The Impact of the Modern Digital Tool BIM on Client Requirement Management: The Case of High-Rise Building Construction Projects in Addis Ababa

By Lensa Mulugeta

A Thesis Submitted to

The Department of Project Management

Presented in Partial Fulfillment of the Requirements for the

Degree of Master of Arts (Project Management)

Addis Ababa University

Addis Ababa, Ethiopia

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School of Graduate Studies

This is to certify that the thesis prepared by Lensa Mulugeta Negassa, entitled: *The Impact of The Modern Digital Tool BIM on Client Requirement Management: The Case of High-Rise Building Construction Projects in Addis Ababa* and submitted in partial fulfillment of the requirements for the degree of Master of Arts (Project Management) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Advisor

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Date: _____

DECLARATION

I, Lensa Mulugeta Negassa, hereby declare that this thesis entitled: **"***The Impact of The Modern Digital Tool BIM on Client Requirement Management: The Case of High-Rise Building Construction Projects in Addis Ababa***"** is my original work and has not been submitted to any other university or institution for the award of any degree, diploma, or certificate. All sources of materials used for the study have been duly acknowledged.

Name: _____

Signature: _____

Date: _____

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List of Abbreviations

Abbreviation	Full Form
AEC	Architecture, Engineering, and Construction
BIM	Building Information Modeling
CRM	Client Requirement Management
CRM2	Client Requirement Management (dependent variable in analysis)
DSR	Design Science Research
eRIM	electronic Requirements Information Management
IFC	Industry Foundation Classes
ISO	International Organization for Standardization
MBA	Master of Business Administration
MSc	Master of Science
PLM	Product Lifecycle Management
PLS-SEM	Partial Least Squares Structural Equation Modeling
P-P Plot	Probability-Probability Plot
Q-Q Plot	Quantile-Quantile Plot
RIBA	Royal Institute of British Architects
SPSS	Statistical Package for Social Sciences
TAM	Technology Acceptance Model

Abbreviation	Full Form
TOE	Technology-Organization-Environment
VIF	Variance Inflation Factor

ABSTRACT

High-rise building construction projects in Addis Ababa face persistent cost overruns, schedule delays and rework majorly caused by poorly managed client requirement changes. Although Building Information Modeling (BIM) is globally recognized as an effective digital tool for improving requirement management, its adoption in Ethiopia remains limited and its actual impact has not been empirically examined. Therefore, the study aimed to investigate the influence of six BIM parameters: - visualization, communication, information storage, requirement-model connection, assessment and traceability on the effectiveness of client requirement management in high-rise building construction projects in Addis Ababa.

The study employed a quantitative research approach using a descriptive and explanatory design. Data were collected from 120 BIM-experienced construction professionals including architects, engineers, quantity surveyors and project managers through structured questionnaires. Purposive sampling was employed and data were analyzed using descriptive statistics, Pearson correlation and multiple linear regression.

The findings revealed that all six BIM parameters have a statistically significant and positive effect on client requirement management ($R^2 = 0.799$, $F = 74.689$, $p < 0.001$). Assessment ($\beta = 0.305$) and communication ($\beta = 0.300$) emerged as the strongest predictors indicating that they have the greatest direct impact on client requirement management.

In conclusion, BIM significantly improves client requirement management by enhancing documentation, communication, evaluation and traceability of requirements throughout the project lifecycle. The findings provide empirical evidence to inform construction professionals, and educational institutions in promoting wider BIM adoption in Ethiopia.

Keywords: Building Information Modeling (BIM), client requirement management, high-rise buildings, construction projects, Ethiopia

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Construction projects often experience costly rework, project overruns and reduced efficiency when changes are not properly managed, particularly due to the dynamic nature of client requirements (Jallow et al., 2014c). Project changes are inevitable throughout the lifecycle of any construction project and often arise due to evolving needs, unforeseen constraints, or incomplete early-stage planning (Santiago, 2008). Change management is a major element of project management, as changes are among the leading causes of delay, disputes, and disruptions between stakeholders. The impacts of change are often difficult to quantify and frequently lead to disagreements during project execution (Automation in Construction, 2006).

In the construction industry, the objectives, needs, wishes, and expectations of the client are defined as client requirements (Kamara et al., 2002). Requirements may also be viewed as measurable statements of the client's needs that are transformed into architectural designs and subsequently into finished facilities, including being used to assess completed projects (Jallow et al., 2014a). Due to their dynamic nature, client requirements frequently evolve throughout the project lifecycle, and when such changes are not effectively managed, they often result in scope creep, miscommunication, rework, and reduced project performance.

Modern digital tools such as Building Information Modeling (BIM) have been increasingly promoted to address challenges related to client requirement change management. BIM enhances requirement management by enabling integrated communication & collaboration, real-time traceability, visualization of client needs, preventing data loss and inconsistency through information storage, assessment through digital evaluation and automated impact analysis of requirement changes capabilities that directly reduce misinterpretation and late-stage modifications (Jallow et al., 2014d).

Despite these advantages, Alemayehu (2025b) found that client requirement change management practices in Ethiopia are largely informal, reactive, and manual, leading to scope creep, misinterpretation of requirements, and stakeholder disputes. The study recommends the adoption of modern tools such as BIM systems to enhance requirement management.

However, the study did not investigate the underlying reasons behind the poor adoption of these tools, nor did it examine the actual impact of BIM where it is utilized.

In Ethiopia, particularly in Addis Ababa, the construction industry is experiencing rapid growth due to urban expansion and national development initiatives. However, numerous building construction projects continue to face cost overruns, time delays, and frequent scope changes caused by client requirement changes during the construction phase (Alemayehu, 2025a). The increasing number of high-rise building construction projects in Addis Ababa, characterized by their scale, technical complexity and involvement of multiple stakeholders, further intensifies the consequences of ineffective client requirement change management. To further explain the reason high-rise building projects were chosen is because they involve complex design coordination, multiple stakeholders and frequent client requirement changes (Jin ,2024) and high-rise building in Ethiopian context include buildings that are six floors and above (G+5 and above) according to Addis Ababa City Government regulation in year 2015.

Therefore, this study examined the impact of the digital tool BIM on client requirement management in high-rise building construction projects in Addis Ababa. While the overall adoption of BIM within the Ethiopian construction industry remains notably low, this research specifically focuses on projects where BIM has been implemented to evaluate its practical influence on requirement management processes.

1.2 Statement of the Problem

Despite the increasing number of high-rise building projects in Addis Ababa, the industry still faces persistent problems such as cost overruns, schedule delays, rework, and frequent disputes among stakeholders. Existing literature indicates that one of the major causes of these problems is poorly managed client requirement changes, which emerge along the construction lifecycle and significantly disrupt project performance (Alemayehu, 2025; Jallow et al., 2014). While modern project management tools such as Building Information Modeling (BIM) have been proven globally to enhance requirement traceability, improve collaboration, and increase responsiveness to change, their adoption within the Ethiopian building construction sector remains very limited (Alemayehu, 2025).

A study by Alemayehu (2025) indicates that the management of client requirements in Ethiopia is mainly manual, informal, and reactive in nature, and is characterized by weak documentation, inadequate stakeholder involvement, and poor change control mechanisms. The study identifies the potential of modern tools such as Building Information Modeling (BIM) to improve requirement management. However, the study does not provide empirical evidence on how BIM influences client requirement management practices in projects where it has been applied. As a result, there remains a clear knowledge gap regarding BIMs practical impact on managing client requirements within the Ethiopian construction context.

In Addis Ababa, the rapid increase in high-rise building construction projects has further intensified the challenges associated with managing changing client requirements. The scale, technical complexity and involvement of multiple stakeholders in such projects increase the likelihood and impact of requirement changes, making effective requirement management even more critical. Despite this, limited empirical research has focused on understanding stakeholders' perceptions of the importance of BIM and its impact on client requirement management practices in high-rise building projects in the city.

Hence, there is a need to investigate the effective use of Building Information Modeling (BIM) in the management of client requirements, particularly in relation to requirement documentation, communication, traceability, assessment and change control processes. In addition, there is a need to examine stakeholders' perceptions of the importance of BIM and to explore its impact on client requirement management practices in projects where it has been partially or selectively implemented. Addressing this gap will provide empirical evidence to support informed decision-making and is essential for improving requirement management effectiveness and enhancing the overall performance of high-rise building construction projects in Addis Ababa.

1.3 Research Questions

1. What is the impact of Building Information Modeling (BIM) on client requirement management in high-rise building construction projects in Addis Ababa?
2. In projects where BIM is applied, how does it affect communication, requirement traceability & assessment, change control, and decision-making?

1.4 Research Objective

General Objective:

The main objective is to examine the impact of modern digital tools such as Building Information Modeling (BIM) on client requirement management in high-rise building construction projects in Addis Ababa.

Specific Objectives:

- To evaluate the impact of BIM application on client requirement management in high-rise building construction projects in Addis Ababa.
- To assess how BIM's capabilities in communication, requirement traceability, change control, and decision-making influence client requirement management and its impact on rework, delays, cost overruns, and disputes

1.5 Significance of the Study

The study clearly found a gap left by prior research (like Alemayehu, 2025). While previous studies identified the problem and the potential solution, this research investigated the actual BIM impact on client requirement management in the specific context of Addis Ababa. In addition, the study contributes to evidence-based decision-making by providing practitioners such as architects, project managers, quantity surveyors, and engineers with empirical evidence to guide their adoption of BIM.

1.6 Scope of the Study

The study was delimited geographically to Addis Ababa, Ethiopia, as the city is experiencing rapid growth driven by urban expansion and national development initiatives which provided a rich context for exploring client requirement management challenges. High-rise building construction projects were specifically selected because client requirement changes are particularly acute and costly in these complex, large-scale developments, making them an appropriate focus for the investigation.

The research scope encompassed an evaluation of how BIM impacts Client Requirement Management (CRM), specifically assessing the impact of BIM through visualization, communication, information storage, requirement-model connection, assessment and traceability on client requirement management effectiveness.

The target population consisted of professionals involved in BIM-enabled high-rise projects, including architects, engineers, project managers, and quantity surveyors. Data were collected through a quantitative approach with 120 valid questionnaire responses analyzed quantitatively from BIM using firms.

The study was limited to BIM functionalities directly related to CRM processes and did not extend to BIM applications for facility management, sustainability or lifecycle cost analysis. Furthermore, the research did not cover non-BIM related causes of requirement management failure or projects outside the defined geographic and typological boundaries.

1.7 Limitation of the Study

This study was carefully designed to achieve its objectives though it encountered several limitations that should be considered when interpreting the findings. It has geographical limitation which is limited to Addis Ababa, Ethiopia, and focused exclusively on high-rise building construction projects. Consequently, the findings may not fully represent other regions within Ethiopia or other categories of construction projects such as residential, infrastructure or low-rise developments.

Due to the limited number of constructions actively utilizing BIM in Ethiopia, the sampling size and sampling technique of the study employed a purposive sampling technique rather than probability sampling. The final sample size is 120 respondents which is adequate for regression analysis but may not capture the full diversity of perspectives within the Ethiopian construction industry.

The study employed a cross-sectional research design which collected data at a single point in time. This limits the ability to establish causality or observe changes in BIM practices and client requirement management over time.

Even though the study has the above limitations it provides valuable empirical evidence on the impact of BIM on client requirement management in the Ethiopian construction context offering practical insights for stakeholders.

1.8 Organization of the study

This thesis is organized into five chapters each according to standard academic research format. The first chapter consists of the introduction part of the study which includes the background of the study, the statement of the problem, research questions, and objectives. It also briefly describes the significance, scope, limitations of the study and key.

The second chapter is 'Review of Related Literature' which consists of comprehensive review of existing theoretical and empirical literature relevant to the research topic. It also examines key concepts, theories and previous studies that exist in the development of the study's conceptual framework.

The third chapter is 'Research Methodology' which describes the research design and methods will be employed employ including the study area, target population, sampling techniques, data sources, collection instruments and the analytical methods and software to be used for data processing and interpretation.

The fourth chapter consists of Data Analysis, Presentation and Discussion. This presents the collected data, performs statistical analysis and will interpret the results including the findings discussed in relation to the research questions and the existing literature reviewed in Chapter Two.

The last chapter consists of Summary, Conclusion, and Recommendations of the study. It will summarize the major findings, draws conclusions based on the analysis and will provide practical recommendations for stakeholders and policymakers.

1.9 Definition of Key Terms

- **Client Requirement**: In the context of construction, client requirement is defined as the objectives, needs, wishes and expectations of the client (Kamara et al. (2002)).
- **Requirements management:** is a methodology that enables development teams to document, trace, analyze, prioritize and agree upon requirements throughout the end-to-end product development lifecycle.
- **Change Management:** Change management in construction is a structured process for formally identifying, evaluating, approving, and documenting any changes that occur during a project. It is a major element of project management as changes are major sources of delay, disputes and disruptions between stakeholders.

- **Building Information Modeling (BIM):** is the holistic process of creating and managing information for a built asset.
- **High-Rise Building Construction Projects:** is a multi-story structure in which most occupants depend on elevators (lifts) to reach their destinations

CHAPTER TWO: REVIEW OF RELATED LITERATURE

Introduction

This chapter focuses on comprehensive review of relevant literature related to client requirement management and BIM (Building Information Modeling) in construction projects. It examines the conceptual, theoretical and empirical basics for client requirements, requirement change management and BIM adoption barriers with main focus on their influence on project performance and stakeholder coordination. The chapter further reviews international, developing-country and Ethiopian empirical studies to identify existing knowledge gaps. It also provides the base for developing the conceptual framework and justifying the need for the present study.

2.1 Meaning and Nature of Client Requirement Management

2.1.1 Meaning of Client Requirements

To properly define what a client requirements in a construction project, we first need to understand what client actually is. According to Kamara et al. (2000), the client is considered a “body” that incorporates the interests of the buyer of construction services, prospective users and other interest groups. Therefore client represents multiple parties or stakeholders. These parties or stakeholders have vested interests in the project and may hold differing perceptions regarding the desired outcomes of the facility to be constructed (Kamara et al., 1999).

Client requirements are defined as the objectives, needs, wishes, and expectations of the client often referred to as the “voice of the client” (Kamara et al., 2002). These requirements form the basis upon which design and construction decisions are made. However, designers’ assumptions about how a product will be used or perform don’t always align with the actual expectations and experiences of the users. These requirements can also be regarded as measurable statements of the client’s needs that are transformed into architectural designs and then into a finished facility, also serve as a benchmark for evaluating the completed project’s performance (Demian & Baldwin, 2015).

Demian and Baldwin (2015) further distinguish between client requirements and technical specifications. Requirements represent the initial foundational inputs that are transformed into design and construction deliverables, whereas technical specifications are solution-specific outputs derived from processed requirements. Technical specifications primarily direct the construction work itself, but they are not designed to manage changes driven by the client. This difference explains why poorly managed requirements often lead to complexity and project difficulties, even when technical specifications are available, as specifications can quickly become misaligned with evolving client needs if the original requirements are not systematically tracked and updated Demian & Baldwin, 2015, pp. 505, 508).

Ineffective requirement management is often associated with project failures (Wiegers and McKinsey, 2005). Therefore, managing client requirements is a critical process in any construction endeavor. According to the Office of Government Commerce (2009), client requirement management involves the elicitation, documentation, organization, tracking, and communication of requirements information across various stakeholders and project teams. Developing and managing requirements is challenging particularly in managing them after they have been initially defined (Wiegers and McKinsey, 2005).

Ultimately, managing client requirements is viewed as an essential project management activity. It ensures the information about client needs and expectations handled in a structured and disciplined way throughout the entire building lifecycle which includes the design, construction, operation, maintentance and eventual demolition (Demian and Baldwin, 2015). Therefore effective management of client requirements is fundamental to ensuring the project outcomes align with client expectations and consequently, to achieving overall project success.

2.1.2. Nature and Characteristics of Client Requirements

Client requirements in construction projects by their nature are stakeholder-driven and often described as the “voice of the client,” representing the collective desires and expectations of the various stakeholders involved, implying it possesses distinctive characteristics (Kamara et al., 2002). The distinctive characteristics of client requirements presented as follows.

- **Dynamic and evolving**: Client requirements are not fixed; they frequently change significantly throughout a bulding's lifecycle and continue to shift as a project progresses. Since they are always subject to modification, any documentation of these requirements must be able to accommodate the evaluation and implementation of changes (Aouad & Arayici, 2010).
- **Measurability and assessment**: Client requirements are considered as measurable statements of a client's needs. They form a base for architectural design and the subsequent development of the finished facility. Ultimately, they are used to review the success and performance of the completed project (Kamara & Anumba, 2000).
- **Variable granularity**: Client requirements vary in their level of precision and detail. As the project progresses from early conceptual ideas to detailed design and construction, the amount of detail in requirement information increases (Royal Institution of British Architects [RIBA], 2012).
- **Information intensive**: Client requirements involve gathering of a large amount of information from multiple sources. This information includes project objectives, functional requirements, performance expectations, operational needs, and after occupancy considerations, where all this information must be organized and managed effectively. (RIBA, 2007).
- **Project-specific**: Client requirements depend on the unique demands, priorities and expectations of the clients and end users involved. This makes it highly specific to each project (Engineering, Construction and Architectural Management, Vol. 21 No. 5, 2014).

2.1.3 Client Requirement Change in Construction Projects

Due to the complex nature of building processes and the involvement of many different people, client requirements frequently evolve throughout a project's duration. There are several reasons identified for this changes to occur which are grouped into three categories (Mahat & Adnan, 2018).

The first reason for requirement change is client and Briefing Related Causes. Limited initial briefing and unclear project objectives are major causes of later changes. In other words, when early instructions are poorly prepared with limited communication and when clients

struggle to clearly express what they want leads to change requests later on (Mahat & Adnan, 2018).

Furthermore, evolving and uncertain client needs such as varying business priorities, unrealistic expectations and rigid or inconsistent leads to requirement changes (Nega, 2024). These problems are often made worse when the project team doesn't fully understand the client's needs including designers and builders might misinterpret client intentions because of poor communication, insufficient collaboration or a lack of organized documentation for requirements (Ameri & Nasaruddin, 2020). Issues within the client's organization or with their staff can also trigger requirement changes. Changes in authority structures, replacement of key client representatives and involvement of inexperienced or unprofessional clients can result in the redefinition of project requirements (Alemayehu, 2024).

The second reason for requirement change is design, coordination, and management related causes. Errors in design, omissions, or poor-quality documentation frequently necessitate corrections and redesign, which are often seen as changes in client requirements (Gharaibeh, 2020).

A lack of coordination and ineffective communication among clients, consultants, and contractors has consistently been ranked as one of the most significant drivers of changes in construction projects (Ameri &Nasaruddin, 2020). Additionally, weak practices for managing risks and requirements such as relying on manual methods, having disconnected information systems, absence of tracking requirements throughout the project's life, or barely using digital tools like Building Information Modeling (BIM) make it difficult to keep evolving client needs stable and control the effects of changes (Ameri &Nasaruddin, 2020).

The third reason for requirement change is external and contextual factors. These changes include requlatory updates, market fluctuations, adoption of new technologies and changes in economic (Gavanmukulya, 2024) which are usually beyond the direct control of project teams even though they strongly influence the project's scope and decision-making.

2.1.3.1 Relationship between Client Requirement Changes and Project Performance

Design and requirement changes have been shown to account for approximately 56.5% of cost overruns and 40% of schedule delays in large construction projects (Ramadhan & Waty,

2025). Other studies report average cost increases ranging from 8% to 34% and time delays of approximately 29% in projects with many change orders (Yap & Skitmore, 2017). Similarly, cost and time increases by 5-20% due to design changes, with costs climbing by an average of 23.8% when changes occur after the contract is signed (Gunduz and Mohammad, 2019).

Apart from affecting costs and timelines, requirement changes negatively impact how much work gets done, the quality of that work, and relationships among everyone involved. Change orders disrupt the work process, causing workers to be less productive and leading to more tasks rework (Lee, 2025). Harmful effects have been observed in many areas, including budget, schedule, quality, how efficiently organizations operate, and how often disagreements arise. Frequently reported outcomes in various situations include having rework, late payments and contractual disputes and reduced project efficiency (Gunduz & Mohammad, 2019).

2.2 Importance of Effective Client Requirement Management and the Digital Model BIM

2.2.1 Client Requirement Management Importance to Project Performance

Effective client requirement management is essential by helping keep projects on schedule and within budget, ensures quality results, and significantly contributes to the project's enduring value. According to Thomson (2011), there is a higher risk of uncontrolled scope expansion, the need for rework, and subsequent disagreements when initial requirements lack clarity. Converting client requirements into clear and unbiased guidelines through well-structured frameworks is crucial since they support simultaneous engineering efforts by increase the quality of design decisions and improve at the ability to track progress throughout the entire project lifespan which leads to overall project outcomes increase (Kamara et al., 2000).

Furthermore, a strong requirement management helps in minimizing unnecessary errors, project delays and potential disagreements. As emphasized clearly by Jallow (2014) for ensuring project stability and achieving desired results, a well-defined and managed requirement is required which helps facilitate early risk prevention, significantly reduce last-minute modifications and minimizes the need for rework or contractual disputes.

2.2.2 Importance to Stakeholder Coordination and Communication

Effectively managing what clients need is crucial for stakeholder coordination and well communication. These requirements lay out the project's purpose, its goals and performance expectations. They form the essential groundwork for all decisions related to design, construction and operation (Jallow, 2014).

Confusions occur about the project's main goals and team roles when client needs are vague, fragmented or not regularly updated. This frequently causes internal disagreements, ensures teams work towards different ends and creates varied ideas of what project success truly means, even when the project stays on schedule and budget (Thomson, 2011).

Furthermore, digital platforms such as BIM (Building Information Modeling) systems and web-based collaboration tools allow for real-time sharing, visual representation and easy tracking of client needs among all parties. These technologies help reduce manual error, ensure aligned information update and significantly improve how different professional teams coordinate their efforts (Prebanic & Vukomanovic, 2021).

2.2.3 Importance of Client Requirement Management in High-Rise Building Construction Projects

High-rise building projects are known for their complex structure, advanced building services, strict safety regulations and high-performance expectations. The successful completion of these building projects relay on client needs that are clearly defined with continuously communicated and managed (Jin, 2024). According to Jin (2024), inadequate management of client needs in these projects result in substantial significant rework, safety risks, cost overrun and schedule delays.

In conclusion the above mentioned researches shows that effectively managed client needs are essential for achieving better project execution, better coordination among all stakeholder and

Successfully delivery of complex building projects by meeting performance objectives related to cost, time, quality, and client satisfaction.

2.2.4 Importance of BIM

2.2.4.1 Nature of BIM

BIM (Building Information Modeling) is defined as a digital representation of the physical and functional characteristics of a built asset that serves as a shared knowledge resource and a reliable basis for decision-making throughout the asset life cycle (Azhar, 2011). Importantly, BIM isn't solely about software applications rather, it broadly encompasses both inderlying data model and the various methods used to create, manage, share, and utilize that information among all involved parties (Azhar, 2011). BIM also operates as a socio-technical system bringing together technology, consistent data formats and collaborative teamwork which influence the role of organizations, contract agreements and professional responsibilities in the construction industry (Turk, 2016).

Furthermore, BIM allows for the seamless integration of information across different specializations and project stages through utilized common data exchange standards. This helps to overcome the fragmentation of information's often seen in the architecture, engineering and construction (AEC) sector (Adepoju, 2020).

2.2.4.2 Importance of BIM in Construction Management

Building Information Modeling (BIM) in construction project management operates as information environment supporting planning, coordination, control and lifecycle management. It helps in interdisciplinary cash detection to eliminated design error and reducing the need for on-site corrective work by integrating data form the disciplines of architectural, structural, mechanical, electrical and plumbing (MEP) (Rui et al., 2021).

Furthermore, BIM enhances planning accuracy, resource allocation and financial control by supporting time and cost management through its 4D and 5D modeling capabilities which involves linking building components with project schedules and cost data (Rui et al., 2021; Farouk & Rahman, 2023). Also it significantly contributes to risk management, quality control, sustainability assessment and facility management by providing consistency, accessibility and reusable project information across the asset lifecycle (Yilmaz et al., 2024).

Beyond project delivery, BIM contributes to risk management, quality control, sustainability, assessment, and facility management by providing consistent, accessible, and reusable project information throughout the operational life of the project (Yilmaz et al., 2024).

Moreover, centralized BIM environments foster higher collaboration and overall project governance achieved by streamlining communication among clients, designers, contractors and facility managers, often orchestrated through well-defined BIM management roles and integrated project delivery methodologies (Wang & Chen, 2023).

2.2.4.3 BIM and Client Requirement Change Management

Client requirement changes are a major source of cost overruns, delays and rework in construction projects. (Alemayehu, 2025). BIM offers a structured platform for documenting, organizing and associating client requirements with specific building elements, spatial arrangements and systems. It also enhances requirement traceability by linking qualitative and quantitative client demands to model objects using standardized data structures by enabling comprehensive impact assessments when changes are proposed (Baldauf et al., 2020).

Client-initiated changes can be recorded, visually represented and evaluated for time and cost implications before approval to promote greater transparency and more informed decision making by integrating BIM with formal change management protocols (Mejlænder-Larsen, 2017). Using BIM coordinated with strong client involvement will also reduce waste and rework associated with change orders which depends on client capability, clear information requirements and adequate organizational and technical readiness (Georgiadou, 2019; Pan et al., 2023). The following BIM characteristics are directly linkend to the effectiveness of managing client requirements according to Mejlænder-Larsen , (2017).

- Visualization

  BIM increase the knowledge of client requirements through 3D (three dimensional) representations of space, component and system allowing clients and project stakeholders for better understanding of design's intent. It also identifies potential issues early and evaluates the implications of design changes which are very helpful

for clients with limited technical backgrounds since visual model lessen confusion and misunderstanding

- Information storage and retrieval
  BIM enables the creation of centralized digital warehouse where client requirements can be systematically documented, updated and reused. It reduces the risk of information loss and inconsistency by allowing requirements to be linked directly to building elements from the storage/warehouse. Also the storage supports knowledge reuse across similar projcts and improves continuity throughout the project life cycle.
- Connection between requirements and building elements
  This linkage enables requirements to be treated as actionable constraints built into the design instead of abstract statement. This helps project team to rapidly pinpoint requirements change and affected elements then evaluate design implication.
- Assessment and compliance checking
  BIM supports the evaluation of design solutions against defined client requirements through manual or automated checking processes which is essential for quality assurance. Whether it is automated or semi-automated assessment, it reduces reliance on subjective judgment, reduces errors and improves design consistency which is more helpful regulatory and institutional requirements.
- Communication and collaboration
  BIM facilitates easier sharing of up-to-date requirement information with the stakeholders which is essential while handling changing or conflicting client requirements.
- Traceability of requirements and changes
  Through time BIM helps in tracking the origin, modification history and status of client requirements. Where there is frequent involvement of client requirement changes, traceability supports accountability, increases clarity in decision-making and helps in better understanding of design changes.

2.3 Scope, Process, and Stages of Client Requirement Management

2.3.1 Scope of Client Requirement Management

Client Requirement Management (CRM) encompasses all information concerning the needs of clients and end-users and how these needs are addressed across various stages of a facility's lifecycle including client, user and lifecycle requirements along with the processes for documenting, storing, accessing, distributing and updating requirements information all over project phases and stakeholder groups (Jallow, 2014).

CRM included both the initial definition of requirements and their ongoing management, including change control, impact assessment and traceability. Effective CRM also ensures the systematically evaluation and communication requirement changes, which helps prevent misinterpretation and inconsistency among stakeholders. Importantly, even once the design phase is complete, CRM should continue throughout the entire construction lifecycle including operation, adaptation, and eventual decommissioning (Jallow, 2017).

2.3.2 Process and Stages of Client Requirement Management

According to Jallow, (2017) CRM involves a series of interrelated stages that support the systematic handling of requirements throughout the project lifecycle. These stages involved in managing client requirements include:

A. Context and stakeholder analysis which involves identifying business objectives, user needs, constraints and stakeholder roles.
B. Capture and definition - This stage collect and articulate requirements through briefing sessions, interviews, and observation.
C. Analysis and structuring - This stage focuses on clarifying, categorizing, prioritizing, and resolving conflicts among requirements.
D. Translation - This crucial step involves converting the "voice of the client" into precise and measurable specifications that are independent of any particular solution.
E. Storage and communication – This stage focuses on maintaining a centralized source and sharing requirements information with relevant parties.
F. Monitoring and change management – this final stage involves tracking changes, assessing impacts and ensuring compliance that ensures all changes are implemented correctly.

This process is iterative rather than linear as requirements are continuously reviewed and refined in response to evolving client needs and project conditions.

2.3.1.1 Lifecycle Perspective and Digital Support

Adopting a lifecycle-oriented approach to CRM, in which requirements are managed from project preparation and briefing through design, construction, operation, and decommissioning vary crucial (Jallow, 2017). However, current practices in many developing contexts, including Ethiopia, remain largely manual and paper-intensive, characterized by fragmented documentation, limited traceability and weak change impact analysis (Alemayehu, 2025).

To address these limitations, researchers have proposed the adoption of enterprise architecture and electronic Requirements Information Management (eRIM) frameworks, integrated digital repositories and BIM-based requirement management methods. Such advanced approaches have already been successfully applied in sectors such as social housing and healthcare. They allow client requirements to be directly linked to 3D models, facilitating continuous evaluation and control of changes throughout the entire project lifespan (Jallow, 2017). These digital tools hold significant potential for enhancing transparency, coordination and responsiveness in client requirement management.

2.3.3 Challenges in Client Requirement Management

Even though managing client requirements (CRM) is crucial, it frequently encounters common difficulties in construction projects. These often issues include inadequate end-user involvement, insufficient time allocated for briefing, unclear or incomplete requirement documentation, misinterpretation of client needs, late or poorly timed requirement changes and the absence of robust methods and digital tools to support systematic requirement management (Alemayehu, 2025).

The literature recommends several measures to address these challenges. These include the adoption of structured briefing and requirement processing models, such as Client Requirement Processing Models (CRPM) and value-based frameworks; the use of centralized digital repositories; the integration of CRM processes with BIM platforms: and improved training and capacity building in requirement management practices (Jallow, 2017). Implementing these measures can significantly enhance the effectiveness of CRM and reduce the negative impacts of requirement changes on project performance.

To tackle these issues, research suggests several approaches including implementing structured ways of handling initial briefings and processing requirement models such as client requirement processing models (CRPM) and value-based frameworks, the use of centralized digital repositories, the integration of CRM processes with BIM platforms and improved training on capacity building in requirement management practices will significantly reduce the negative impacts of requirement changes on project performance. (Jallow, 2017).

2.4. Theoretical Frame Work

2.4.1 Change Management Theory in Construction

2.4.1.1 Nature and Causes of Change in Construction Projects

Change in construction involves adding, removing, or modifying scope, design, specifications or initial assumptions. Such modifications are usually documented and approved through formal “change orders” or “variation instructions” as in project execution (Hao et al., 2008).

Causes of Change are systematically classified into multiple categories which include client-driven decisions, design errors and omissions, inadequate site investigations, contractor-related issues, external environmental conditions and technological shifts (Birgonul et al., 2024).

The literature provides systematic taxonomies that classify the causes of change into multiple categories, including client-driven decisions , design errors and omissions, inadequate site investigations, contractor-related issues, external environmental conditions, and technological shifts (Birgonul et al., 2024). Large-scale empirical studies which examined between 3,951 and

over 5,000 change instances across multiple projects indicate that the majority of changes occur during the feasibility, design and planning stages rather than during construction execution. This finding shows that how vital it is to clearly define requirements early on and to have proactive change control mechanisms (Padala et al., 2020).

2.4.1.2 Impacts of Change on Project Performance

Poorly managed changes consistently lead to negative project performance outcomes. From a cost perspective, uncontrolled changes lead to budget overruns and weak cost control mechanisms (Bitamba & An, 2020). Regarding schedule performance, changes frequently cause delays and require extensions that are difficult to make up impacting the entire project delivery schedule.

Change also negatively affects construction quality by increasing defects, rework and non-conformance to specifications. At the same time, they raise project risks and disputes leading to productivity losses. (Bitamba & An, 2020). Additionally real-world evidence from various contexts such as Singapore, Nigeria, Congo, and India show that well-implemented change management practices are linked with improved cost, time, and quality outcomes, higher use satisfaction and enhanced overall project performance (Hwang & Low, 2012).

2.4.1.3 Change Management Theories and Tools

Various theories and models have been developed to manage change effectively in construction. Systems dynamics and model-based approaches focus on how changes, rework, productivity and schedules influence each other in a continuous cycle. In addition they allow teams to predict the downstream impacts of changes and support proactive policy and decision-making (Park & Pefia-Mora, 2003).

Change management frameworks that focus on process view change as an ongoing cycle involving anticipation, recognition, evaluation, resolution and learning. By building change management into standard project workflows, ensure structured responses to changes, rather than just reacting to them as they happen (Hao et al., 2008).

Recent studies also point out the role of agility and digitalization in managing change. Agile principle such as flexible workflows, continuous client involvement and iterative learning increase a project team’s capacity to respond effectively to evolving requirements. Simultaneously adopting Building Information Modeling (BIM) in particular requires clear change management strategies. These strategies are needed to manage the technical, organizational, and cultural adjustments that associated with using digital tools (Arefazar et al., 2019).

2.4.2 Requirements Engineering Theory

2.4.2.1 Core Requirements Engineering Constructs for Construction

An evidence-based theory of Requirements Engineering by Wagner (2018) pinpoints that recording, modification oversight and tracking technologies as key elements relavant to various fields including construction. This theory's primary RE activities include requirement elicitation, documentation, change management and continuous improvement supported by enabling technologies such as traceability methods and formal change control tools (Wagner, 2018).

2.4.2.2 Traceability as a Theoretical Mechanism

Requirement traceability stands as a fundamental concept in Requirements Engineering theory and refers to the ability to create and maintain explicit links between requirements and other project elements like design components, cost estimates, schedules and implemented building elements. Traceability facilitates examination of interdepend analysis and verification of compliance with client needs (Jallow, 2014).

In construction projects lack of systematic traceability of requirement changes lead to making the process error-prone and highly dependent on individual experience. Jallow et al (2014) highlighted that document-centric and non-granular storage of requirements significantly limits effective traceability and change impact analysis in practice.

Foundational RE literature further distinguishes between pre-specification traceability and post-specification traceabiltity. Pre-requirements specification traceability is particularly critical in managing evolving client needs and identifying the origins of changes especially during early project stages where decisions have the significant impact (Gotel & Finkelstein, 1994).

2.4.2.3 Requirement Documentation and Layered Views

Requirements Engineering theory underscores the necessity of documentation in a structured, consistent and high-quality manner. In construction, requirements are commonly stored as textual briefs, drawings, tender documents and specifications. Poor inconsistent structure in documentation have been strongly associated to subsequent failures in cost control, schedule performance and quality delivery (Jallow, 2014).

Layered documentation and traceability introduced by contemporary RE theories treats documents as different perspectives over a common set of requirements. Strong relationship among documents supports reuse, consistency checking and automated validation across project artifacts (Großer et al., 2022).

Within the construction sector, similar concepts are reflected in developing frameworks for structured estimation documents and BIM data requirements. These frameworks establish identifiers and relationships to support reliable cost estimation and alignment between two-dimensional and three-dimensional representations (Karakozova, 2022).

2.4.2.4 Change Control as Requirement-Driven Configuration Management

In Requirements Engineering theory, change control is treated as a requirement-driven process of configuration management and requirements are seen as the primary source of design and configuration changes through project components, activities, schedules, and resources (Padala & Maheswari, 2022).

Frameworks for change management that are matrix-based and requirement-driven have been developed to predict the ripple effects of requirement changes on project configuration and schedule performance, formalizing change control processes and reducing reliance on subjective expert judgment alone (Padala & Maheswari, 2022).

2.4.2.5 Theoretical Basis of BIM in Requirements Engineering

BIM integrates building models with design, construction and operation enabling requirements to be embedded, traced and validated throughout the lifecycle (Succar, 2009). Additionally, information management theory frames BIM as a shared, non-redundant repository that supports the capture, storage, validation and retrieval of requirement related information to improve information quality, quantity and accessibility key mediators between BIM use and project performance (Chen & Lu, 2019).

Furthermore, systems and lean thinking approaches highlight BIM's role in supporting value generation by facilitating structured requirement capture, communication, evaluation and continuous alignment with client objectives. Therefore the significance of Building

Information Modeling (BIM) in requirements management is theoretically grounded in information management theory, systems thinking and value-generation principles. BIM is not only used as a three-dimensional modeling tool but aso as an integrated information infrastructure that links stakeholder requirements to product and process models throughout the project lifecycle.

(Baldauf et al., 2021).

2.4.3 Information Management and Systems Theory

Construction projects are commonly understood as complex and dynamic systems composed of interacting technical, organizational and informational subsystems. These subsystems are interdependent inevitably spread through the entire project system. (León-Romero, Aguilar-Fernández, Luque-Sendra, Zamora-Polo, & Francisco-Marquez, 2024)

Structural information models are used to illustrate these interdependencies by linking functional subsystems of production and management. Such models establish logical relationships between information modules, management functions and system states, enabling coordinated control and decision-making across project phases. This system based perspective highlights that information structures are not just passive records; they actively influence how a project is shaped (Arutiunian, 2020).

Approaches like system dynamics and systems thinking are widely applied in construction research to model feedback loops, delays and non-linear behaviors affecting risk, productivity waste and quality performance (Wu, Yang, Lai, & Antwi-Afari, 2020)

System dynamics and systems thinking approaches are widely applied in construction research to model feedback loops, delays, and non-linear behaviors affecting risk, productivity, waste, and quality performance showing how poor or delayed information feedback amplifies project problems, while integrated information flows promotes adaptive and resilient project management (Wu, Yang, Lai, & Antwi-Afari, 2020).

In addition, the quality of information especially accuracy, integrity, consistency and timeliness is identified as a critical system property influencing managerial decisions and overall project performance. Fragmented, outdated or inconsistent information lead to coordination failures, rework and inefficiencies (León-Romero et al., 2024).

2.4.4 Technology Adoption Theories

The Technology Acceptance Model (TAM) explains technology adoption at the individual level, proposing that Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) shape users' attitudes and behavioral intentions, which in turn determine teir actual use of system (Sanchís-Pedregosa, Vizcarra-Aparicio, & Leal-Rodríguez, 2020). Also in contruction sector, TAM has been applied to explain designers', engineers' and project managers' willingness to use BIM for tasks such as coordination, information sharing, and requirement documentation (Sanchís-Pedregosa, Vizcarra-Aparicio, & Leal-Rodríguez, 2020).

However, TAM alone is limited in explaining BIM adoption in construction projects because adoption choices are often organizational rather than purely individual. To overcome this, the Technology Organization Environment (TOE) framework extends the analysis to organizational and environmental factors. It identifies three contextual dimensions influencing adoption which are the technological factors, the organizational and the environmental factors (Chen, Yin, Browne, & Li, 2019).

In BIM adoption the Combination of TAM and TOE models are more useful for linkage of user attitudes iwht organizational readiness and external pressures (Qin, Shi, Lyu, & Mo, 2020).

2.4.5 BIM as a Theoretical Enabler

2.4.5.1 BIM as an Enabler of Integrated Management Theories

BIM acts as a core information backbone that enables the integration of Lean Constrruction, Product LifeCycle Management (PLM) and digital transformation concepts into unified construction management systems and viable-system models of project organizations (Alnajjar, Atencio, & Turmo, 2025). It helps align coordination throughout design, construction and operation enabling systematic approach on handling client requirements, changes and performance data.

Theoretical models that combine BIM with project management view BIM's features as visualization, data richness, interoperability and real-time information exchange that link project phases and management functions across the lifecycle (Olawumi & Chan, 2019).

These elements clarify how BIM can enhance how requirements are communicated, how progress is tracked and how choices are made in intricate projects.

BIM is also considered as a single, non-redundant information source and a reference system for structuring project information flows, performance indicators and accountability mechanisms. It helps supports the formal documentation and linkage of client requirements to design elements, schedules and cost estimation (Yang, Han, Zeng & Sun, 2021).

Such theoretical viewpoints establish BIM as a key facilitator integrated information management, client requirement traceability and structured change control which directly aligns with the objectives of the current study.

2.5 Review of Empirical Studies

2.5.1 International Empirical Studies

2.5.1.1 Empirical study on the use of BIM to manage client requirements in social housing projects in Brazil (Baldauf et al., 2020)

A study by Baldauf et al. (2020) empirically investigated the application of Building Information Modeling (BIM) in administering client requirements within social housing projects in Brazil. The study adopted a Design Science Research (DSR) approach combined with an in-depth single case study. The collection of data was through project document analysis, stakeholder workshops and iterative development and validation of a BIM-based requirements management process model.

A key outcome of this study was the formulation of a structured process model for managing client requirement, elicitation, structuring, modeling, validation, and monitoring. Furthermore, nine constructs were proposed to assess the use of BIM for requirements management. The empirical findings elucidated that BIM possesses the capability to effectively connect diverse client demands including qualitative attributes qualitative, social , and environmental needs to building elements and spaces using IFC standards. This integration consequently facilitates comprehensive requirement traceability and compliance verification throughout the entire project lifecycle.

The proposed BIM-based guidelines improved decision-making and value generation under the cost constraints typical of social housing projects. Since the findings are based on a single case and are context-specific the author noted the generalizability to other project types and geographic contexts are limited. Also the study identified significant challeges, including the large volume of qualitative requirement information, the diversity of user profiles and the limited maturity of industry practices in systematic requirement management.

2.5.2 Empirical Studies in Developing Countries

2.5.2.1 Empirical study on investigating the benefits of Building Information Modeling (BIM) in Nigeria

The study by Daoud et al. (2025) explored the benefits of Building Information Modeling (BIM) for sustainable construction using the developing-country Nigeria as the study setting. The study aim was to examine how BIM contributes in project performance improvement and in identifying the major barriers limiting its adoption in construction industries which are characterized by resource constraints and fragmented practices.

The research was base on quantitative research design where questionnaire survey was used to administer construction professionals. For data analysis, Exploratory Factor Analysis and Parital Least Squares Structural Equation Modeling (PLS-SEM) was used. This helped to assess the relationships between BIM adoption and sustainable construction outcomes so that the researcher empirically tests the influence of BIM-related capabilities on project performance indicators relevant to developing economies.

In the finding, implementing Building Information Modeling (BIM) significantly enhances the overall success of construction projects. It also improves the quality of projects by helping to identify clash detection, reduced design errors and minimized rework. Moreover, it enhances time performance and productivity through better planning and coordination. BIM also promotes improved communication, collaboration and documentation which support integrated project delivery and well-informed decision-making throughout a project's entire lifecycle. Additionally it contributes to optimized material use and reduced waste fostering more sustainable building practices.

Even though the clear advantages, BIM adoption remains somewhat limited due to insufficient technical expertise, high implementation costs, lack of standardized protocols, weak institutional support and resistance to change from traditional 2D practices. While the current research offers valuable insights into the perceived advantages of BIM, especially in developing regions.

This current research offers valuable insights into the perceived advantages of BIM, especially in developing regions: it does not provide quantified project performance results. Furthermore, the study doesn't specifically explore BIM's role in handling client requirements, including aspects like documenting needs, ensuring their traceability and change control.

2.5.3 Empirical Studies in Ethiopia

Empirical research on client requirement management and the use of contemporary digital tooks in the Ethiopian construction sector remains limited. Alemayehu's (2025) study examined the practice of how changing client requirements managed in Ethiopian building projects using a questionnaire-based survey. The study shows that the practice of requirement management is largely manual, unstructured and reactive, characterized by poor documentation, weak communication and ineffective change control leading to contribute to cost overruns, schedule delays, rework and stakeholder conflicts.

Alemayehu's study recognized the potential of advanced tools like Building Information Modeling (BIM) for better managing client management thought it noted that BIM's practical adoption in the sector was still remains limited. In addition, the study research didn't delve into 'why' BIM adoption was so minimal, nor did it measure BIM's actual impact on requirement management in the few instances where it has been applied.

2.6 Conceptual Framework of the Study

The conceptual model is derived accordingly to the above reviewed literature. Client requirement is center of the study which makes it the dependent variable. BIM is the interdependent variable with multi-dimensional parameters to help determine impact in client requirement. These parameters are visualization, information storage, requirement-model connection, assessment, communication and traceability. The parameters has influence on key

project-related outcomes, such as effective client requirements management, minimized design changes, improved coordination and enhance project performance.

The BIM parameters act as enabling mechanisms in capturing, communicating, evaluating and controlling of client requirements and reducing ambiguity, minimizing errors and improving decision-making throughout the project life cycle. The conceptual framework aims to provide guide to empirical investigation using quantitative methods.

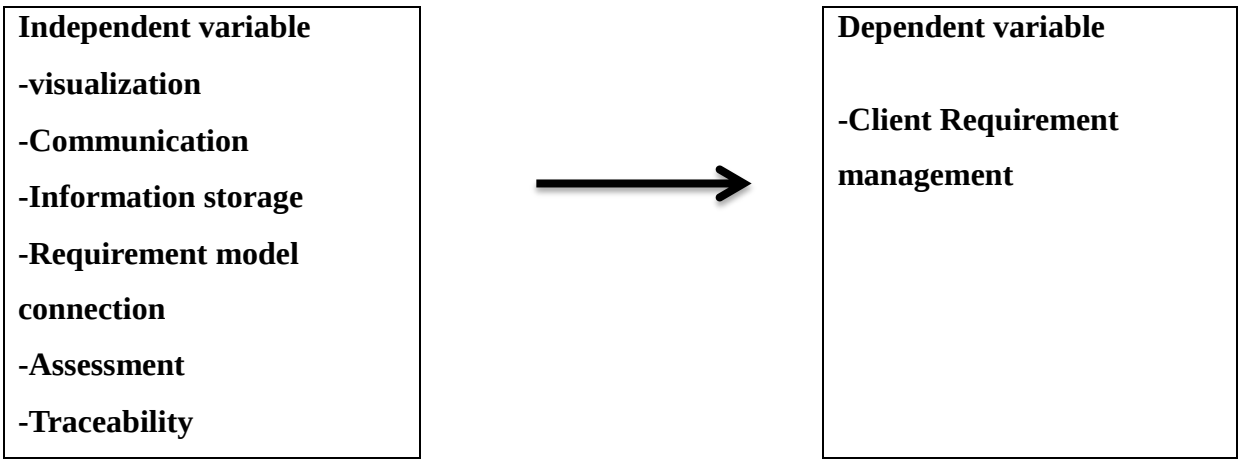


Figure 2.1 conceptual model diagram

2.7 Research Hypotheses

The following hypotheses were developed based on the conceptual framework and the reviewed literature

H1: Visualization capability of BIM has a significant positive effect on Client Requirement Management in high-rise building projects.

H2: Communication and collaboration capability of BIM has a significant positive effect on Client Requirement Management in high-rise building projects.

H3: Information storage capability of BIM has a significant positive effect on Client Requirement Management in high-rise building projects.

H4: Requirement–model connection capability of BIM has a significant positive effect on Client Requirement Management in high-rise building projects.

H5: Assessment and compliance capability of BIM has a significant positive effect on Client Requirement Management in high-rise building projects.

H6: Traceability capability of BIM has a significant positive effect on Client Requirement Management in high-rise building projects.

CHAPTER THREE: RESEARCH METHODOLOGY

Introduction

This chapter focuses on research methodology which is adopted to achieve the objectives of the study describing the overall research design and approach, the study variables, the study area and target population, sampling techniques and sample size determination, data collection methods, data analysis techniques, reliability and validity tests and the ethical considerations.

The methodology of this study is designed to address the objectives systematically with valid, reliable and credible findings.

3.1 Research Design and Approach

A research design may be defined as the general framework which specifies the structure of how the research will be carried out in order to address the research questions or objectives in a logical manner, thus providing an outline on how to collect, analyze and interpret data so that the research becomes systematic and replicable, being consistent with the objectives of the research (Creswell, 2014). Also the research approach refers to the overall approach which guides the research and includes qualitative, quantitative and mixed approaches (Creswell & Plano Clark, 2017).

The study adopted a qualitative research approach which integrates quantitative methods to achieve a comprehensive understanding of the role of Building Information Modeling (BIM) in managing client requirements in building construction projects. This approach captured the measurable relationships and contextual insights. It employed an explanatory research design which examined the effect of BIM adoption through each parameter on effectiveness of client requirements management which is implemented through structured questionnaire and statistical analysis.

Therefore, the research is a cross sectional research strategy since data will be collected at a single point in time from construction professionals who are involved in building projects.

The study involved measurable relationships to provide practical insights. The measurable relationships included how BIM parameters like visualization, traceability, communication

,assessment, information storage or requirement influence effective client requirement management providing rich descriptions leading to established evidence of relationships between the dependent variable Client requirement management and the six independent BIM variables and BIMs effect.

3.2 Description of study variables

The study has two variables, client requirement being the dependent variable and the digital tool BIM as an independent variable. This independent variable consists of six measuring parameters which are described in the following table.

Independent variable	BIM measuring parameters	Description	Questionnaire Indicators
Digital tool BIM	Visualization	Extent to which BIM improves understanding of client requirements through 3D models	- BIM improves visualization of client requirements. - BIM helps clients understand design changes clearly.
	Information Storage	BIM's ability to store and retrieve client requirement information	-BIM is used as a repository for client requirements. - Previous project requirements can be reused through BIM.
	Connection between requirement and building elements	Ability of BIM to link client requirements with building elements	- Client requirements are linked to BIM model elements. -Changes in requirements are reflected in the model.
	Assessment	Use of BIM to check whether designs meet client requirements	-BIM is used to assess design compliance with client requirements. - BIM reduces errors during design evaluation.
	Communication	BIM support for information exchange among stakeholders	-BIM improves communication among project participants. -BIM supports sharing up-to-date client requirements.

Independent variable	BIM measuring parameters	Description	Questionnaire Indicators
	Traceability of requirements	Ability to track changes and origins of client requirements	- BIM enables tracking of requirement changes. BIM records who made changes and when.

Table 1.1 tables of independent variables

3.3 Description of the Study Area and Target Population

This research is conducted in Addis Ababa, the capital city of Ethiopia, since it has a rapid urbanization and numerous public and private building projects. The city has experienced significant growth in high-rise and large-scale developments which makes it an appropriate location for studying the role of Building Information Modeling (BIM) in managing client requirements . The reason High-rise building projects were chosen is because they involve complex design coordination, multiple stakeholders and frequent client requirement changes (Jin ,2024).

The target population of the study consisted of construction professionals working in BIM-user contractor and architectural design companies operating in Addis Ababa .These firms were selected because BIM adoption in Ethiopia is still limited and only a relatively small number of firms actively utilize BIM in project delivery. The selection and identification of these companies are through their publicly available company portfolios and involvement in large-scale and high-rise building projects.

This study specifically addressed individuals who actively participate in BIM-based projects. These individuals included architects, engineers, quantity surveyors and project managers. These professionals were considered appropriate since they have practical experience in BIM implementation and client requirement management within building construction projects. Focusing on BIM-user companies engaged in complex projects ensures that the collected data is relevant to evaluating the impact of BIM capabilities on client requirement management effectiveness.

3.4 Sampling Technique and Sample Size

A purposive sampling technique is used in this research to select respondents who have prior knowledge and experience in Building Information Modeling (BIM) and client requirements management. Since BIM adoption in the Ethiopian construction industry is still limited and concentrated within a relatively small number of firms and professionals, Purposive sampling is considered appropriate, implying not all construction professionals have adequate exposure to BIM-based project practices.

The study targets architects, engineers, quantity surveyors and project managers in BIM-using architectural and contracting companies undertaking in large-scale and high-rise building projects in Addis Ababa. These firms were identified through publicly available company portfolios and evidence of BIM utilization in project delivery. Also the respondents were selected based on their direct involvement in BIM implementation and client requirement management activities which ensures that the collected data was obtained from information-rich participants relevant to the study objectives.

The probability sampling technique was not adopted because there is no inclusive sampling frame or official database identifying BIM practitioners in the Ethiopian construction sector. Also BIM usage is not uniformly distributed across construction companies which make random selection less appropriate for obtaining respondents with sufficient BIM experience. Therefore, purposive sampling is more suitable for identifying qualified participants capable of providing reliable and relevant information.

The sample size determination was made considering the guidelines for multiple regression analysis as stated in the methodological literature where a minimum of 10 respondents per independent variable is considered adequate for reliable regression analysis. Since the study included six independent variables, the minimum required sample size was 60 respondents. However, to improve statistical reliability and increase the representativeness of the findings, the study used a larger sample of BIM-experienced professionals which are 120 valid questionnaire responses for the final quantitative analysis.

3.5 Data Collection Methods

In order to gather comprehensive and reliable data, the study is employed quantitative and data collection method which aligns with the research approach**.** Primary data is collected from the main sources of information which are professionals involved in building construction projects. It is gathered through a validated questionnaire designed to understand the effectiveness of client requirements management.

The secondary data are obtained from published journal articles, books, thesis and industry reports to support the development of the research framework, variables and measurement parameters.

It was difficult to identify a single standardized instrument that fully captures all variables of the study. Therefore, validated measurement scales were adopted for each variable individually.

For the independent variable (BIM), a validated questionnaire was adopted from Asim, J., Ahmed, R. R., Streimikiene, D.,Rasheed, S. and Streimikis, J. (2021) which also consist of the study parameters that connects BIM to client requirement. In the process of adopting, the validated BIM measurement items were reorganized to align with the study parameters. No modifications were made to the original wording. Additional items were minimally introduced to address missing constructs such as requirement model linkage and traceability.

For the dependent variable (client requirement management effectiveness), a validated instrument was adapted from Sławomir Wawak (2024), particularly focusing on requirement tracking, control and evaluation practices. Minor modifications were made to align with the construction context.

Questionnaires are distributed in both printed and electronic formats to increase accessibility and improve the response rate.

3.6 Data Analysis Methods

The collected data through the questionnaires is coded and analyzed using the **static Package for Social Sciences (SPSS).** To assess the strength and direction of relationships between BIM adoption parameters and effective client requirements management Pearson correlation

analysis is conducted. To examine the effect of individual BIM parameters on client requirements management, **multiple regression analysis** is employed.

3.7 Reliability and Validity Analysis

The questionnaire used is Reliability and Validity tested with Cronbach's alpha coefficient with higher value than 0.70 indicating the measuring parameters is reliable. This measured the internal consistency of the questionnaire items that are used in assessing BIM adoption parameters and effective client requirements management which helped in ensuring the accuracy and credibility of the study findings. Validity instrument ensures the questionnaire items adequately represent the study variables Therefore, these measures ensure the data that are collected are both reliable and valid for subsequent statistical analysis.

3.8 Ethical Consideration

Consideration of Ethics plays an important role in protecting participants while ensuring validity of research. In the data collection process, the purpose of the research is explained clearly and participation is voluntary. In order to maintain confidentiality and anonymity, no personal details are recorded and data collected remain strictly confidential. The data is used only for academic purposes and is stored in a secure manner where only the researcher has access to it. In addition, all secondary data and theoretical perspectives have been duly cited as per academic convention.

CHAPTER FOUR: DATA ANALYSIS AND INTERPRETATION

Introduction

This chapter presents the analysis and interpretation of the data collected from respondents regarding the impact of Building Information Modeling (BIM) parameters on Client Requirements Management (CRM2). The analysis is structured into descriptive statistics, correlation analysis, regression analysis, and diagnostic tests to ensure the validity of the model. The findings are presented using tables and interpreted in line with the study objectives.

4.1 Response rate, Demographic Information of the respondents

Table 4.1.1 Response rate

Response rate		
	Count	Percentage
Distributed	140	100%
Returned/Invalid	20	14.3%
Valid	120	85.7%

A total of 140 questionnaires were distributed to construction professionals working in BIM-user architectural and contracting firms in Addis Ababa were 120 questionnaires (85.7%.) properly completed and used for the final analysis. For unknown reasons the rest 20 questionnaires were returned with incomplete response therefore they are excluded resulting final sample size of 120 respondents which are considered adequate for the study. The final sample size which is 120 respondents is sufficient to proceed with multiple regression analysis and provides sufficient data for reliable statistical interpretation since it exceeds the minimum sample size.

Table 4.1.2 Gender Distribution of Respondents

Gender		
	N	%
Female	43	35.8%
Male	77	64.2%

The sample comprises 64.2% male and 35.8% female. This reflects the common gender composition in the construction industry which is male-dominated. The imbalance is due to industry norms and not a sampling bias. No further adjustment or weighting is needed for analysis.

Table 4.1.3 Level of Education of Respondents

Education Level		
	N	%
BSc. Degree	82	68.3%
MSc/MBA	38	31.7%

Among the respondents, 68.3% hold a BSc degree, 31.7% hold an MSc or MBA and no respondent reported education level below a bachelor's degree. This shows a sample with strong academic qualifications. The high educational level enhances the credibility and reliability of the respondents.

Table 4.1.4 Profession of Respondents

Profession		
	N	%
Architect	66	55.0%
Engineer	33	27.5%
Project Manager	13	10.8%
Quantity Surveyor	8	6.7%

The largest professional group represented is architects accounting for 55%. Following are engineers with 27.5% and project managers together with quantity surveyors accounting for 17.5% of the sample. This distribution is in alignment with the typical user base of BIM in construction projects. Thus the sample captures perspectives of diverse professionals on BIM implementation.

Table 4.1.5 *Respondents' Years of Experience in Their Profession*

Year Of Experience

	N	%
>15	2	1.7%
11-15	38	31.7%
5-10	51	42.5%
<5	29	24.2%

42.5% of the respondents i.e. the majority, have 5-10 years of experience followed by 31.7% with 11-15 years ,24.2% less than five years and only 1.7% with more than 15 years of experience. This shows a sample of predominantly mid-career professionals with substantial exposure in the industry.

Table 4.1.6 *Respondents' Types of Project Involved*

Types of Project involved		
	N	%
High-Rise	51	42.5%
All Types	69	57.5%

Over half of the respondents (57.5%) have experience working in all types of projects whereas 42.5% specialized in high-rise buildings. Across the sample there is broad range of project experience. The diversity in project types allows for higher generalizability of the findings.

Table 4.1.6 *Respondents Who Have Experience with BIM*

Experience with BIM		
	N	%
Yes	120	100.0%

All respondents (100%) reported having experience with BIM. This confirms that the sample are relevant and qualified to answers questions related to BIM. There are no respondents without BIM experience which eliminates potential confounding effects. The sample being homogenous with regard to BIM familiarity strengthens internal validity.

4.2 Descriptive Statistics

4.2.1 Frequency distribution

Statistics								
		Visualization	Communication	Information	Requirement	Assessment	Traceability	CRM2
N	Valid	120	120	120	120	120	120	120
	Missing	0	0	0	0	0	0	0

Table 4.2.1: Frequency Distribution of Visualization

Visualization		
	N	%
3.50	3	2.5%
3.67	2	1.6%
3.85	3	2.5%
4.00	13	10.8%
4.15	7	5.8%
4.25	20	16.7%
4.35	5	4.1%
4.50	29	24.2%
4.67	12	10.1%
4.75	11	9.1%
4.85	5	4.1%
5.00	10	8.3%

The frequency distribution of the variable visualization shows a strong positive perception among respondents on capabilities for managing client requirements. As per the Table 4.2.1, the respondent rated visualization at or below the neutral midpoint (3.00) since the score ranges from 3.50 to of 5.00. This reflect a consistently assessment through the entire sample.

The distribution is clearly concentrated at the higher end of the scale. 55.8% of the respondents rated 4.50 or above, additional 37.5% of respondents scored between 4.00 and only 6.7% of respondents assigned scores below 4.00, and none fell below 3.50.

The Reponses are cluttered towards the upper end of the scale reflecting a negatively skewed distribution. The implication is that the vast majority of BIM-experienced professionals in Addis Ababa's high-rise construction sector strongly agree that BIM's visualization

capabilities including 3D model representation and spatial coordination a of client requirements effectively support client requirement management.

Table 4.2.2: Frequency Distribution of Communication

Communication		
	N	%
3.25	1	0.9%
3.50	2	1.9%
3.75	1	0.9%
4.00	14	13.2%
4.25	16	15.1%
4.50	37	34.9%
4.75	21	19.8%
5.00	14	13.2%

The frequency distribution of the parameter Communication shows BIM's capacity to support real-time information sharing and inter-stakeholder coordination perceived positively by the respondents. As per the Table 4.2.2 the score of the respondents range from 3.25 to 5.00 with no respondent rating below 3.00. This indicates a positive assessment through the sample.

The distribution is strongly concentrated at the upper end of the scale. 67.9% of respondents rated Communication 4.50 or above, 28.3% rated between 4.00 and only 3.8% rated it below 4.00.

The distribution is negatively skewed which indicates that BIM's communication capabilities is highly effective in supporting client requirement management. Specifically shows that respondents value BIM's ability to ensure that updated requirement information is accessible to all project participants simultaneously.

Table 4.2.3: Frequency Distribution of Information

Information		
	N	%
3.00	3	2.8%
3.33	4	3.8%
3.67	7	6.6%

4.00	20	18.9%
4.33	33	31.1%
4.67	24	22.6%
5.00	15	14.2%

The frequency distribution of the parameter information storage shows the respondents perceive BIM's capacity to serve as a centralized, structured and reliable repository for client requirement data positively. The score ranges from 3.00 to 5.00 and only 2.8 % scoring at 3.00as per the Table 4.2.3.

The distribution of the respondents is concentrated around the mid-to-upper range of the scale. 68.0% of respondents rated Information Storage at 4.33 or above, 32.0% scored it between 3.00 and 4.00. 13.2% scored below 4.00. This shows respondents agree BIM's centralized information storage capability effectively reduces data inconsistency, supports documentation of requirement changes and ensures that all project participants work from a single and unified source implying BIM clearly improves data organization and accessibility.

Table 4.2.4: Frequency Distribution of Requirement

Requirement		
	N	%
3.00	2	1.9%
3.50	6	5.7%
4.00	27	25.5%
4.50	44	41.5%
5.00	27	25.5%

The frequency distribution of the BIMs parameter requirement model connection shows clearly polarized and concentrated patterns where respondents clustered at only five score values: 3.00, 3.50, 4.00, 4.50 and 5.00.The distribution is strongly concentrated at the higher end of the scale. 41.5% respondents score 4.50, 25.5% of respondents scored 5.00, 25.5% scored 4.00 and only 7.5% scored below 4.00.

This strongly negatively skewed distribution shows a very high and consistent level of agreement among respondents with BIMs support in the linking of client requirements to specific building elements, spaces and systems within the model effectiveness . This supports that the direct association between client needs and model components enables rapid impact

assessment when requirement changes occur. Therefore it reduces the probability of omissions, errors and coordination failures during construction. The absence of responses below scoring 3.50 further explain that BIMs capability is perceived as valuable for client requirement management in high-rise projects..

Table 4.2.5: Frequency Distribution of Assessment

Assessment		
	N	%
3.00	1	0.9%
3.50	3	2.8%
3.75	4	3.8%
4.00	10	9.4%
4.25	19	17.9%
4.50	37	34.9%
4.75	24	22.6%
5.00	8	7.5%

The frequency distribution of the BIMs variable assessment shows highest mean score (4.42) among all six independent variable. According to Table 4.2.5 the Scores range from 3.00 to 5.00 with only 0.9% of respondents score near 3.00. This indicates that the respondents agreement on the effectiveness of this BIM capability.

The modal score is 4.50 covering 34.9% responses making it the largest single frequency group. 27.4% scored between 4.00 and 4.49 and only 7.5% of respondents scored below 4.00

The distribution is clearly negatively skewed with a strong concentration of responses between 4.25 and 4.75. The dominance of Assessment as the highest-rated variable reflects the fact that BIM's automated compliance checking, clash detection and design validation features directly address one of the most critical failure points in client requirement management which is the gap between what the client specified and what the design actually delivers.

Table 4.2.6: Frequency Distribution of Traceability

Traceability		
	N	%

2.67	2	1.9%
3.00	7	6.6%
3.33	1	0.9%
3.67	6	5.7%
4.00	18	17.0%
4.33	28	26.4%
4.67	31	29.2%
5.00	13	12.3%

Traceability's frequency distribution show the response score ranging from 2.67 to 5.00 where 1.9% scoring below 3.00. The distribution is concentrated toward the upper portion of the scale except the 1.9% respondents. The modal score is 4.67 where 29.2% of the respondents, 26.4% scored 4.33, 17.0% scored 4.00 and 12.3% scored 5.00. Only 15.1% of respondents scored below 4.00.

The distribution is negative skew with few lower scores. This indicates that the dominant perception positive but minority of the respondents perceive limitations in BIM's traceability capabilities.

This is consistent with findings from the existing literature which suggest that effective requirement traceability depends not only on BIM software but also on disciplined data entry practices, organizational protocols and team commitment to maintaining audit trails throughout the project lifecycle

Table 4.2.7: Frequency Distribution of CRM2

Score Range	**N**	**%**
3.35 – 3.99	15	14.2%
4.00 – 4.39	30	28.3%
4.40 – 4.79	51	48.1%
4.80 – 5.00	10	9.4%

The frequency distribution of CRM2 which is the dependent variable representing overall client requirement management effectiveness is presented in Table 4.2.7.

The respondents score range from 3.35 to 5.00 and there is no respondent scoring below 3.00

The distribution is concentrated in the upper-middle range of the scale. The largest group of respondents which is 48.1% scored between 4.40 and 4.79. 28.3% scored between 4.00 and 4.39, 14.2% scored in the 3.35 to 3.99 range and 9.4% of scored 4.80 to 5.00.

The 14.2% of respondents scoring below 4.00 represent professionals for whom BIM-supported CRM has not yet fully delivered its potential benefits which may reflect inconsistent BIM implementation. The majority cluster ranging between 4.40and 4.79 suggests that BIM improves client requirement management in high-rise projects in Addis Ababa.

4.2.2 Average (Mean, Mode, Median), SD

Table 4.2.8: Descriptive Statistics of All Study Variables (N = 120)

Statistics								
		Visualization	communication	Information	Requirement	Assessment	Tractability	CRM2
N	Valid	120	120	120	120	120	120	120
	Missing	0	0	0	0	0	0	0
Mean		4.4147	4.2287	4.3306	4.4021	4.4167	4.2934	4.396897378914743
Median		4.5000	4.2500	4.3333	4.5000	4.5000	4.3333	4.421155466348367
Mode		4.50	4.25	4.33	4.50	4.50	4.67	3.7528229280484960[a]
Std. Deviation		.35158	.39159	.47436	.45524	.35993	.43600	.341212505804482
a. Multiple modes exist. The smallest value is shown								

To further elaborate, the high agreement on Core Variables or the narrow range of the standard deviations (all below 0.5) confirms that the perceptions regarding Visualization, Communication, Information, Requirement, Assessment, and Traceability are highly uniform across the 120 respondents. This indicates robust and reliable data as there are no significant outliers polarizing the feedback.

The dominant Areas of Perception such as Visualization (Mean = 4.41), Assessment (Mean = 4.42), and Requirements (Mean = 4.40) emerge as the most highly rated factors. The fact that

the mean, median, and mode for these three variables are nearly identical (at ~4.50) which confirms a strong and symmetric distribution of positive feedback also highlighting them as the most critical perceived pillars in the current project environment. Communication (Mean = 4.23) is still rated highly but it maintains the lowest mean in the set implying while respondents agree on the necessity of these factors, communication is perceived as slightly less optimized than technical or assessment processes.

Reliability of CRM2 (Dependent Variable) shows a strong Mean (4.40) and Median (4.42), further reinforcing that the overall effectiveness of Client Requirement Management is perceived as high. However, the discrepancy in its Mode (3.75) compared to the mean and median suggests that while the "average" experience is positive, a small subset of respondent's reports lower-end experiences, likely reflecting the "reactive and manual" challenges as identified on the literature review.

In conclusion the descriptive analysis demonstrates the sample population is well-aligned in their understanding of these management pillars. The slight lag in Communication and the multi-modal nature of CRM2 suggest that while the industry is performing well, there is specific room for improvement in how requirements are communicated and consistently managed a gap that BIM, as an integrated digital solution, is theoretically positioned to fill.

4.3 Correlation Analysis (Tests)

Table 4.3.1: Correlation Matrix of All Study Variables (N = 120)

Correlations								
		Visualization	communication	Information	Requirement	Assessment	Traceability	CRM2
Visualization	Pearson Correlation	1	.440**	.415**	.368**	.390**	.491**	.622**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000
	N	120	120	120	120	120	120	120
Communication	Pearson Correlation	.440**	1	.482**	.331**	.392**	.544**	.685**
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.000
	N	120	120	120	120	120	120	120
Information	Pearson Correlation	.415**	.482**	1	.566**	.421**	.516**	.627**

	Sig. (2-tailed)	.000	.000		.000	.000	.000	.000
	N	120	120	120	120	120	120	120
Requirment	Pearson Correlation	.368**	.331**	.566**	1	.536**	.542**	.612**
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.000
	N	120	120	120	120	120	120	120
Assessment	Pearson Correlation	.390**	.392**	.421**	.536**	1	.590**	.702**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000
	N	120	120	120	120	120	120	120
Traceability	Pearson Correlation	.491**	.544**	.516**	.542**	.590**	1	.708**
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.000
	N	120	120	120	120	120	120	120
CRM2	Pearson Correlation	.622**	.685**	.627**	.612**	.702**	.708**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	
	N	120	120	120	120	120	120	120
**. Correlation is significant at the 0.01 level (2-tailed).								

The study examines how the digital tool BIM (Building Information Modeling) impact client requirement management (CRM) in high-rise construction projects in Addis Ababa. Given that CRM2 is the dependent variable, representing the success of Client Requirement Management, the following interpretation focuses on Correlation Analysis (N = 120) based on *Table 4.3.1: Correlation Matrix of All Study Variables (N = 120)*

A The Pearson correlation analysis was conducted to examine the strength and direction of the relationships among the study variables. The results indicate that all independent variables Visualization, Communication, Information, Requirement, Assessment and Traceability have positive and statistically significant relationships with CRM2 which is the dependent variable, with correlation coefficients ranging from 0.612 to 0.708 ($p < 0.001$)**.**This shows that as project teams improve in these specific areas, the efficacy of managing client requirement changes increases similarly.

The following shows the table format of ranking the strength of the six BIM parameters

Independent Variable Correlation with CRM (r) Statistical Significance (p)

1. Traceability 0.708 0.000 indicating strong correlation

2. Assessment 0.702 0.000 indicating strong correlation

Independent Variable	Correlation with CRM (r)	Statistical Significance (p)
3. Communication	0.685	0.000 indicating strong correlation
4.Information	0.627	0.000 indicating strong correlation
5. Visualization	0.622	0.000 indicating strong correlation
6. Requirement	0.612	0.000 indicating strong correlation

The following are findings from correlation analysis

Traceability (r = 0.708) appeared as the strongest predictor of effective CRM which indicates that, in the context of high-rise development in Addis Ababa, the ability to track client requirements throughout the project lifecycle is the most critical BIM capability for ensuring effective requirement management. This finding suggests that Ethiopia's current manual and reactive procedures hinder performance and implementing BIM to enhance traceability is essential for decreasing scope creep and rework.

Assessment (r = 0.702) is the second strongest predictor and has a strong positive relationship with CRM. This indicates that the assessment abilities of BIM in terms of design validation, code checking and performance evaluation is helpful in ensuring that the requirements of the client are met. Organizations that have good assessment capabilities in BIM are more likely to deliver projects that meet client expectations.

The communication ability (r = 0.685) also has a strong positive relationship with CRM. This implies that the capability of BIM in terms of maintaining open lines of communication is very crucial in achieving project success. Communication in BIM helps to understand, document and satisfy client requirements.

Information (r = 0.627) shows a significant positive association with CRM. This implies that information management characteristics of BIM like information storing and management characteristics such as centralized databases and well-maintained project documents, are crucial for successful requirement management. Also makes information available to all stockholders which increases clarity.

Visualization (r = 0.622) shows strong positive association though it ranks fifth among the six BIM parameters. This indicates that visual representations of requirements such as 3D

models, renderings and walk through are useful in increasing understanding and feedback of clients.

Requirement (r = 0.612) ranks sixth place showing relatively the weakest correlation among all BIM parameters with CRM2 but it remains statistically significant and strong in absolute terms. This suggests that BIM features that captures requirement and documentation are positively associated with CRM outcomes.

2. Correlations among BIM Parameters

As shown on *Table 4.3.1: Correlation Matrix of All Study Variables (N = 120)*
the inter-correlations between the independent variables vary between 0.331 and 0.590 which indicates relatively low to moderate correlations between the variables. The values therefore show that although the independent variables are correlated, there is no indication of extreme correlation that may raise concerns regarding multi collinearity. In general, the findings of this analysis support the inclusion of these variables in the regression model, as well as suggest their influence on CRM2 which is the independent variable.

4.4 Regression Analysis (Tests)

4.4.1 Diagnosis Tests (Assumption of tests)

4.4.1.1 Normality Test, Linearity, Homoscedasticity, Multi Cillinearity Tests

A. Normality test

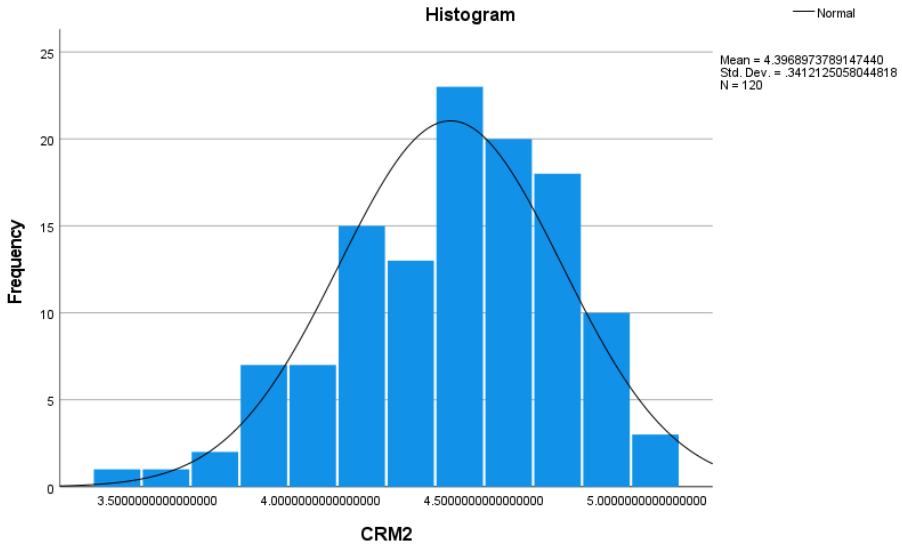
Table 4.4.1: Tests of Normality for CRM2

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
CRM2	.068	120	.200*	.974	120	.020
*. This is a lower bound of the true significance.						
a. Lilliefors Significance Correction						

The Kolmogorov-Smirnov test indicated normality (p = .200), while the Shapiro-Wilk test showed a slight deviation from normality (p = .020). However, inspection of the histogram and Q-Q plot demonstrated approximate normal distribution. Since regression analysis is

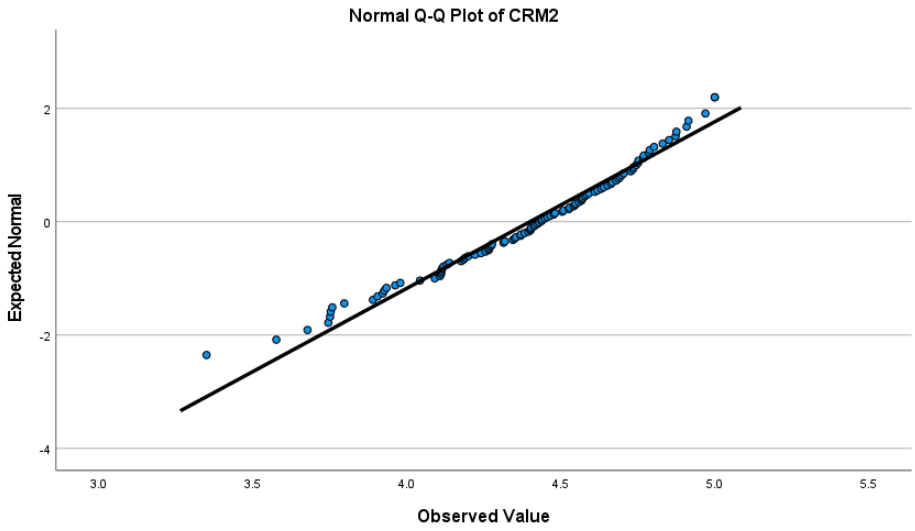
robust to mild deviations from normality with sample sizes above 100, the assumption of normality was considered sufficiently satisfied.

Figure 4.4.1: Histogram



The bell shaped line on the graph shows that the data is distributed normally.

Figure 4.4.2: Normal Q-Q Plot of CRM2



The Normal Q-Q plot of CMR2 (the dependent variable) graph also shows that the data is normally distributed since the data are scattered along the diagonal line. There for the data is used for regression test.

B. Linearity Test

- Linearity test between Client Requirement Management and Visualization

Table 4.4.2: *Tests of Linearity test between CRM2 and Visualization*

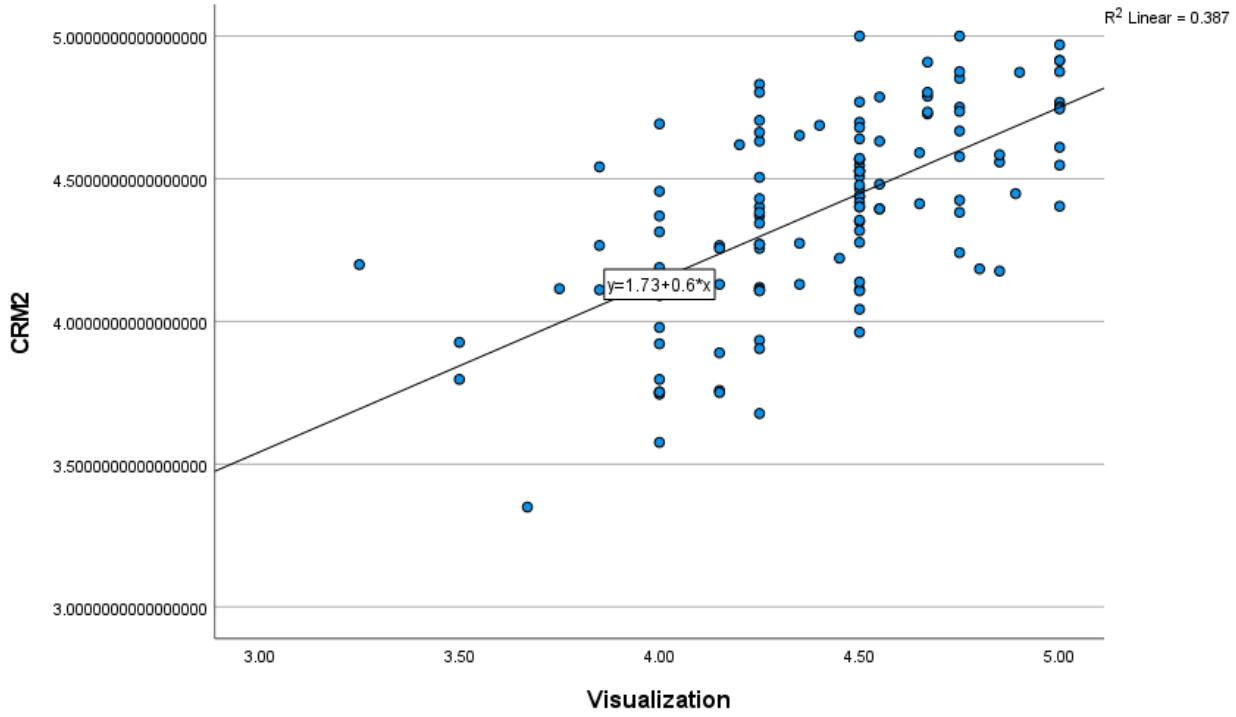
Case Processing Summary						
	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
CRM2 * Visualization	120	100.0%	0	0.0%	120	100.0%

ANOVA Table							
			Sum of Squares	df	Mean Square	F	Sig.
CRM2 * Visualization	Between Groups	(Combined)	7.672	21	.365	5.791	.000
		Linearity	5.367	1	5.367	85.069	.000
		Deviation from Linearity	2.306	20	.115	1.827	.028
	Within Groups		6.182	98	.063		
	Total		13.855	119			

Measures of Association				
	R	R Squared	Eta	Eta Squared
CRM2 * Visualization	.622	.387	.744	.554

The linear component is statistically significant ($p < .001$) though the deviation from linearity is significant ($p = .028$), the linear relationship remained dominant. Also the scatterplot indicated an approximately linear trend. Therefore, the linearity assumption is considered practically acceptable.

Figure 4.4.3: Linearity graph of visualization and CRM2



- Linearity test between Client Requirement Management and Communication

Table 4.4.2: Tests of *Linearity test* **between** *CRM2 and* Communication

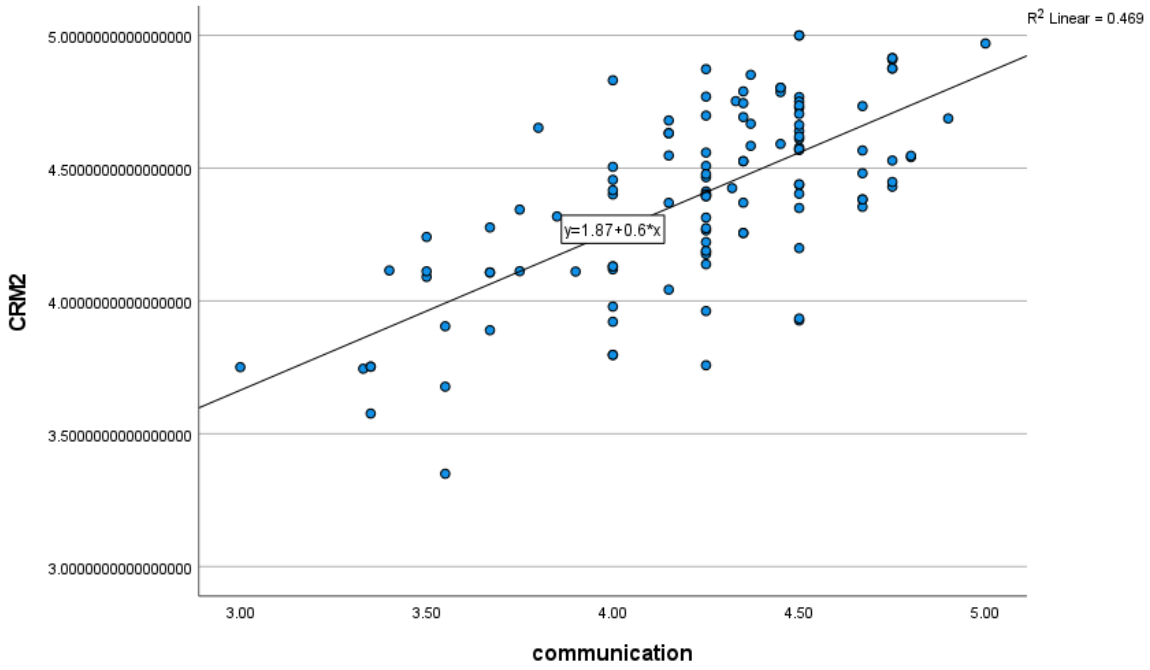
Case Processing Summary						
	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
CRM2 * communication	120	100.0%	0	0.0%	120	100.0%

ANOVA Table							
			Sum of Squares	df	Mean Square	F	Sig.
CRM2 * communication	Between Groups	(Combined)	8.375	24	.349	6.049	.000
		Linearity	6.492	1	6.492	112.540	.000
		Deviation from Linearity	1.883	23	.082	1.419	.122
	Within Groups		5.480	95	.058		
	Total		13.855	119			

Measures of Association				
	R	R Squared	Eta	Eta Squared
CRM2 * communication	.685	.469	.777	.604

The linear component is statistically significant (p = .001), while the deviation from linearity is not significant (p = 0.122). This indicates that the relationship between Communication and CRM2 is stably linear and satisfies the linearity assumption.

Figure 4.4.4: Linearity graph of communication and CRM2



- Linearity test between Client Requirement Management and Information

Table 4.4.3: Tests of *Linearity test between CRM2 and Information*

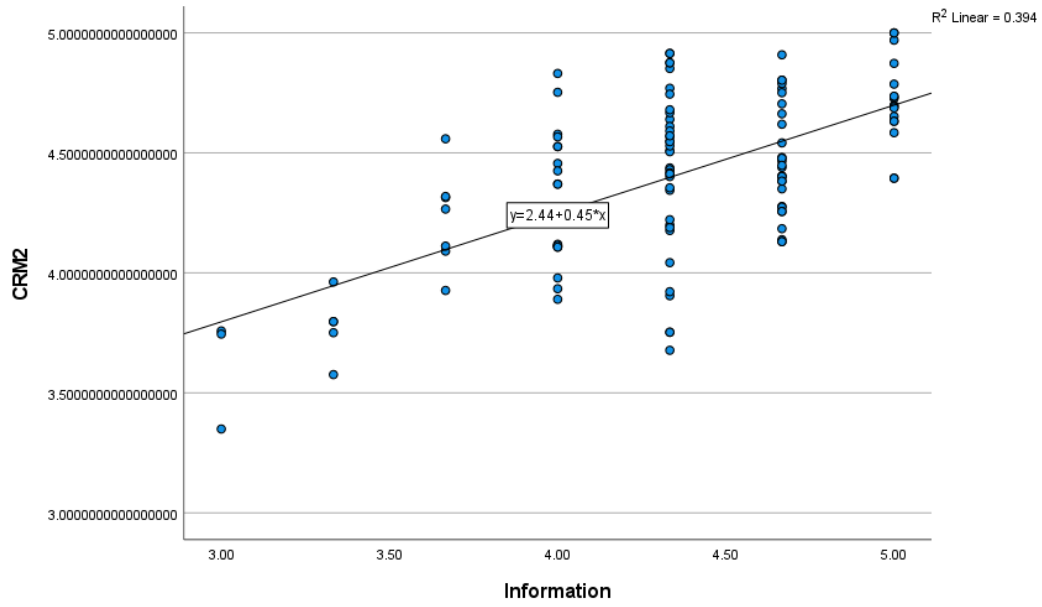
Case Processing Summary						
	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
CRM2 * Information	120	100.0%	0	0.0%	120	100.0%

ANOVA Table							
			Sum of Squares	df	Mean Square	F	Sig.
CRM2 * Information	Between Groups	(Combined)	6.103	6	1.017	14.829	.000
		Linearity	5.455	1	5.455	79.517	.000
		Deviation from Linearity	.649	5	.130	1.891	.101
	Within Groups		7.751	113	.069		
	Total		13.855	119			

Measures of Association				
	R	R Squared	Eta	Eta Squared
CRM2 * Information	.627	.394	.664	.441

The linear relationship is highly significant (p = .000), and the deviation from linearity is not significant (p = .101). This confirms a strong and appropriate linear association between Information and CRM2.

Figure 4.4.5: Linearity graph of Information and CRM2



- Linearity test between Client Requirement Management and Requirement

Table 4.4.4: *Tests of Linearity test between CRM2 and Requirement*

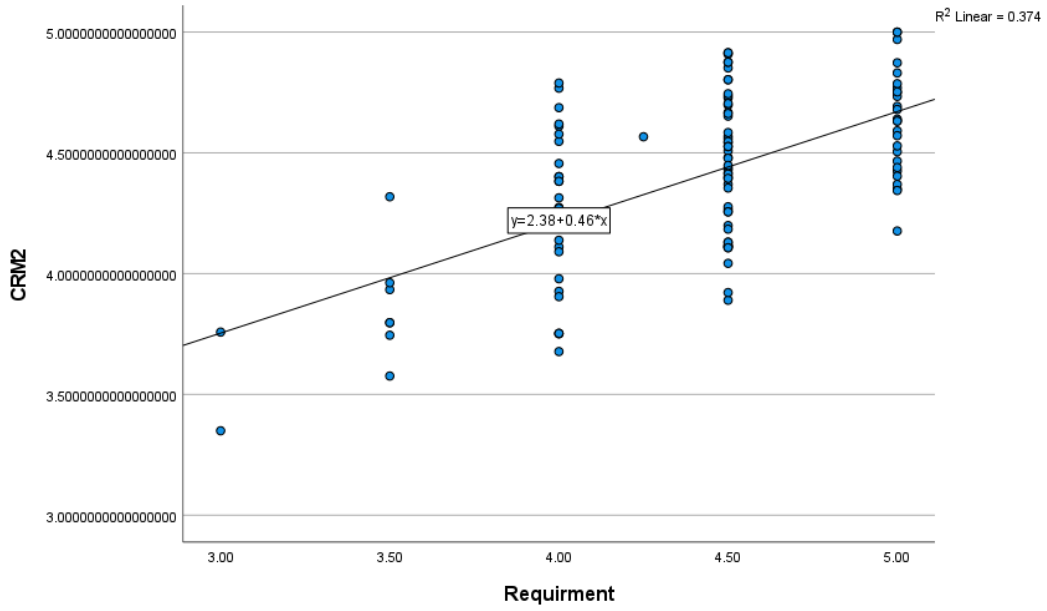
Case Processing Summary						
	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
CRM2 * Requirment	120	100.0%	0	0.0%	120	100.0%

ANOVA Table							
			Sum of Squares	df	Mean Square	F	Sig.
CRM2 * Requirment	Between Groups	(Combined)	5.532	5	1.106	15.154	.000
		Linearity	5.186	1	5.186	71.033	.000
		Deviation from Linearity	.346	4	.086	1.184	.322
	Within Groups		8.323	114	.073		
	Total		13.855	119			

Measures of Association				
	R	R Squared	Eta	Eta Squared
CRM2 * Requirement	.612	.374	.632	.399

The linear component is significant (p = .000), with no significant deviation from linearity (p = .322). This indicates that Requirement has a stable linear relationship with CRM2.

Figure 4.4.6: Linearity graph of Requirement and CRM2



- Linearity test between Client Requirement Management and Assessment

Table 4.4.5: Tests of Linearity test between CRM2 and Assessment

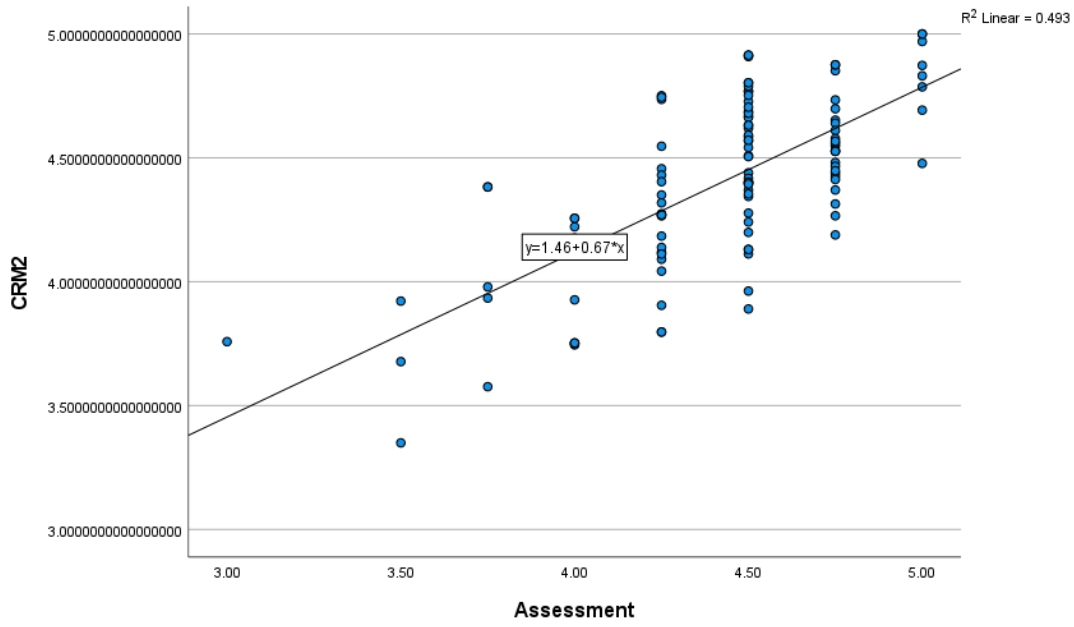
Case Processing Summary						
	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
CRM2 * Assessment	120	100.0%	0	0.0%	120	100.0%

ANOVA Table							
			Sum of Squares	df	Mean Square	F	Sig.
CRM2 * Assessment	Between Groups	(Combined)	7.485	7	1.069	18.800	.000
		Linearity	6.830	1	6.830	120.083	.000
		Deviation from Linearity	.655	6	.109	1.919	.084
	Within Groups		6.370	112	.057		
	Total		13.855	119			

Measures of Association				
	R	R Squared	Eta	Eta Squared
CRM2 * Assessment	.702	.493	.735	.540

The linear relationship is significant with p = .000 and the deviation from linearity is not significant with p = .084 since the standard suggests greater value than 0.005. This suggests that the linearity assumption is reasonably met with only minor non-linear influence. But the scatter graph shows that the points are scattered along the regression line implying that the relationship between CRM2 and Assessment satisfies the assumption.

Figure 4.4.7: Linearity graph of Assessment and CRM2



- Linearity test between Client Requirement Management and Traceability

Table 4.4.5: Tests of Linearity test between CRM2 and Traceability

Case Processing Summary			
	Cases		
	Included	Excluded	Total

	N	Percent	N	Percent	N	Percent
CRM2 * Traceability	120	100.0%	0	0.0%	120	100.0%

ANOVA Table

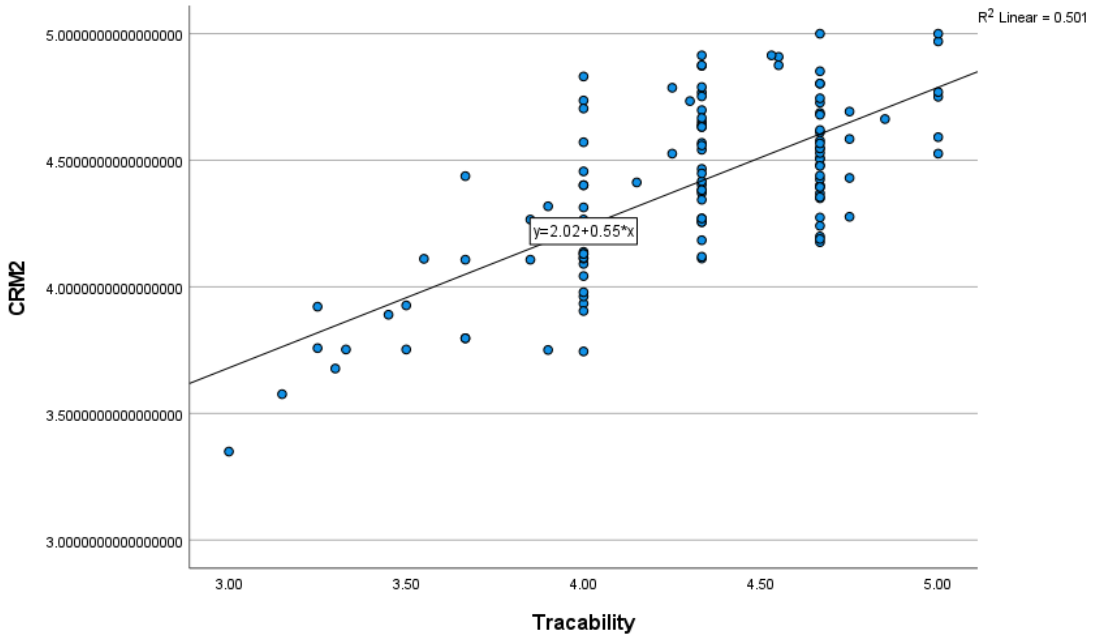
			Sum of Squares	df	Mean Square	F	Sig.
CRM2 * Tracability	Between Groups	(Combined)	8.488	21	.404	7.381	.000
		Linearity	6.943	1	6.943	126.782	.000
		Deviation from Linearity	1.546	20	.077	1.411	.135
	Within Groups		5.367	98	.055		
	Total		13.855	119			

Measures of Association

	R	R Squared	Eta	Eta Squared
CRM2 * Tracability	.708	.501	.783	.613

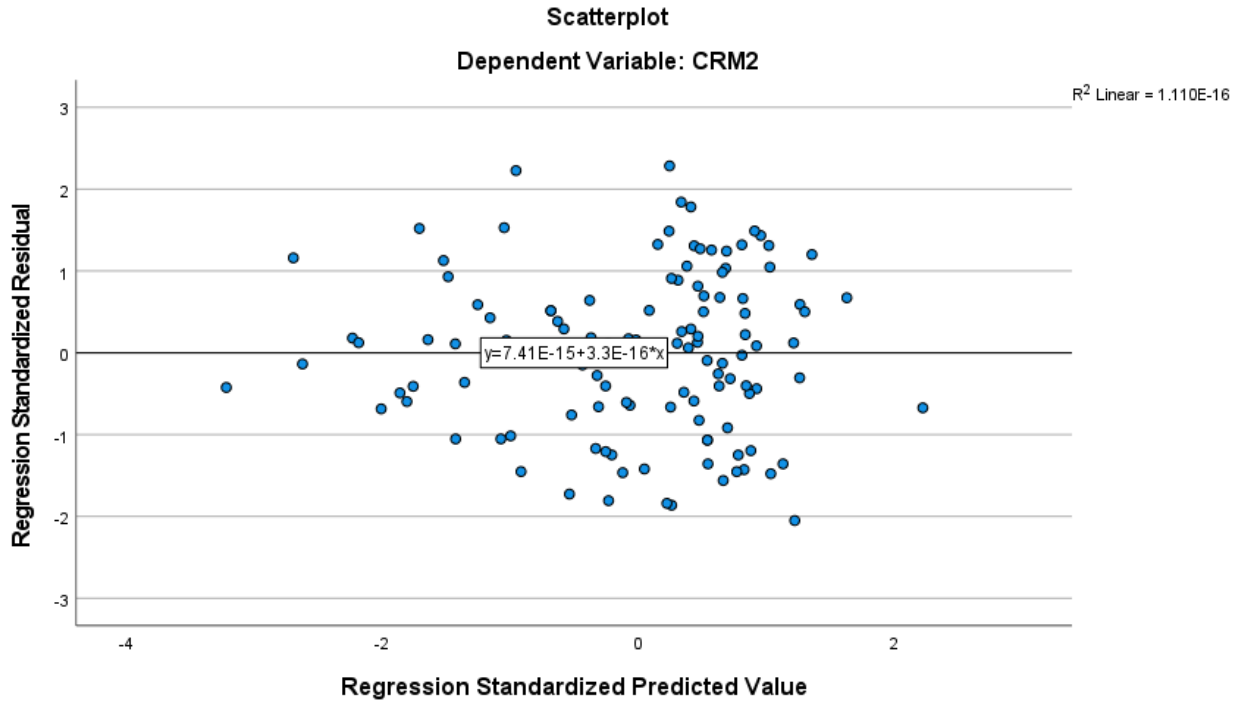
The linear component is statistically significant (p = .000), and the deviation from linearity is not significant (p = .135). This confirms that the relationship between Traceability and CRM2 is linear.

Figure 4.4.8: Linearity graph of Traceability and CRM2



C. Homoscedasticity Test

Figure 4.4.9: Homoscedasticity Graph



The standardized residuals fall within the acceptable range which is between −2.54 to 1.97 as shown in *Figure 4.4.9: Homoscedasticity Graph.* There are no patterns evident among the plotted data points as the scatter is random around different values of x which verifies that the residual plots are approximately normally distributed also meeting the normality assumption. The residuals have a constant variance for all levels of fitted values and there are no evident patterns or funnels. Therefore, that the assumption of homoscedasticity is satisfied.

D. Multi collinearity test

Table 4.4.6: *Multi collinearity test*

Collinearity Diagnostics[a]										
				Variance Proportions						
Model	Dimension	Eigenvalue	Condition Index	(Constant)	Visualization	communication	Information	Requirement	Assessment	Traceability
1	1	6.972	1.000	.00	.00	.00	.00	.00	.00	.00
	2	.008	30.451	.08	.07	.07	.27	.23	.00	.00
	3	.006	33.944	.03	.00	.24	.34	.20	.10	.00
	4	.005	36.951	.17	.05	.05	.13	.00	.01	.51
	5	.004	43.630	.03	.50	.43	.04	.10	.03	.16
	6	.003	45.675	.04	.17	.14	.22	.47	.40	.01
	7	.002	53.394	.64	.21	.06	.00	.00	.46	.32
a. Dependent Variable: CRM2										

Coefficients[a]												
		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
Model		B	Std. Error	Beta	T	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-.131	.225		-.586	.559					
	Visualization	.202	.049	.208	4.096	.000	.622	.360	.173	.589	1.451

	Communication	.261	.047	.300	5.586	.000	.685	.465	.236	.591	1.615
	Information	.093	.041	.129	2.289	.024	.627	.210	.097	.559	1.788
	Requirement	.099	.043	.132	2.295	.024	.612	.211	.097	.543	1.843
	Assessment	.289	.053	.305	5.480	.000	.702	.458	.231	.576	1.736
	Traceability	.098	.049	.125	2.009	.047	.708	.186	.085	.462	2.001
a. Dependent Variable: CRM2											

Collinearity diagnostics have been conducted to determine whether there is multicollinearity between the independent variables used. Although some condition index values exceeded the threshold of 30 As shown on *Table 4.4.6***:** *Multi collinearity test*, the VIF values ranged from 1.451 to 2.001 and tolerance values remained above 0.3 indicating that multicollinearity is not severe. Therefore, the independent variables are sufficiently distinct for regression analysis.

4.4.2 Linear Regressions Analysis

Table 4.4.6: *Linear Regressions Analysis Model Summary*

Model Summary[b]										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.894[a]	.799	.788	.15713194 4621138	.799	74.689	6	113	.000	1.991
a. Predictors: (Constant), Tracability, Visualization, Information, communication, Assessment, Requirment										
b. Dependent Variable: CRM2										

According to the results of the model summary, there is a strong relationship between the independent variables (Visualization, Communication, Information, Requirement, Assessment, and Traceability) and the dependent variable (CRM2) as correlation coefficient of **R = 0.894** shows. Also the value of R squared is 0.799 which is explained as the independent variables (Visualization, Communication, Information, Requirement, Assessment and Traceability) are a strong predictor of the dependent variable client requirement without no chance of overfitting the

model as explained by the **value of R^2 = 0.788**. Even more the Durbin-Watson statistic with the result shows of 1.991 indicates that there is no autocorrelation present in the residuals since it is close to 2. (Hair et al., 2019; Field, 2018).

Table 4.4.7**:** *ANOVA[a] Analysis*

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	11.065	6	1.844	74.689	.000[b]
	Residual	2.790	113	.025		
	Total	13.855	119			
a. Dependent Variable: CRM2						
b. Predictors: (Constant), Tracability, Visualization, Information, communication, Assessment, Requirment						

The ANOVA results according to *Table 4.4.7: ANOVAa Analysis* shows significant regression model since the F-value is 74.689 while the p-value is less than 0.001which can be explained as the independent variables together have a significant effect on the dependent variable CRM2. This means that the analysis shows the model is significantly better fit compared to a model with no predictors. Similarly, the F-test implies that at least one independent variable is significant in explaining variations of the dependent variable CRM2(client requirement).

Table 4.4.8: Residual Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	-.131	.225		-.586	.559			
	Visualization	.202	.049	.208	4.096	.000	.622	.360	.173
	communication	.261	.047	.300	5.586	.000	.685	.465	.236

	Information	.093	.041	.129	2.289	.024	.627	.210	.097
	Requirment	.099	.043	.132	2.295	.024	.612	.211	.097
	Assessment	.289	.053	.305	5.480	.000	.702	.458	.231
	Tracability	.098	.049	.125	2.009	.047	.708	.186	.085

The coefficients *Table 4.4.8: Residual Coefficients*[a] shows that all independent variables have a statistically significant positive effect on the dependent variable CRM2. In ascending order Visualization (β = 0.208), Communication (β = 0.300), Information (β = 0.129), Requirement (β = 0.132), Assessment (β = 0.305) and Traceability (β = 0.125) significantly influence CRM2(requirement Management). Assessment and Communication are the strongest predictors of the six as they show higher standardized beta coefficients, suggesting that they have the greatest impact on CRM2. The detail discussion of each parameter addressing the standardized beta coefficient, its unstandardized coefficient and its statistical significance are presented as follows.

Assessment

Among all the six BIM parameters assessment emerged strongest predictor of client requirement management effectiveness with β = 0.305 which indicates that for every one standard deviation increase in the use of BIM's assessment CRM2 increases by 0.305 standard deviations, holding all other variables constant. This confirms that the relationship is highly significant and extremely unlikely to have occurred by chance which is further explained by Baldauf et al. (2020) that BIMs assessment supported throughout the building lifecycle significantly by reducing the frequency and cost of late-stage design revisions.

Communication

Communication is the second strongest predictor with β = 0.300 indicating that the two together form the primary drivers of client requirement management effectiveness. This shows the role of communication in requirement management which is providing a shared, centralized, real-time information environment in which all stakeholders access the same model simultaneously making requirement changes visible to all parties involved. Prebanic and Vukomanovic (2021)

also demonstrated that BIM-enabled communication significantly reduce requirement fragmentation among construction project participants.

Visualization

Visualization is the third strongest predictor with of $\beta = 0.208$ to improve client requirement management effectiveness. It occupies a unique position in the BIM requirement management process since it operates at the interface between the client and the technical team.

It enables clients to navigate and interrogate the model directly, to review spatial relationships and to approve or reject design solutions with comprehension rather than assumed understanding which directly reduces the frequency of late-stage requirement changes arising from client misinterpretation. Mejlænder-Larsen (2017) also demonstrated that BIM visualization based client engagement in requirement significantly reduces design revision cycles.

Requirement-Model Connection

The Requirement-Model Connection variable has $\beta = 0.132$ which remains statistically significant indicating that the practice of directly linking client requirements to specific building elements within the BIM model makes independent contribution to client requirement management effectiveness.

The relatively smaller beta coefficient compared to assessment and communication shows this capability requires a higher level of BIM maturity and disciplined model management to implement effectively. Also shows that BIM is not yet uniformly practiced across all organizations.

Information Storage

Information Storage has $\beta = 0.129$ which indicates a statistically significant, positive and independent effect on client requirement management effectiveness reflecting its role as a centralized, non-redundant repository for all project information, including client requirement documents, design specifications, change orders, approval records and correspondence.

It also confirms that centralized information management in BIM is a necessary condition for effective client requirement management.

Traceability

Traceability carries the smallest standardized beta coefficient which is $\beta = 0.125$ among the six predictors approaching the threshold value but significant.

This means that traceability When BIM records a complete, chronological audit trail of all requirement changes capturing who changed what, when it was changed, what was approved and what the impact on the model was enabling assessment and communication to function at their highest levels. Chen and Lu (2019) also noted that BIM traceability functions as an enabling infrastructure for higher-order requirement management capabilities rather than as a standalone predictor of outcomes.

Regression Equation and Overall Interpretation

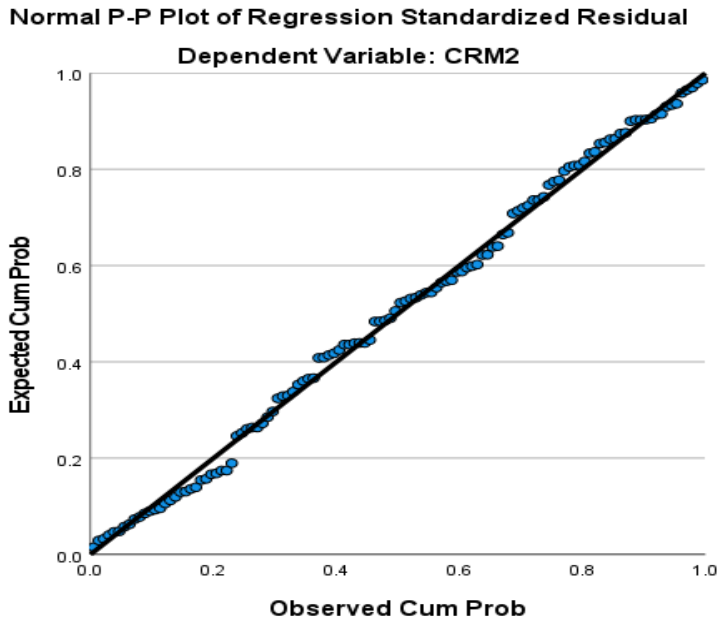
The full unstandardized regression equation derived from Table 4.4.8 is

$$CRM2 = -0.131 + 0.202(Visualization) + 0.261(Communication) + 0.093(Information) + 0.099(Requirement) + 0.289(Assessment) + 0.098(Traceability)$$

The practical interpretation of the regression equation is therefore entirely dependent on the positive contributions of the six BIM predictors where each unit improvement in any one of the six capabilities (while the others are held constant) produces a corresponding improvement in CRM2.

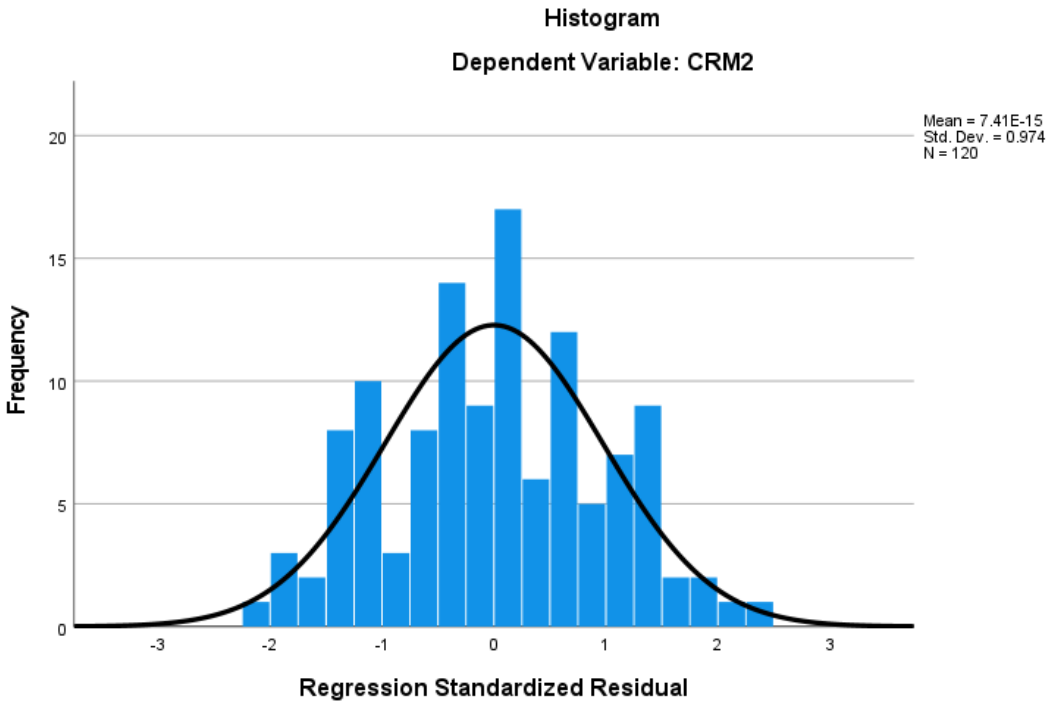
The six parameters combine explain 79.9% of the variance in CRM2 ($R^2 = 0.799$) showing that the six BIM dimensions identified in this study are primary drivers in client requirement management with better association in the context of high-rise building construction projects in Addis Ababa.

Figure 4.4.10: Normal P-P plot of regression standardized residual Graph



The Normal P-P (Probability-Probability) plot of regression standardized residuals presented in Figure 4.4.10 is a diagnostic graph used to assess whether the residuals produced by the regression model conform to the assumption of normality. It helps to understand the differences between observed and predicted values of CRM2 are normally distributed across the sample.

The P-P plot for this regression model shows that the data points follow the diagonal reference line closely throughout the full range of the distribution. The points do not deviate substantially from the line at either the lower end or the upper end of the distribution and there is no pronounced S-curve which shows consistency. Therefore, the normality assumption for regression is reasonably satisfied.



The histogram shows a roughly bell-shaped distribution centered near zero with no extreme outliers extending beyond ±3 standard deviations. This pattern indicates that the residuals approximate a normal distribution. Therefore, the normality assumption for the regression model is tenable. The symmetry of the histogram around the zero midpoint is consistent with a mean residual of approximately zero which is a required property of regression and the gradual tapering of frequency counts toward both tails conforms to the expected shape of a normal distribution. The normal P-P plot and the standardized residual histogram both provide convergent, graphically compelling evidence that the normality assumption is satisfied in this regression model implying validity and credibility.

4.7 Discussion of Findings

This study examined the impact of Building Information Modeling (BIM) on client requirement management in high-rise building construction projects in Addis Ababa. The discussion the quantitative findings and compares them with existing theoretical and empirical literature. The finding of the study also indicates that BIM significantly improves client requirement

management through enhanced visualization, communication, information storage, requirement traceability, assessment and requirement-model connection.

The discussion of the findings of each BIM variables influence on client requirement management is presented as follows.

4.7.1 BIM Visualization and Client Requirement Management

Visualization has a positive influence on client requirement management as shown in quantitative findings indicating that BIM-supported three-dimensional visualization improves stakeholders' understanding of project requirements and reduces ambiguity during project execution. It suggests that visualization enables clients and project participants to better interpret design intent and evaluate requirement changes before implementation which helps minimize misunderstanding and rework.

The regression result $\beta = 0.208$ of visualization shows visualization capabilities positively affect stakeholders' understanding of project requirements through enhanced graphical representation, 3D modeling and design simulation indicating that BIM visualization reduces ambiguity and improves communication between project participants and clients. This finding is consistent with Azhar (2011), who reported that BIM visualization enhances project understanding and decision-making. Baldauf et al. (2020) also found that BIM-based visualization significantly improves the management of client requirements in building projects through better information interpretation to stakeholders.

4.7.2 BIM Communication and Client Requirement Management

Communication also has a positively influence client requirement management as demonstrated by the quantitative analysis. It implies that BIM facilitates coordinated information exchange among project stakeholders and improves the management of evolving client requirements.

BIM environments reducing fragmentation and inconsistencies between project participants by support real-time sharing of updated information as explained in the qualitative finding also, firms relying on traditional communication methods experience delays in information transfer

and inconsistencies between disciplines during requirement changes such as poor coordination between architects, engineers and contractors.

The regression result β = 0.300 of communication also indicates that BIM improves coordination among project stakeholders through simultaneous access to project information and reduced document conflicts leading to improved information exchange which aligns with Olawumi and Chan (2019), who concluded that BIM enhances project information management and stakeholder coordination. Rui et al. (2021) also emphasized that BIM-based collaboration improves project efficiency and reduces communication-related problems which supports the finding.

4.7.3 Information Storage and Client Requirement Management

Information storage has a significant positive effect on client requirement management as further shown by the finding suggesting that BIM provides a centralized and organized digital environment for documenting, updating and retrieving client requirements throughout the project lifecycle. Proper storage and accessibility of project information improve continuity, reduce information loss, and support consistent decision-making.

The regression result β = 0.129 of information storage indicates that centralized digital storage and retrieval systems improve the accessibility, consistency and management of project information throughout the construction lifecycle. The respondents agree with BIM facilitating efficient retrieval of client requirements, design information and project documentation which improves project control and decision-making. This finding is consistent with Chen and Lu (2019), who explained that BIM improves information integration and accessibility in construction projects and Wang and Chen (2023) also reported BIM-based information management systems significantly improve project coordination and lifecycle management.

4.7.4 Requirement-Model Connection

The finding of the study shows requirement-model connection positively affects client requirement management suggesting that suggests that linking client requirements directly to

building components and design elements improves change assessment and facilitates more effective management of design modifications.

The regression result $\beta = 0.132$ of requirement indicates that integrating client requirements directly into BIM models helps stakeholders better understand project expectations and enables efficient management of requirement changes. As respondents agree, BIM allows modifications in client requirements to be reflected immediately within the project model which minimizes inconsistencies and rework. Padala and Maheswari (2022) concluded that BIM-based requirement integration improves change management and project consistency which the study aligns with and consistent with Gotel and Finkelstein (1994), who emphasized the importance of linking requirements to project systems for effective requirement traceability and control.

4.7.5 Assessment and client requirement management

Assessment positively influence client requirement management as shown on the quantitative results indicating that BIM supports systematic evaluation of design solutions against predefined client requirements and project standards. The ability to evaluate compliance digitally reduces reliance on subjective judgment and improves design consistency.

The qualitative findings further explained that firms without BIM experience difficulties in evaluating whether changing requirements align with project specifications and stakeholder expectations. The regression result $\beta = 0.305$ of assessment also suggests that BIM improves design evaluation, cost accuracy, compliance verification and reduction of discrepancies among project documents. This finding aligns with Farouk and Rahman (2023), who found that BIM enhances project cost management and design evaluation accuracy also Yilmaz et al. (2024) reported BIM integration improves construction cost management and compliance assessment throughout project implementation.

4.7.6 Traceability and Requirement Change Management

Traceability positively influences client requirement management as shown on the study finding indicating that BIM improves the ability to monitor the origin, modification history and implementation status of client requirements during the project lifecycle. When traceability is

effective, it supports accountability and enables project teams to assess the consequences of requirement changes more efficiently.

The regression analysis result $\beta = 0.125$ further indicates that BIM improves the ability to track design modifications, monitor requirement changes and maintain project consistency throughout the project lifecycle significantly. As respondents agree with BIM provides an effective mechanism for recording and updating requirement changes which reduces errors associated with unmanaged design revisions showing alignment with Mejlænder-Larsen (2017), who found that BIM-based change control systems improve project change management and traceability. The result also supports Wagner et al. (2018), who highlighted the importance of systematic requirement traceability for effective project management and stakeholder coordination.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter presents the summary of the major findings of the study, conclusions drawn from the analysis, recommendations for stakeholders, and the limitations of the research. It also provides suggestions for future studies related to Building Information Modeling (BIM) and client requirement management in the Ethiopian construction industry. The chapter is based on the quantitative findings obtained from BIM user firms involved in high-rise building construction projects in Addis Ababa.

5.1 Summary of Findings

The main objective of this study is to examine the impact of Building Information Modeling (BIM) on client requirement management in high-rise building construction projects in Addis Ababa specifically investigates the influence of BIM dimensions such as visualization, communication, information storage, requirement-model connection, assessment and traceability on client requirement management.

BIM has a significant positive influence on client requirement management as indicted by the quantitative findings. . Visualization is found to improve stakeholders' understanding of project requirements and minimize misinterpretation during project implementation. Communication enhances coordination among project participants and improves the management of changing client requirements while Information storage contributed to better documentation, accessibility and consistency of project information throughout the project lifecycle.

Requirement-model connection similarly improve the ability to assess the implications of requirement changes on building components and project systems where assessment supports the evaluation of project requirements against design solutions and project standards and traceability improves the monitoring of requirement modifications and strengthened accountability during project execution.

Overall, BIM (building information modeling) significantly enhances client requirement management practices in high-rise building projects which are confirmed by quantitative findings.

The multiple regression analysis $R^2 = 0.799$ indicates that the six BIM dimensions explain 79.9% of the variance in client requirement management effectiveness with $F = 74.689$ and $p < 0.001$. Among the six dimensions assessment emerged as the strongest predictor with $\beta = 0.305$& $p = .000$ followed by Communication with $\beta = 0.300$ & $p = .000$ confirming that BIM's capacity to evaluate designs against client requirements and facilitate real-time information exchange are the main drivers of CRM effectiveness. Visualization contributed a moderate independent effect with $\beta = 0.208$& $p = .000$, requirement-model connection with $\beta = 0.132$, Information Storage with $\beta = 0.129$ and traceability with $\beta = 0.125$ with each statistically significant contributions in descending order confirming that all six dimensions play a measurable and meaningful role in improving client requirement management.

Beyond statistical significance, these findings carry important practical implications for high-rise construction projects in Addis Ababa. The R^2 value of 0.799 implies BIM is a supplementary project management tool and fundamental enabler for systematic, structured and accountable requirement management

In the Ethiopian context, where client requirement changes are among the leading causes of cost overruns, schedule delays and disputes (Alemayehu, 2025; Alemayehu et al., 2024), the findings suggest that consistent BIM adoption has the potential to substantially improve construction project outcomes through improved client requirement management.

5.2 Conclusion

The study confirmed that BIM enhances visualization, communication, information management, requirement traceability, assessment and requirement-model integration which directly improves the management of changing client requirements and contribute to better project coordination, reduced misunderstanding and for informed decision-making. Based on this it can be concluded that Building Information Modeling (BIM) significantly improves client requirement management in high-rise building construction projects in Addis Ababa.

The impact of BIM on client requirement management in the Ethiopian high-rise construction sector had not been empirically measured and the existing literature most notably Alemayehu (2025) had identified the problem without quantifying the solution therefore this study contributes original empirical evidence in this particular context. By demonstrating that six BIM dimensions together explain 79.9% of the variance in client requirement management effectiveness with $R^2 = 0.799$ it fills that gap and establishes a statistically grounded and evidence-based foundation for BIM adoption decisions in the Ethiopian construction industry.

The findings confirm that the transition from traditional and manual requirement management practices to BIM-enabled digital workflows a technological upgrade as well as a strategic necessity for improving project performance through meeting client requirements in high-rise building construction.

Similarly the study concludes that BIM supports more systematic and structured management of client requirements compared to traditional manual methods commonly practiced in the Ethiopian construction industry since BIM improves the documentation, monitoring and evaluation of requirement changes throughout the project lifecycle through integrated digital information environments.

As Addis Ababa continues to expand vertically and as the demand for complex, multi-stakeholder construction projects increases, the adoption of BIM as a core requirement management will be very impactful for the benefit of clients as well as professionals involved

5.3 Recommendations

The following recommendations are proposed based on the findings and conclusions of the study.

A. Construction Firms and Industry Practitioners

Construction firms should also invest in BIM training and capacity building for professionals like architects, engineers, quantity surveyors, project managers and other construction professionals. Gradually firms should transition from traditional two-dimensional methods toward integrated digital project management systems to improve coordination and requirement management.

B. Universities and Academic Institutions

Higher education institutions such as Universities should integrate BIM courses into architecture, engineering, construction management and project management programs which will help address the shortage of BIM-skilled professionals within the Ethiopian construction industry.

C. Professional Associations

To strengthen industry readiness, professional associations and industry organizations should promote awareness about the benefits of BIM in client requirement management and project performance improvement.

5.4 Research Limitation and Areas of Further Research

5.4.1 Limitation of the Study

This study was carefully designed to achieve its objectives though it encountered several limitations that should be considered when interpreting the findings. It has geographical limitation which is limited to Addis Ababa, Ethiopia, and focused exclusively on high-rise building construction projects. Consequently, the findings may not fully represent other regions

within Ethiopia or other categories of construction projects such as residential, infrastructure or low-rise developments.

Due to the limited number of constructions actively utilizing BIM in Ethiopia, the sampling size and sampling technique of the study employed a purposive sampling technique rather than probability sampling. The final sample size is 120 respondents which is adequate for regression analysis but may not capture the full diversity of perspectives within the Ethiopian construction industry.

The study employed a cross-sectional research design which collected data at a single point in time. This limits the ability to establish causality or observe changes in BIM practices and client requirement management over time.

Even though the study has the above limitations it provides valuable empirical evidence on the impact of BIM on client requirement management in the Ethiopian construction context offering practical insights for stakeholders.

5.4.2 Suggestion for Future Research

Expanding the geographical scope in future studies by including other cities and regions in Ethiopia will improve the generalizability of the findings. In addition future research should also investigate BIM adoption and its impact in other construction sectors such as longitudinal studies are recommended to examine the long-term impact of BIM implementation on client requirement management.

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APPENDICES

Appendix A: Questionnaire

Addis Ababa University

College of Engineering and Architecture

Department of Construction Technology and Management

Questionnaire

Dear Respondent,

My name is Lensa Mulugeta, a postgraduate student at Addis Ababa University conducting academic research on the role of Building Information Modeling (BIM) in managing client requirements in building construction projects in Addis Ababa.

The purpose of this questionnaire is to collect data from professionals involved in building projects to better understand BIM practices and client requirement management.

Your participation is voluntary. All responses will remain strictly confidential, used only for academic purposes, and reported in aggregated form without identifying any individual or organization.

Thank you for your valuable time and contribution.

Section A: Background Information

(Please tick ✓ where appropriate)

A1. Gender

- ☐ Male
- ☐ Female

A2. Educational Background

- ☐ Diploma
- ☐ Bachelor's Degree
- ☐ Master's Degree
- ☐ PhD/Doctorate
- ☐ Other (please specify): _____

A3. Profession

- ☐ Architect
- ☐ Engineer
- ☐ Quantity Surveyor
- ☐ Project Manager
- ☐ Other (please specify): _____

A4. Years of Experience

- ☐ Less than 5 years
- ☐ 5–10 years
- ☐ 11–15 years
- ☐ More than 15 years

A5. Experience with BIM

- ☐ Yes
- ☐ No

A6. Type of Projects Involved

- ☐ High-rise
- ☐ Medium-rise
- ☐ Low-rise
- ☐ Other (please specify): _____

Section B: BIM Capabilities on Requirement Management

Instruction

Please indicate your level of agreement with the following statements.

Scale

1 = Strongly Disagree | 2 = Disagree | 3 = Neutral | 4 = Agree | 5 = Strongly Agree

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B1. Visualization

1. BIM facilitates the instant generation of new sections, elevations, and 3D views.
2. BIM produces graphical representations that make concepts clearer.
3. BIM enables innovative design and visualization tools.
4. Design visualization enhances understanding of project characteristics.

B2. Communication and Collaboration

1. BIM allows AEC professionals at different locations to work on the same model simultaneously.
2. BIM reduces conflicts among project stakeholders.
3. BIM reduces time wasted in cross-checking documents.
4. Collaboration among teams reduces design information problems.

B3. Information Storage and Retrieval

1. BIM stores data for 3D modeling and simulation.
2. BIM is used to store client requirement information.
3. BIM allows retrieval of previously stored project information.

B4. Requirement–Model Connection

1. BIM links client requirements with building elements.
2. Changes in client requirements are reflected in the BIM model.

B5. Assessment and Compliance

1. BIM improves accuracy of construction cost projections.
2. BIM minimizes discrepancies between drawings.
3. BIM reduces errors and improves design evaluation.
4. BIM is used to check whether designs meet client requirements.

B6. Traceability of Requirements

1. BIM integrates and updates design changes efficiently.
2. BIM enables tracking of changes in client requirements.
3. BIM records changes and their history.

Section C: Client Requirement Management Effectiveness

Scale

1 = Strongly Disagree | 2 = Disagree | 3 = Neutral | 4 = Agree | 5 = Strongly Agree

C1. Requirement Tracking and Control

1. Project requirements are continuously monitored throughout the project.
2. Conflicting requirements are effectively identified and resolved.
3. Relationships between requirements are clearly identified.
4. Changes in requirements are properly analyzed for their impact.
5. Requirements are consistently updated and synchronized.
6. All requirements are fully covered and implemented.

C2. Requirement Quality and Evaluation

1. Project outcomes meet defined client requirements.
2. Requirements comply with relevant standards and regulations.
3. Requirement specifications are clear and complete.
4. Requirement implementation meets expected quality levels.