.195		
	Total		58.000	49			
Decision- Making Process * Office/Center	Between Groups	(Combined)	13.084	7	1.869	1.919	.091
	Within Groups		40.916	42	.974		
	Total		54.000	49			
Scope Clarification * Office/Center	Between Groups	(Combined)	7.767	7	1.110	1.442	.214
	Within Groups		32.313	42	.769		
	Total		40.080	49			