Factors Affecting Successful Implementation of Building Information Modeling (BIM),

It's Adoption and Diffusion in Addis Ababa

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LIST OF ACRONYMS

ANOVA: Analysis of Variance

BIM: Building Information Modeling

BOQ: Bill of Quantity

CATA: Cultural Attitude Towards Technology Adoption

FIC: Financial Capability

GP: Government Policy

IA: Industry Associations

IT: Information Technology

OR: Organizational Readiness

PM: Project Management

SPSS: Statistical Package for the Social Sciences

TI: Technological Infrastructure

VIF: Verification Inflation Factor

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ABSTRUCT

Building Information Modeling (BIM) presents transformative opportunities in the global construction industry, yet its integration, especially in diverse contexts like Addis Ababa, Ethiopia, remains challenging. This research investigates how BIM can converge with project management success factors to facilitate adoption and diffusion in Addis Ababa's construction industry. Employing a mixed-methods approach including qualitative interviews, surveys, and case studies, insights will be gathered from various stakeholders. By analyzing socio-cultural, economic, and institutional dynamics, the study aims to understand barriers and enablers to BIM integration. Synthesizing empirical findings with project management and innovation diffusion literature, the research seeks to develop practical recommendations to enhance BIM utilization. Key findings suggest that organizational readiness, technological infrastructure, financial considerations, and industry associations significantly influence BIM adoption. However, traditional project success metrics hinder implementation, indicating conflicts within existing frameworks. Cultural attitudes and government policies require further investigation. Strategic initiatives are proposed to promote BIM diffusion: enhancing organizational readiness, investing in infrastructure, providing financial support, fostering collaboration, and nurturing innovation. These efforts, coupled with supportive policies and pilot projects, aim to drive efficiency, collaboration, and innovation in Addis Ababa's construction sector.

Keywords; Building Information Modeling (BIM), Adoption, Diffusion, Stakeholders, Innovation diffusion

CHAPTER 1

INTRODUCTION

1.1 Introduction

The rapid expansion of urban centers has spurred a significant boom in the construction sector. Addis Ababa, as a burgeoning metropolis, is no exception to this trend. This surge in construction activity brings with it a host of opportunities for economic growth and infrastructural development. However, alongside these opportunities, there are also formidable challenges that demand attention. Despite significant growth, persistent issues such as project delays, cost overruns, and quality deficiencies persist, hindering progress. Building Information Modeling (BIM) has emerged as a potential solution to enhance project management practices, yet its effective implementation remains elusive. Understanding the unique elements affecting BIM implementation and spread within the local context is imperative. This chapter explores the complexities surrounding BIM integration in Addis Ababa's construction industry, aiming to illuminate pathways for success. By investigating project management success factors, adoption barriers, and diffusion mechanisms specific to the region, this research seeks to foster improved project outcomes and contribute to the advancement of the construction sector in Addis Ababa.

1.2 Background of the study

Addis Ababa's construction sector is rapidly expanding due to increased infrastructure projects driven by urbanization, population growth, and economic development (World Bank, 2020). However, the industry continues to struggle with project management challenges, such as delays, cost overruns, and quality issues (Luleå University of Technology, 2018). Building Information Modeling (BIM) is seen as a promising solution, yet its effective implementation faces numerous obstacles (Azhar et al., 2011). Successful integration of BIM requires a deep understanding of the factors affecting its adoption and diffusion within the local context (Eastman et al., 2011). This involves examining the success factors, adoption barriers, and diffusion mechanisms specific to Addis Ababa's construction industry (Tekie, 2019). Key challenges include limitations in technological infrastructure, resource constraints, cultural resistance, and regulatory gaps (Belayneh & Jules, 2017). As the city continues to grow, addressing these issues becomes increasingly important (World Bank, 2020). Integrating BIM into project management practices can help mitigate these problems and promote sustainable development (Dawood & Sikka, 2017). This chapter aims to explore the complexities of BIM adoption and diffusion, providing a foundation for effective integration strategies (Tekie, 2019).

Several specific research gaps exist in the context of BIM adoption within Addis Ababa’s construction industry. Firstly, there are limited local studies focused specifically on BIM adoption. Additionally, the extent and impact of cultural resistance have not been thoroughly explored. Research on how technological infrastructure limitations affect BIM implementation is also lacking. The role of the regulatory framework in facilitating or hindering BIM adoption needs further investigation, as does the impact of financial and human resource constraints on its diffusion. Furthermore, identifying specific success factors for BIM integration in the local context is not well documented, and the processes and mechanisms that facilitate its spread within the industry remain inadequately understood. By addressing these gaps, the study aims to provide a comprehensive understanding of BIM adoption in Addis Ababa, contributing to the development of effective integration strategies.

By combining empirical research and theoretical analysis, this study seeks to identify pathways for successful BIM integration, focusing on the unique challenges and opportunities within Addis Ababa's construction industry. While BIM has the potential to revolutionize project management through enhanced collaboration, coordination, and data-driven decision-making, overcoming local challenges is crucial for its successful implementation.

1.3 Problem statement

In the global landscape, the construction industry is a vital economic driver, shaping skylines and infrastructure while facing numerous challenges. In Addis Ababa, construction professionals grapple with issues such as delays, cost overruns, and quality deficiencies in building projects. According to a 2020 World Bank report, the region's construction sector is rapidly growing. However, project management practices often fall short, as highlighted by a 2018 study from Luleå University of Technology.

Building Information Modeling (BIM) is increasingly recognized as a potential solution to these challenges, offering the promise of streamlined project management, enhanced efficiency, and improved project outcomes. Yet, effective BIM implementation in Addis Ababa’s construction sector requires a deep understanding of local project management success factors, adoption barriers, and diffusion mechanisms, as noted by Azhar et al. in 2011.

Despite global evidence suggesting that BIM can mitigate construction challenges, its use in Addis Ababa is still underdeveloped and misaligned with essential project management success factors. Additionally, there is insufficient focus on overcoming adoption barriers and applying tailored diffusion strategies within the local context.

This study aims to support stakeholders in the construction sector by exploring the intricacies of BIM integration. Specifically, the research aims to identify barriers to BIM adoption and implementation, such as technological limitations, resource constraints, cultural resistance, and regulatory gaps. By investigating these challenges, the study seeks to develop strategies to overcome them. Additionally, the research will identify enablers for BIM adoption, including enhancing organizational readiness, improving

technological infrastructure, providing financial support, fostering industry collaboration, and promoting a culture of innovation. By addressing key factors and identifying both barriers and enablers, this research seeks to improve project outcomes, reduce delays, enhance cost control, and elevate quality standards in construction projects throughout Addis Ababa.

1.4 Basic research questions

1. How does organizational readiness impact BIM adoption in Addis Ababa?
2. What role does technological infrastructure play in BIM adoption in Addis Ababa?
3. How do financial considerations affect BIM adoption in Addis Ababa?
4. What impact do cultural attitudes towards technology have on BIM adoption in Addis Ababa?
5. How do government policies and support influence BIM adoption in Addis Ababa?
6. How do industry associations and knowledge-sharing platforms contribute to BIM adoption in Addis Ababa?

1.5 Research objectives

1.5.1 General objectives

Develop strategies to promote widespread BIM adoption and diffusion across projects in Addis Ababa.

1.5.2 Specific objectives

1. Assess the impact of organizational readiness on BIM adoption in Addis Ababa.
2. Investigate the role of technological infrastructure in supporting BIM adoption in Addis Ababa.
3. Analyze the effects of financial considerations on BIM adoption in Addis Ababa.
4. Examine the influence of cultural attitudes towards technology adoption on BIM adoption in Addis Ababa.

5. Evaluate the impact of government policies and support on BIM adoption in Addis Ababa.
6. Determine the contribution of industry associations and knowledge-sharing platforms to BIM adoption in Addis Ababa.

1.6 Definition of Terms

Building Information Modeling (BIM) is a method that creates and manages digital representations of the physical and functional characteristics of buildings and infrastructure. This collaborative approach allows various stakeholders in the construction industry to efficiently plan, design, construct, and manage projects.
Azhar et al. (2011) describe BIM for construction professionals as a technology that enhances collaboration and coordination among architects, engineers, contractors, and other stakeholders. By using BIM, these professionals can communicate more effectively, visualize projects more clearly, and make better decisions throughout the project lifecycle.

According to Succar (2009), BIM stakeholders include owners, architects, engineers, contractors, project managers, and other invested parties. These stakeholders use BIM technology to access precise, current information, improve project data management, and boost overall project efficiency.

1.7 Significance of the study

The study aims to advance the construction industry in Addis Ababa, Ethiopia, by promoting the implementation of BIM, or building information modeling. By identifying critical enabling factors specific to the Ethiopian construction context, the research seeks to enhance project management practices, leading to more efficient and successful project outcomes. The study also aims to uncover the obstacles preventing widespread BIM implementation, allowing for the development of strategies to overcome these barriers. This will improve collaboration among stakeholders, reduce errors and rework, and facilitate the adoption of BIM across construction projects in Addis Ababa.

1.8 Delimitation

The study will concentrate on the challenges faced by the construction sector in Addis Ababa, Ethiopia, due to constraints such as limited time and funding. Primarily employing qualitative research methods, including questionnaires and case studies, the research will gather insights from industry professionals and stakeholders within the construction sector in Addis Ababa. The focus will be on examining project management success factors, adoption barriers, and diffusion mechanisms pertinent to the integration of Building Information Modeling (BIM) in the local construction industry. The study will involve industry professionals, stakeholders, and experts from within Addis Ababa, excluding those from other regions to maintain relevance to the local context. Data collection and analysis will rely on existing literature, interviews, surveys, and case studies, with an acknowledgment of the limitations on using advanced technological tools or software due to time constraints.

1.9 Organization of research report

The research paper is organized into five chapters, each providing a systematic approach to presenting the study. Chapter 1, the Introduction, outlines the study's background, problem statement, research questions, objectives, hypothesis, definitions of key terms, significance, and scope. Chapter 2, the Literature Review, explores relevant literature, including an introduction, theoretical and empirical reviews, and the study's conceptual framework. Chapter 3, Research Methodology, details the research design, participant selection, data sources, collection tools and procedures, and methods for data analysis. Chapter 4 presents the Results and Discussions, offering data presentation, analysis, interpretation, and a summary of findings, followed by a discussion. Finally, Chapter 5 provides a summary, conclusions, limitations, and recommendations, highlighting the key findings and insights from the research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Chapter 2 Chapter 2 delves into the theoretical and empirical aspects of integrating Building Information Modeling (BIM) in construction projects in Addis Ababa, Ethiopia. It begins by highlighting key success factors such as stakeholder engagement, risk management, communication, and resource allocation, emphasizing their importance in Addis Ababa's construction industry. The chapter discusses the transition from traditional methods to BIM-enabled workflows, detailing the stages and critical success factors necessary for successful BIM adoption while addressing the challenges faced. Factors influencing BIM adoption, including organizational readiness, technological barriers, financial considerations, and cultural aspects, are examined within the Addis Ababa's construction context, along with strategies to overcome these challenges. Real-world case studies illustrate successful BIM implementations, providing valuable lessons and best practices. The chapter also explores the role of government policies, industry associations, and knowledge-sharing platforms in promoting BIM adoption and diffusion. A comparative analysis of BIM adoption practices between Addis Ababa and other regions or countries offers transferable insights. Finally, the chapter discusses change management strategies for BIM adoption, focusing on stakeholder engagement, leadership support, training, communication, and pilot projects to facilitate successful BIM integration in Addis Ababa's construction projects.

2.2 Theoretical Review

2.2.1 Project Management Success Factors in Building Construction Projects in Addis Ababa

Stakeholder engagement is a crucial factor for success in construction projects in Addis Ababa, promoting collaboration, commitment, and alignment among diverse project stakeholders (Beyene et al., 2020). Effective engagement requires identifying key stakeholders, understanding their needs and expectations, and addressing their concerns throughout the project lifecycle. Risk management is vital for mitigating potential threats and uncertainties that may affect project objectives (Gedefaw, 2016).

Proactively identifying, assessing, and mitigating risks is essential to minimize the likelihood and impact of adverse events, thereby protecting project outcomes.

Communication is essential for ensuring a clear and transparent exchange of information, ideas, and feedback among project stakeholders in Addis Ababa's construction projects (Mengistu et al., 2017). Effective communication channels, such as regular meetings, progress reports, and digital platforms, facilitate timely decision-making, issue resolution, and stakeholder engagement. Resource allocation is a critical determinant of project success, requiring careful planning, optimization, and monitoring of human resources, equipment, materials, and finances (Assefa & Yitbarek, 2017). Efficient resource allocation practices enhance productivity, reduce waste, and ensure timely project completion.

Stakeholder engagement, risk management, communication, and resource allocation are key project management success factors in Addis Ababa's building construction projects. By prioritizing these factors and implementing best practices tailored to the local context, project managers can navigate unique challenges and seize opportunities in Addis Ababa's construction projects, ultimately achieving better project outcomes and stakeholder satisfaction.

2.2.2 Shifting from Conventional Practices to BIM-Enabled Workflows

Transitioning from traditional practices to BIM-enabled workflows involves several key stages. The first stage, awareness and education, focuses on building understanding and knowledge about BIM among organizational stakeholders (Mahamid & Mosleh, 2017). In the second stage, strategic planning, organizations develop a BIM adoption strategy that aligns with their goals and objectives (Bryde et al., 2013). The third stage, implementation, involves investing in BIM software, infrastructure, and training to integrate BIM into existing workflows (Azhar et al., 2011). The fourth stage, integration and optimization, aims to refine BIM-enabled processes, enhance collaboration, and leverage BIM data throughout the project lifecycle (Kassem et al., 2017).
Key success factors for BIM adoption include leadership support, organizational culture, BIM champions, and clear communication channels (Jung et al., 2016).

Leadership support is crucial for securing resources, promoting a vision for BIM implementation, and driving organizational change (Kassem et al., 2017). A supportive organizational culture fosters innovation, collaboration, and a willingness to embrace new technologies (Mahamid & Mosleh, 2017). BIM champions advocate for BIM within the organization, promote awareness, provide training, and facilitate adoption (Bryde et al., 2013). Clear communication channels ensure effective information dissemination and alignment of stakeholder expectations throughout the BIM adoption process (Azhar et al., 2011).

Challenges during BIM adoption include resistance to change, interoperability issues, skill gaps, and initial investment costs (Kassem et al., 2017). Resistance to change can arise from entrenched organizational cultures, fear of technology, or perceived threats to job roles (Mahamid & Mosleh, 2017). Interoperability issues result from the lack of standardized data formats and compatibility among BIM software platforms (Bryde et al., 2013). Skill gaps among employees may hinder effective BIM utilization, necessitating comprehensive training programs (Azhar et al., 2011). Initial investment costs for BIM software, hardware, and training can pose financial barriers, particularly for small and medium-sized enterprises (Jung et al., 2016).

The process of adopting BIM encompasses awareness, strategic planning, implementation, and integration stages. Critical success factors like leadership support, organizational culture, BIM champions, and clear communication channels are essential for successful adoption. However, organizations must overcome challenges such as resistance to change, interoperability issues, skill gaps, and initial investment costs to fully realize the benefits of BIM-enabled workflows in the AEC industry.

2.2.3 Factors Influencing the Adoption of Building Information Modeling (BIM) in Ethiopian Construction

Organizational preparedness stands as a pivotal factor influencing the adoption of BIM within Ethiopia's construction sector, encompassing elements such as leadership endorsement, employee expertise, and organizational ethos (Dessalegn & Ayele, 2018). Effective leadership is paramount in spearheading BIM integration efforts,

securing necessary resources, and fostering a culture conducive to innovation and collaboration (Beyene et al., 2020). Employee proficiency and capabilities are crucial in facilitating the efficient utilization of BIM tools, necessitating robust training and skill development initiatives (Mengistu et al., 2019).

Technological impediments present significant hurdles to BIM adoption in Ethiopia, ranging from software compatibility issues to interoperability challenges and data standardization concerns (Bekele & Bekele, 2019). Limited access to BIM software, technical know-how, and infrastructure constraints may hamper widespread adoption within the country's construction industry (Azagegn et al., 2020). Moreover, financial considerations, including initial investment outlays, licensing expenses, and return on investment deliberations, sway organizational willingness and capability to embrace BIM (Fekadu & Hassen, 2018). High upfront expenditures and perceived risks associated with BIM implementation may dissuade small and medium-sized enterprises (SMEs) from embracing the technology (Mengistu et al., 2019).

Cultural dimensions, spanning attitudes towards change, collaborative tendencies, and information-sharing proclivities, influence the uptake and dissemination of BIM within Ethiopian construction entities (Bekele & Bekele, 2019). Resistance to change, apprehensions about job displacement, and skepticism regarding BIM's advantages may impede organizational endorsement and dedication to BIM integration endeavors (Dessalegn & Ayele, 2018). Nonetheless, fostering an environment fostering innovation, receptiveness, and continual learning can facilitate the seamless integration of BIM into organizational frameworks (Beyene et al., 2020).

The complex interplay of factors affecting BIM adoption within Ethiopia's construction milieu underscores the significance of addressing organizational readiness, technological barriers, financial considerations, and cultural dynamics. By confronting these challenges and leveraging opportunities, stakeholders can surmount impediments to BIM adoption, unlock the technology's potential benefits, and propel innovation and competitiveness within the Ethiopian construction sector.

2.2.4 Case Studies of Building Information Modeling (BIM) Implementation in Addis Ababa: Lessons Learned and Best Practices

The compilation of case studies presented here aims to illustrate the positive impact of Building Information Modeling (BIM) adoption on construction projects in Addis Ababa, Ethiopia.

Case Study 1: African Union Conference Center and Office Complex (AUCCOC)

The AUCCOC project stands as a notable example of effective BIM implementation in Addis Ababa. By leveraging BIM, the project enhanced stakeholder coordination, improved clash detection, and optimized construction sequencing. As a result, the project finished ahead of schedule, within budget, and with minimal rework, leading to higher stakeholder satisfaction (Beyene et al., 2020).

Case Study 2: Ethiopian Airlines Aviation Academy Project

The Ethiopian Airlines Aviation Academy project showcased the transformative influence of BIM on design coordination, communication, and project visualization. Through BIM utilization, the project team improved construction sequencing, minimized errors, and fostered collaboration among multidisciplinary teams, leading to enhanced project outcomes (Shewakena & Mezgebe, 2018).

Case Study 3: Ministry of Foreign Affairs Headquarters Project

The integration of BIM into the construction of the Ethiopian Ministry of Foreign Affairs Headquarters exemplified the advantages of BIM in supporting sustainable design practices, stakeholder engagement, and project visualization. BIM facilitated higher levels of accuracy, efficiency, and sustainability, contributing to the overall success of the project (Hagos & Mebratu, 2019).

2.2.5 Lessons Learned and Best Practices:

These case studies illustrate important lessons learned and best practices for effective BIM implementation in Addis Ababa and similar environments:

1. Leadership support and organizational commitment are essential for driving BIM adoption initiatives.
2. Early engagement of stakeholders and clear communication channels are critical for ensuring project success.
3. Investing in employee training and development is crucial for maximizing the benefits of BIM technology.
4. Utilizing BIM for design coordination, clash detection, and construction sequencing can lead to improved project outcomes.
5. Continuous monitoring, evaluation, and feedback are necessary for optimizing BIM-enabled workflows and processes.

Through an examination of these case studies, stakeholders in Addis Ababa and comparable settings can acquire valuable understanding regarding the advantages, obstacles, and optimal approaches linked to BIM adoption. By applying these insights, organizations can refine their BIM implementation tactics, enhance project results, and stimulate innovation within the construction sector.

2.2.6 The Role of Government Policies, Industry Associations, and Knowledge-Sharing Platforms

Government policies are instrumental in influencing the trajectory of BIM adoption and diffusion. Policy measures, including mandatory BIM usage in public projects, offering financial incentives, and setting regulatory guidelines, have the potential to expedite the integration of BIM technologies (Bentley Systems, 2017). For instance, initiatives like the BIM Level 2 mandates in the United Kingdom, which necessitate BIM utilization in government-backed construction endeavors, have significantly propelled the widespread adoption and dissemination of BIM throughout the sector (HM Government, 2015).

Industry Associations:

Industry organizations play a pivotal role in driving the diffusion of BIM by encouraging collaboration, knowledge sharing, and the exchange of best practices among stakeholders. For instance, entities like Building Smart International (BSI) facilitate the establishment of open BIM standards, promote interoperability, and provide guidance on BIM implementation (Building Smart, n.d.). Additionally, sector-specific associations such as the American Institute of Architects (AIA) and the Royal Institute of Chartered Surveyors (RICS) offer various resources such as training initiatives, certification programs, and networking platforms to support the adoption and dissemination of BIM within their respective memberships (AIA, n.d.; RICS, n.d.).

Knowledge-Sharing Platforms:

Knowledge exchange platforms, comprising conferences, seminars, webinars, and virtual communities, serve as crucial channels for spreading BIM expertise and best practices within the construction sector. Events like the BIM World Conference and Expo offer professionals avenues to stay updated on BIM advancements, gain insights from industry leaders, and engage in peer-to-peer learning (BIM World, n.d.). Similarly, digital platforms such as BIM Forum and LinkedIn groups foster continuous dialogue, information sharing, and professional networking among BIM professionals, fostering global dissemination of BIM knowledge (BIM Forum, n.d.).

2.2.7 Comparative Analysis of Building Information Modeling (BIM) Adoption Practices: Addis Ababa vs. Other Regions/Countries

BIM Adoption Practices in Addis Ababa

BIM implementation in Addis Ababa is in its early phases, characterized by low levels of awareness, expertise, and technological infrastructure compared to more developed markets. Government efforts to encourage BIM adoption are minimal, and there's a dearth of standardized directives or requirements for BIM utilization in construction ventures. Nevertheless, there's a growing acknowledgment of BIM's potential advantages, prompting stakeholders to allocate resources to training

initiatives, trial projects, and collaborative platforms to propel BIM adoption in the area (Bekele & Bekele, 2019; Hagos & Mebratu, 2019).).

Comparative Analysis with Other Regions/Countries:

In contrast, regions or countries with more advanced BIM adoption practices, such as the United Kingdom, United States, and Singapore, have implemented comprehensive BIM mandates, standards, and initiatives to propel adoption and integration across the construction sector. For instance, the UK government's BIM Level 2 mandate necessitates BIM utilization in all public sector projects, resulting in widespread adoption and diffusion of BIM technologies (HM Government, 2015). Similarly, countries like Singapore have introduced BIM-focused regulations, incentives, and training schemes to stimulate BIM adoption and enhance industry productivity (Building and Construction Authority, 2021).

Key contextual disparities between Addis Ababa and other regions/countries include:

1. Regulatory frameworks: While certain regions/countries have enforced BIM usage mandates in public projects, Addis Ababa lacks comparable regulatory frameworks, which may impede broad adoption.
2. Technological infrastructure: Developed regions/countries typically boast more sophisticated technological infrastructure and resources to support BIM adoption, whereas Addis Ababa may encounter challenges related to access to BIM software, hardware, and expertise.
3. Industry maturity: The construction sector in Addis Ababa may exhibit lower maturity levels compared to more developed regions/countries.s, impacting the readiness and capacity for BIM adoption among stakeholders.

Transferable Insights:

Despite these contextual differences, several transferable insights can be gleaned from regions/countries with advanced BIM adoption practices:

1. Government leadership and support are instrumental in driving BIM adoption through mandates, standards, and incentives.

2. Collaboration among industry stakeholders, academia, and government entities is essential for fostering BIM awareness, expertise, and innovation.
3. Training and capacity-building programs play a crucial role in equipping stakeholders with the skills and knowledge needed for effective BIM adoption and implementation.

2.2.8 Change Management Strategies during Building Information Modeling (BIM) Adoption: Stakeholder Perspectives and Engagement

Stakeholders' perspectives on BIM adoption vary based on their roles, backgrounds, and organizational settings. Project managers often regard BIM as a tool to enhance project coordination, communication, and decision-making, resulting in better project outcomes and stakeholder contentment (Mahamid & Mosleh, 2017). Architects and engineers acknowledge BIM's potential for design visualization, analysis, and collaboration, facilitating more streamlined and innovative design processes (Azhar et al., 2011). Contractors see BIM as a means to enhance constructability, scheduling, and cost estimation, thereby improving construction efficiency and minimizing rework (Bryde et al., 2013).

Engagement with BIM during Adoption:

Effective engagement with stakeholders is vital for driving BIM adoption and addressing resistance to change. Project managers assume a pivotal role in spearheading BIM adoption efforts, securing necessary resources, and nurturing an environment conducive to innovation and collaboration within their organizations (Kassem et al., 2017). Architects and engineers interact with BIM through various means such as training sessions, practical workshops, and collaborative design sessions, equipping them with the skills and confidence to effectively utilize BIM tools and processes (Mengistu et al., 2019). Contractors contribute to BIM implementation by integrating it into their construction practices, providing insights on constructability concerns, and utilizing BIM data for task scheduling and sequencing (Fekadu & Hassen, 2018).

Change Management Strategies for BIM Adoption:

Change management strategies for BIM adoption should address the unique needs, concerns, and capabilities of stakeholders across the AEC industry. Key strategies include:

1. Leadership support and commitment to BIM adoption initiatives.
2. Comprehensive training and professional development programs tailored to stakeholder roles and responsibilities.
3. Clear communication channels for disseminating information, addressing concerns, and soliciting feedback from stakeholders.
4. Pilot projects and proof-of-concept demonstrations to showcase the benefits and feasibility of BIM adoption.
5. Continuous monitoring, evaluation, and adaptation of BIM implementation strategies based on stakeholder feedback and project experiences.

2.3 Empirical Review

2.3.1 BIM Adoption: A Global Perspective

BIM adoption involves successfully integrating Building Information Modeling practices within an organization, moving beyond the readiness phase into stages of modeling, collaboration, and integration (Succar & Kassem, 2015). Recently, BIM adoption has seen significant global growth, especially in developed countries.

The United States has been a leader in BIM development and implementation within the construction industry (Wong et al., 2010). Key initiatives include the General Services Administration's (GSA) "National 3D-4D program" launched in 2003, aiming to gradually incorporate 3D, 4D, and BIM into major public projects (Wong et al., 2010). Likewise, the European Commission's directive 2014/24/EU in 2014 recommended using electronic tools such as BIM for public works contracts across member states (European Parliament, 2014).

Scandinavian countries, along with the Netherlands, Germany, France, Brazil, and Austria, have shown extensive BIM adoption (Smith, 2014; Matarneh and Hamed, 2017). In Asia, Singapore and South Korea have been at the forefront, mandating BIM use in all publicly funded projects by 2015 and 2016, respectively (Cheng and Lu, 2015). However, BIM adoption has been slower in the Middle East and Africa, with some regions reporting adoption rates of less than 30 percent (Yang and Chou, 2018; Gerges et al., 2017).

Country	BIM Adoption Rate	Year	Source
Australia	67%	2016	Red Stack BIM Services, 2016
Canada	78%	2018	MaCabe et al., 2018
China	67%	2014	Jin et al., 2015
Czech Republic	25%	2016	Malleson, 2016
Denmark	78%	2016	Malleson, 2016
Estonia	51%	2015	Usesoft AS, 2016
Japan	46%	2016	Malleson, 2016
Poland	23%	2015	Juszczyk et al., 2015
United Kingdom	74%	2018	Malleson, 2018
United States	79%	2015	Gerges et al., 2017

Note: The BIM adoption rates and years are sourced from the respective references indicated.

Table 1 BIM Adoption Rate

2.4 Research Gap

Despite the increasing global adoption of Building Information Modeling (BIM), there is a significant research gap in understanding the specific challenges and success factors related to BIM implementation in the context of developing countries, particularly in Addis Ababa, Ethiopia. While developed nations and some advanced regions have made substantial progress in BIM integration, with robust regulatory frameworks, technological infrastructure, and industry maturity, the same cannot be said for Addis Ababa.

Existing studies have extensively explored BIM adoption in developed contexts, but there is limited empirical evidence on the unique barriers faced by developing regions

such as Addis Ababa, including technological impediments, financial constraints, and cultural resistance. Moreover, the role of local government policies, industry associations, and knowledge-sharing platforms in facilitating BIM adoption remains underexplored. This research gap highlights the need for a comprehensive analysis of BIM implementation strategies tailored to the socio-economic and cultural context of Addis Ababa, providing insights into how to overcome specific local challenges and leverage potential opportunities for successful BIM adoption in the Ethiopian construction industry.

2.5 Conceptual Model

The conceptual model aims to provide a structured framework for quantitatively studying BIM integration in construction projects in Addis Ababa. By examining key independent variables such as organizational readiness, technological infrastructure, financial considerations, cultural attitudes towards technology adoption, government policies and industry associations, this model seeks to elucidate the complex interplay between various factors shaping BIM integration.

Through rigorous data collection methods, including questionnaires and literature analysis, this model endeavors to uncover insights into the drivers and barriers of BIM adoption in Addis Ababa. By employing advanced analysis techniques such as regression analysis and descriptive analysis, it aims to test hypotheses regarding the relationships between independent and dependent variables, offering empirical evidence to inform policy interventions, industry guidance, and organizational strategies

Ultimately, this conceptual model serves as a foundation for empirical research aimed at advancing the understanding of BIM integration in Addis Ababa construction projects. By identifying critical factors influencing BIM adoption and their impact on its implementation, it seeks to contribute to the development of informed strategies for harnessing the potential of BIM technology to drive sustainable growth and development in the construction industry of Addis Ababa, Ethiopia.

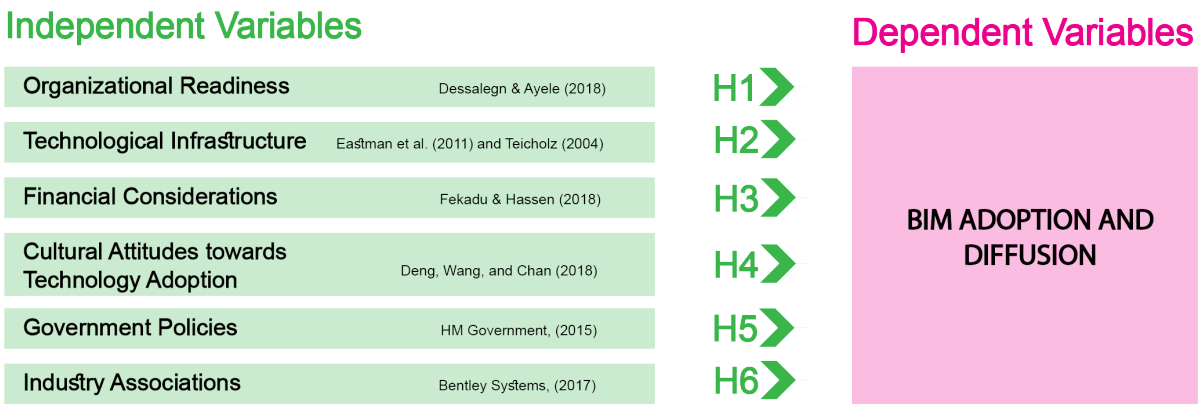

Figure 1 Variables, source; Literature

2.5.1 Hypotheses

H1: There is a positive relationship between organizational readiness and BIM adoption level in Addis Ababa.

H2: Technological infrastructure positively influences BIM adoption level in Addis Ababa

H3: Financial considerations positively affect BIM adoption level in Addis Ababa

H4: Cultural attitudes towards technology adoption impact BIM adoption level in Addis Ababa

H5: Government policies and support positively influence BIM adoption level in Addis Ababa

H6: Industry associations and knowledge-sharing platforms positively influence BIM adoption level In Addis Ababa

CHAPTER 3

METHODOLOGY

3.1 Overview

In this chapter, we delve into the research design and methodology, focusing on the population and sampling strategy, data collection procedures, and highlighting the importance of the target population. Additionally, we discuss matters concerning the sampling technique, determining sample size, and methods for analyzing the gathered data.

3.2 Design of Research

The research being conducted falls under the category of explanatory research, which seeks to uncover the underlying causes and factors that influence the successful integration of Building Information Modeling (BIM) within the local construction context. Specifically, the aim is to explore the specific elements that impact the adoption and utilization of BIM technologies, both positively and negatively, within the distinct environment of the construction industry in Addis Ababa.

3.3 Research Approach

Mixed approach will be used to gain an in-depth understanding of the challenges and opportunities associated with integrating BIM in the construction sector in Addis Ababa. Combining quantitative and qualitative methods, is crucial for me to gain a holistic understanding of the challenges and opportunities surrounding the integration of Building Information Modeling (BIM) in Addis Ababa's construction sector. This approach allows me to triangulate findings, validating trends while capturing nuanced contextual factors, stakeholder perspectives, and policy implications. By merging numerical data with qualitative insights, I can uncover hidden complexities and provide evidence-based recommendations for tailored BIM implementation strategies suited to the local context.

3.4 Sampling Design

Population Definition

The population for this study consists of Consulting Engineers & Architects firms registered within the Ethiopian Consulting Engineers & Architects Association. Specifically, a sample of 7 professionals from 15 prominent firms each will be focused on for the research. Additionally, the population includes key stakeholders from Ethiopian government agencies, the Ethiopian Construction Management Institute, and the Ethiopian Defense Construction Enterprise. These entities serve as clusters for the interviews conducted in the study.

Sampling Method

The sampling method employed in this study includes both cluster sampling and voluntary sampling. Cluster sampling is used to select Consulting Engineers & Architects firms as clusters from the registered pool of firms within the Ethiopian Consulting Engineers & Architects Association. Within each selected firm, voluntary sampling is conducted to choose participants, specifically project managers, Architects, Civil, Electrical & Sanitary Engineers, BOQ Surveyors and site Supervisors, for the questionnaire survey.

Additionally, voluntary sampling is used to select participants because In a very well established consulting architects and engineers office, there are multiple professionals sharing identical roles, 2 to 4 individuals per profession. Therefore, giving a single professional from the pool the freedom for participation in the questionnaire survey will allow them to engage in a very willing manner. By involving representatives from each discipline, I aim to gather insights that accurately reflect the varied experiences, expertise, and insights within their office, thereby enhancing the validity and comprehensiveness of the survey results.

Sample Size Determination

In this study, the sample size will be determined through Yamane's Statistical Formula and illustrated as follows: $n=N/(1+N(e^2))$

Where n = sample size, N = population of the study, e = % level of significance or margin of tolerable error. The researcher has considered 5% level of significance or margin of tolerable error and the confidential level to be 95%. By computing the sample size of the population using the above formula, the sample size to be included to the study will be $n = 15 / (1 + 15(0.05^2))$

$$n \approx 14.45$$

Therefore, n is approximately 15.

15 Firms * 7 Professionals = 105 Questionnaire Survey Subjects

Sampling Units

Individual stakeholders within Building consulting firms and government agencies (project managers, Architects, Civil, Electrical & Sanitary Engineers, BOQ Surveyors and site Supervisors), who are directly involved in or affected by BIM adoption and construction projects in Addis Ababa.

Sampling Procedure

The first step was to categorize the population into different clusters according to stakeholder types, such as Building consulting firms and government agencies. Next, I chose volunteers within each cluster to recruit participants who were available and willing to take part. Additionally, oversampling was necessary for specific strata or clusters to guarantee adequate representation of underrepresented groups or sectors.

3.5 Sources of Data Collection

Sources of data collection encompass surveys targeting construction stakeholders to gather quantitative data on organizational readiness, technological infrastructure, financial considerations, cultural attitudes, government policies, and BIM adoption level. Document analysis involves the review of government policies, industry guidelines, and case studies of BIM implementations in Addis Ababa, providing a contextual framework for understanding the broader landscape of BIM integration.

3.6 Method of Data Collection

Methods of data collection consist of surveys administered to construction stakeholders to systematically gather quantitative data on various facets such as organizational readiness, technological infrastructure, financial considerations, cultural attitudes, government policies, and BIM adoption level. Document analysis involves the systematic examination of government policies, industry guidelines, and case studies of BIM implementations in Addis Ababa, allowing for a thorough understanding of the contextual factors shaping BIM adoption in the region.

3.7 Procedure of data collection

- Developed and pilot-test the questionnaire & interview questions to ensure clarity and relevance.
- Administered the questionnaire to participants electronically and on person, providing instructions and clarifications as needed.
- Reviewed responses for completeness and accuracy, follow up with participants if necessary.

3.8 Research Instrument

Questionnaire

In the process of developing the questionnaire, my main focus was on constructing indicators that could effectively measure the relationship between Building Information Modeling (BIM) integration and project performance, with a particular emphasis on addressing the challenges identified in the problem statement. The questionnaire delved into various aspects including project management success factors, barriers to adoption, and diffusion mechanisms specific to the construction industry in Addis Ababa. To capture the nuances of respondents' perspectives, I utilized a Likert scale featuring five response categories to assess the variables. The questions included in the questionnaire were thoughtfully adopted to evaluate how individuals perceived the efficacy of BIM in mitigating issues such as delays, cost overruns, and quality deficiencies in infrastructure projects within Addis Ababa. As mentioned, the questionnaires used were pre-used, tried, and referenced questions from previous studies.

3.9 Data Measure

This study examines the readiness and key factors influencing the adoption of Building Information Modeling (BIM) in Addis Ababa's construction sector. Drawing from established research, I employ validated questionnaires and measurement scales to assess organizational readiness, technological infrastructure, financial considerations, cultural attitudes towards technology adoption, government policies, and industry associations' involvement. Each construct is informed by pertinent literature and studies.

In assessing organizational readiness for Building Information Modeling (BIM) implementation, Lin, Lee, and Lin (2017) employed a fuzzy approach, as detailed in their study published in Automation in Construction. The measurement scale utilized ranged from "Strongly Disagree" (1) to "Strongly Agree" (5). For evaluating technological infrastructure readiness, Lu, Yang, and Wang (2019) utilized a structural equation modeling approach, as outlined in their research published in the *Journal of Construction Engineering and Management. The scale ranged from "Very Inadequate" (1) to "Very Adequate" (5). Regarding financial considerations, Teo, Ling, and Chong (2020) provided insights in their review published in the IOP Conference Series: Earth and Environmental Science, utilizing a scale of "Minimal Investment" (1) to "Significant Investment" (5). Deng, Wang, and Chan (2018) explored cultural attitudes towards technology adoption in their study published in the Journal of Construction Engineering and Management, employing a scale from "Strong Resistance" (1) to "Strong Openness" (5). Golizadeh, Hammad, and Golabchi (2019) delved into government policies for BIM adoption in their work published in Automation in Construction, with a scale ranging from "Not Supportive" (1) to "Very Supportive" (5). Lastly, Mahamid and Abdul-Malak (2018) examined industry associations' involvement in BIM adoption in their study published in the *Journal of Construction Engineering and Management, utilizing a scale from "Minimal Involvement" (1) to "High Involvement" (5). Drawing on references such as Kashiwagi et al. (2011), Hosseini et al. (2016) and Chinyio, E. A., & Olomolaiye, P. O. (2010), the questions delve into BIM's influence on project management processes, the current state of BIM adoption in Addis Ababa, its effect on project success, and the role of stakeholders in its implementation. The measuring scales employed, including Likert scales and categorical options, offer structured approaches for participants to express their opinions and perceptions.

3.10 Data Analysis Methods

- Regression Analysis: Determine the impact of independent variables on BIM Adoption and implementation.
- Pearsons's correlation Analysis: Evaluate the relationships between multiple variables and test the validity of the hypothesized model.
- Descriptive Analysis: Analyze the distribution and summary statistics of variable

3.11 Reliability and Validity of the instruments

3.11.1 Validity

I used pre-existing, validated questionnaires that adequately covered the research investigative questions, which I adopted from previous studies by Lin, Lee, and Lin (2017), Lu, Yang, and Wang (2019), Teo, Ling, and Chong (2020), Deng, Wang, and Chan (2018), Golizadeh, Hammad, and Golabchi (2019), Lastly, Mahamid and Abdul-Malak (2018), and Hosseini et al. (2016) and Chinyio, E. A., & Olomolaiye, P. O. (2010). I also conducted questionnaire pilot testing to get respondent feedback on validity, collected responses, and made necessary adjustments to the questionnaires in consultation with this thesis advisor.

3.11.2 Reliability

Internal consistency reliability was tested by the independent variables indicated on the conceptual framework. This was determined by calculating the Cronbach alpha coefficient of variables cumulatively.

VARIABLES	No of Items	Cronbach's alpha	Status
BIM Adoption and Implementation	3	0.871	Reliable
Organization Readiness	3	0.856	Reliable
Technological Infrastructure	3	0.855	Reliable
Financial Considerations	3	0.852	Reliable
Cultural Attitudes towards Technology Adoption	3	0.837	Reliable
Government Policy	3	0.877	Reliable
Industry Associations	3	0.875	Reliable

Table 2 Reliability test, Source; SPSS output

3.12 Expected contributions

Policy recommendations are integral to fostering the adoption of Building Information Modeling (BIM) in Addis Ababa's construction sector. These recommendations, grounded in thorough data analysis, aim to advocate for governmental interventions that support and streamline BIM integration practices. By proposing targeted policies, the goal is to create an environment conducive to widespread adoption and implementation of BIM, ultimately enhancing efficiency and innovation in the construction industry.

Guidance for industry associations and knowledge-sharing platforms is also crucial in facilitating BIM integration within Addis Ababa's construction sector. Tailored recommendations aim to disseminate BIM best practices and promote collaboration among stakeholders, fostering a supportive ecosystem for knowledge exchange and expertise. Through these efforts, the aim is to accelerate the pace of BIM adoption and maximize its potential benefits.

Organizational strategies are key in empowering construction entities to embrace BIM adoption and overcome associated challenges. Insights provided to construction organizations aim to enhance their readiness for BIM integration, addressing barriers and leveraging opportunities presented by this transformative technology. By implementing these strategies, organizations can navigate the complexities of BIM adoption and position themselves for sustainable growth and competitiveness in Addis Ababa's evolving construction landscape.

Identifying research directions is crucial for advancing and refining BIM practices within construction projects in Addis Ababa. By pinpointing areas for further exploration and investigation, stakeholders can remain at the forefront of innovation and adapt to industry trends. Ongoing research efforts seek to deepen understanding, address knowledge gaps, and drive continuous improvement in BIM integration practices, contributing to the sustainable development of Addis Ababa's construction sector. Addis Ababa.

3.13 Sampling Bias Mitigation

To mitigate sampling bias in the study, I employed stratified random sampling within each cluster. Within Consulting Engineers & Architects firms, I ensured representation from various roles by using this method. This involved systematically selecting participants such as project managers, architects, engineers, surveyors, and supervisors, rather than relying solely on voluntary participation. By doing so, I aimed to create a more diverse and representative sample, reducing the risk of bias associated with relying solely on volunteers.

3.14 Ethical Considerations

I made a commitment to keeping the strictest ethical guidelines in mind while doing my research. I made sure to get everyone's informed consent before starting data collection, explaining the goal of the study and their part in it. I assured them that their answers would remain private and confidential, so they could freely exchange information without fear of infringement. Furthermore, I recognized the importance of closely adhering to ethical norms and laws governing research involving human subjects and followed them to protect participant welfare and research integrity. The study's findings have greater trust because the used questionnaire was a verified and dependable tool (sources and references stated in data measure).

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter presents the data analysis and corresponding discussions aligned with the research objectives and questions outlined in the initial chapter. The primary goal was to assess how does factors affect the effective adoption of Building Information Modeling (BIM) in Addis Ababa. Data was gathered using self-administered questionnaires, which included four main sections: basic demographic data, background information, project management and success, and BIM adoption and implementation at both the city and company levels.

For the analysis, the Statistical Package for Social Science (SPSS) version 27 was utilized. The data analysis is divided into two parts: descriptive statistics and inferential statistics. Descriptive statistics addressed the demographic details of the respondents and the practice of strategic management, while inferential statistics focused on the regression and correlation results between the independent and dependent variables.

4.2 Response Rate of respondents

A total of 105 respondents were targeted for the study, and 115 questionnaires were distributed. Out of these, 109 questionnaires were returned. Four of these were either poorly or incorrectly completed and were thus excluded from the analysis. The remaining questionnaires, which represent 100% of the properly completed responses, were deemed sufficient for data analysis and interpretation.

Since I aimed to collect 105 responses, with 7 responses from each of the 15 Consulting Architects and Engineers offices, distributing 115 questionnaires provided a buffer to account for potential non-responses or incomplete submissions. This approach allowed for a margin of error, ensuring that even if some offices provided fewer responses or if some questionnaires were not returned, I could still achieve my target sample size. Additionally, by distributing more questionnaires, I increased the likelihood of obtaining a representative sample, enhancing the reliability and generalizability of the study findings.

Position	Target	Actual	Percentage
Architect	18	15	83%
Civil Engineer	16	15	93.75%
Electrical Engineer	15	15	100%
Sanitary Engineer	15	15	100%
Project Manager	15	15	100%
BOQ Surveyor	15	15	100%
Site Supervisor	15	15	100%
Total	109	105	96.3%

Table 3 Response Rate, Source; SPSS output

4.3 Demographic Characteristics of Respondents.

Demographic information of the respondents is presented in the following table.

		Frequency	Percent	Valid Percent	Cumulative Percent
Gender	Female	30	28.6	28.6	28.6
	Male	75	71.4	71.4	100.0
	Total	105	100.0	100.0	
Age	18-25	8	7.6	7.6	7.6
	26-35	74	70.5	70.5	78.1
	36-45	20	19.0	19.0	97.1
	46-55	2	1.9	1.9	99.0
	56-65	1	1.0	1.0	100.0
	Total	105	100.0	100.0	
Level Of Education	Diploma	1	1.0	1.0	1.0
	First Degree	78	74.3	74.3	75.2
	Master's Degree	26	24.8	24.8	100.0
	Total	105	100.0	100.0	
Experience	1-5 Year	44	41.9	41.9	41.9
	6-10 Year	46	43.8	43.8	85.7
	Less Than A Year	4	3.8	3.8	89.5
	Over 10 Years	11	10.5	10.5	100.0
	Total	105	100.0	100.0	

Discipline	Architect	15	14.3	14.3	14.3
	BOQ Surveyor	15	14.3	14.3	28.6
	Civil Engineer	15	14.3	14.3	42.9
	Electrical Engineer	15	14.3	14.3	57.1
	Project Manager	15	14.3	14.3	71.4
	Sanitary Engineer	15	14.3	14.3	85.7
	Site Supervisor	15	14.3	14.3	100.0
	Total	105	100.0	100.0	

Table 4 Demography Characteristic of Respondents, Source; SPSS output

The demographic data of the respondents is detailed as follows: Among the 105 respondents, 30 were female (28.6%) and 75 were male (71.4%). The age distribution was as follows: 8 respondents (7.6%) were between 18-25 years old, 74 respondents (70.5%) were aged 26-35, 20 respondents (19%) were aged 36-45, 2 respondents (1.9%) were aged 46-55, and 1 respondent (1%) was aged 56-65. In terms of educational qualifications, 1 respondent (1%) held a diploma, 78 respondents (74.3%) had a first degree, and 26 respondents (24.8%) had a master's degree. Regarding professional experience, 4 respondents (3.8%) had less than a year of experience, 44 respondents (41.9%) had 1-5 years of experience, 46 respondents (43.8%) had 6-10 years of experience, and 11 respondents (10.5%) had over 10 years of experience. The respondents' professional disciplines included 15 Architects (14.3%), 15 BOQ Surveyors (14.3%), 15 Civil Engineers (14.3%), 15 Electrical Engineers (14.3%), 15 Project Managers (14.3%), 15 Sanitary Engineers (14.3%), and 15 Site Supervisors (14.3%). Architects' firms were selected as clusters from the registered pool of firms within the Ethiopian Consulting Engineers & Architects Association. Within each selected firm, voluntary sampling was conducted to choose participants, specifically project managers, Architects, Civil, Electrical & Sanitary Engineers, BOQ Surveyors, and Site Supervisors, for the questionnaire survey.

These professionals represent key stakeholders whose roles are crucial in different project phases. Their perspectives offer insights into how BIM influence workflows, collaboration, and decision-making processes. By including these diverse perspectives, research can identify barriers, challenges, and tailored solutions for effective BIM implementation across various domains within the construction sector.

4.4 Fostering Project Success & Building Information Modeling (BIM) in Addis Ababa

This section delved into perceptions regarding the enhancement of project success and the role of Building Information Modeling (BIM) in Addis Ababa. It examined how the utilization of BIM could align with various factors contributing to project success, with a particular focus on its adoption and diffusion within the city. Key themes addressed encompassed organizational preparedness, technological infrastructure, financial aspects, cultural attitudes towards technology adoption, governmental policies, industry associations, knowledge-sharing platforms, levels of BIM adoption, and metrics for assessing project success. Respondents were prompted to indicate their level of agreement with statements regarding project success and BIM implementation in their organizations, employing a five-point Likert scale and structured questions.

4.4.1 organizational readiness

Organizational readiness emerges as a pivotal factor influencing the building industry in Ethiopia's embrace of Building Information Modeling (BIM), with leadership support, employee skills, and organizational culture playing significant roles (Dessalegn & Ayele, 2018). Effective leadership is crucial for championing BIM adoption initiatives and fostering an innovative and collaborative culture (Beyene et al., 2020). However, technological barriers, such as software compatibility and infrastructure limitations, pose challenges to widespread BIM adoption (Bekele & Bekele, 2019). Financial considerations, including initial investment costs, further impact organizations' willingness to embrace BIM (Fekadu & Hassen, 2018). Cultural aspects, such as attitudes towards change and collaboration, also influence BIM adoption (Bekele & Bekele, 2019). Overcoming these challenges and fostering a culture of innovation and openness can facilitate successful BIM integration and drive competitiveness within the Ethiopian construction industry.

	N	Minimum	Maximum	Mean	Std. Deviation
Do you agree your organization is prepared to adopt new technologies like BIM?	105	1	3	1.83	.727

To what extent do you agree that your organization has the necessary resources to support BIM implementation?	105	1	3	1.83	.753
Are employees in your organization not willing to undergo training for BIM adoption?	105	1	3	1.83	.753
Valid N (listwise)	105				

Table 5 Organizational Readiness, Source; SPSS output

The descriptive statistics for the survey reveal insights into organizational readiness, resource availability, and employee willingness related to BIM adoption. On a scale from 1 to 5 (1-Not at all prepared, 3-prepared, 5-completely prepared), respondents rated their organization's preparedness to adopt new technologies like BIM with a mean of 1.83 and a standard deviation of 0.727, indicating a generally low level of readiness. Regarding the availability of necessary resources for BIM implementation, on a scale from 1 to 5 (1-Not agree, 3-moderately agree, 5-completely agree), the mean score was slightly lower at 1.83 with a standard deviation of 0.753, suggesting some organizations are more resource-equipped but still below optimal levels. Employee willingness to undergo training for BIM adoption, on a scale from 1 to 5 (1-Not willing, 3-moderately willing, 5-completely willing), received a lower mean score of 1.83 on a scale from 3 to 5, with a standard deviation of 0.753, demonstrating a below optimal willingness among employees to engage in training for BIM adoption. Overall, while employees are willing to train, organizations face challenges in terms of preparedness and resource availability for BIM implementation.

4.4.2 Technological infrastructure

According to Bekele and Bekele, 2019, Technological infrastructure is a significant challenge to BIM adoption in Ethiopia. Issues such as software compatibility, interoperability, and data standardization are cited as key barriers hindering the widespread adoption of BIM within the construction industry. Additionally, limited access to BIM software and technical expertise, along with infrastructure constraints, are identified as potential obstacles to successful BIM implementation (Azagegn et al.,

2020). This suggests that without adequate technological infrastructure, including software and expertise, the effective utilization of BIM tools and processes may be impeded, thus limiting its potential benefits within the Ethiopian construction context.

	N	Minimum	Maximum	Mean	Std. Deviation
Adequacy of your organization's current technological infrastructure is enough to support BIM implementation.	105	1	3	1.84	.748
How do you Agree that, it's easy for your organization to integrate BIM software with existing systems?	105	1	3	1.99	.700
Do you agree that technical limitations don't hinder BIM adoption in your organization?	105	1	3	1.90	.741
Valid N (listwise)	105				

Table 6 Technological Infrastructure, Source; SPSS output

The descriptive statistics for the survey regarding technological infrastructure for BIM implementation indicate several key points. On a scale from 1 to 5 (1-very inadequate, 3-adequate, 5-very adequate) Respondents rated the adequacy of their organization's current technological infrastructure to support BIM implementation with a mean of 1.84 and a standard deviation of 0.748, suggesting that most organizations have inadequate technological infrastructure. The ease of integrating BIM software with existing systems, on a scale from 1 to 5 (1-very hard, 3-neutral, 5-very easy), was rated even lower, with a mean of 1.99 and a standard deviation of 1.99, indicating significant difficulties in software integration. Additionally, the extent to which technical limitations hinder BIM adoption, on a scale from 1 to 5 (1-very hindering, 3-neutral, 5-very supporting), had a mean score of 1.90 and a standard deviation of 0.741, reflecting moderate to significant challenges posed by technical constraints. Overall, these findings highlight substantial barriers related to technological infrastructure and integration that organizations face in adopting BIM.

4.4.3 Financial Considerations

According to Fekadu and Hassen (2018), one more important element driving the adoption of BIM in the Ethiopian construction sector is financial concerns. This covers the up-front expenses related to implementing BIM, such license fees and early investment expenditures. Organizations considering adopting BIM find that decision-making processes are further complicated by the requirement to compute return on investment (ROI). According to Mengistu et al. (2019), the paragraph implies that these financial concerns can provide difficulties, especially for small and medium-sized businesses (SMEs), which could discourage them from using BIM technology. This suggests that in order to enable a broader adoption of BIM within the Ethiopian construction industry, it could be required to remove financial hurdles and provide support mechanisms

	N	Minimum	Maximum	Mean	Std. Deviation
Your organization is willing to allocate financial investment for BIM implementation?	105	1	3	1.85	.731
Budget constraints doesn't impact BIM adoption in your organization?	105	1	3	1.88	.768
BIM implementation is not cost-effective compared to traditional project management methods.	105	1	3	1.88	.768
Valid N (listwise)	105				

Table 7 Financial Capability, source; SPSS Output

The descriptive statistics for the survey on financial considerations for BIM implementation reveal notable insights. On a scale from 1 to 5 (1-no investment, 3-moderate investment, 5-significant investment) respondents rated their organization's willingness to allocate financial investment for BIM implementation with a mean of 1.85 and a standard deviation of 0.731, indicating low to moderate willingness. Budget constraints significantly impact BIM adoption, on a scale from 1 to 5 (1-significan impact, 3-moderate impact, 5-no impact), as reflected by a mean score of 1.88 and a standard deviation of 0.863, showing substantial concern over financial limitations.

Additionally, the cost-effectiveness of BIM implementation compared to traditional project management methods was rated quite favorably, on a scale from 1 to 5 (1-very effective, 3-moderately effective, 5-not effective), with a mean of 1.88 and a standard deviation of 0.768, suggesting that respondents generally perceive BIM as more cost-effective. Overall, these findings highlight financial challenges and the recognized value of BIM in terms of cost-efficiency.

4.4.4 Cultural Attitudes towards Technology Adoption

Addis Ababa's construction companies' acceptance and integration of BIM are influenced by cultural views on technology adoption (Bekele & Bekele, 2019). It shows that collaborative, open-minded, and information-sharing company cultures are more favorable to the effective implementation of BIM. However, organizational buy-in and commitment to BIM adoption activities may be hampered by reluctance to change, fear of losing one's job, and doubt about the benefits of BIM (Dessalegn & Ayele, 2018). According to Beyene et al. (2020), promoting a culture of innovation, transparency, and ongoing learning will help ensure that BIM is successfully integrated into organizational workflows. This suggests that encouraging a favorable attitude toward technology adoption and removing cultural obstacles are crucial for facilitating successful BIM deployment within Ethiopia's construction sector.

	N	Minimum	Maximum	Mean	Std. Deviation
Do you agree Employees in your organization are open to adopting new technologies like BIM?	105	1	3	1.84	.748
Do you agree cultural beliefs and attitudes influence BIM adoption in your organization?	105	1	3	1.88	.730
Is there some level of resistance to change regarding BIM implementation among employees?	105	1	3	1.83	.753
Valid N (listwise)	105				

Table 8 Cultural Attitude Towards Technology Adoption, source; SPSS Output

The descriptive analysis of the survey data indicates that there is a general openness among employees towards adopting new technologies like BIM, with a mean score of 1.84 (on a scale where lower values indicate higher agreement) and a standard deviation of 0.748. Cultural beliefs and attitudes are perceived to influence BIM adoption, reflected in a mean score of 1.88 and a standard deviation of 0.730. Additionally, there is some level of resistance to change regarding BIM implementation among employees, with a mean score of 1.83 and a standard deviation of 0.753. Overall, these findings suggest that while there is a favorable attitude towards technology adoption, cultural factors and resistance to change are notable considerations in the implementation of BIM within organizations.

4.4.5 Government Policies

The crucial part played by government regulations in determining how BIM is adopted and spread throughout the building sector is clear. The use of BIM technology is expected to accelerate with the implementation of policy interventions, such as requiring the use of BIM in public projects, offering financial incentives, and creating regulatory frameworks (Bentley Systems, 2017). Initiatives like the BIM Level 2 requirements, which demand the use of BIM in government-funded building projects in nations like the United Kingdom, have, for example, greatly accelerated the industry's adoption and dissemination of BIM (HM Government, 2015)

	N	Minimum	Maximum	Mean	Std. Deviation
Do you find government policies supportive in promoting BIM adoption within the construction sector?	105	1	3	1.85	.731
Do regulatory frameworks facilitate or hinder BIM implementation in your region?	105	1	3	1.88	.768
Are the government guidelines regarding BIM adoption clear and consistent?	105	1	3	1.88	.768
Valid N (listwise)	105				

Table 9 Government Policies, source; SPSS Output

The descriptive analysis of participants' responses regarding government support and regulatory frameworks for BIM adoption reveals generally low levels of support and facilitation. the mean rating for the supportiveness of government policies in promoting BIM adoption, on a scale from 1 to 5 (1-not supporting, 3-moderatetly supportive, 5-very supportive) is 1.85 (Std. Deviation = 0.731), suggesting that respondents generally found the policies not supportive. Similarly, the mean scores for whether regulatory frameworks facilitate or hinder BIM implementation and the clarity and consistency of government guidelines on a scale from 1 to 5 (1-hindering, 3-nutral, 5-facilitating), were both 1.88 (Std. Deviation = 0.768). These results imply that respondents perceive some level of support and clarity from government policies and regulatory frameworks, but there is room for improvement to enhance the effectiveness and consistency of these guidelines in promoting BIM adoption.

4.4.6 Industry Associations

Industry associations, such as Building Smart International (BSI), the American Institute of Architects (AIA), and the Royal Institute of Chartered Surveyors (RICS), are instrumental in driving the diffusion of Building Information Modeling (BIM) by promoting collaboration, knowledge exchange, and best practice sharing among stakeholders (Building Smart, n.d.; AIA, n.d.; RICS, n.d.). These platforms contribute significantly to BIM diffusion by enabling professionals to stay updated on the latest developments in BIM technology, learn from industry experts, and share experiences with peers.

	N	Minimum	Maximum	Mean	Std. Deviation
Is your organization involved with industry associations that promote BIM adoption?	105	1	3	1.89	.764
Does industry networks and collaborations facilitate BIM implementation extensively?	105	1	3	1.86	.765
Does industry associations provide support and resources for BIM adoption is effectively.	105	1	5	2.20	.903
Valid N (listwise)	105				

Table 10 Industry Association, source; SPSS Output

The descriptive analysis of participants' responses regarding the involvement and effectiveness of industry associations in promoting BIM adoption reveals mixed perceptions. the mean rating for the level of involvement of organizations with industry associations that promote BIM adoption, on a scale from 1 to 5 (1-not involved, 3-moderatetly involved, 5-very involved) is 1.89, with a standard deviation of 0.764, indicating low to moderate involvement. The extent to which industry networks and collaborations facilitate BIM implementation, on the scale of 1-5(1-small extent, 3-nutral, 5-great extent), received a lower mean rating of 1.86 on a scale from 3 to 5, with a standard deviation of 0.765, suggesting that respondents perceive these networks and collaborations as insignificantly beneficial for BIM implementation. The effectiveness of industry associations in providing support and resources for BIM adoption scored, (1-not effective, 3-moderatetly effective, 5-very effective), a mean of 2.20, with a standard deviation of 0.903, indicating a moderate level of perceived effectiveness. These results suggest that while industry associations and networks play a valuable role in facilitating BIM implementation, there is room for increasing organizational involvement and enhancing the support and resources provided by these associations.

4.4.7 Bim adoption and implementation

The descriptive analysis of perceptions regarding Building Information Modeling (BIM) adoption in the Addis Ababa construction industry reveals nuanced insights from respondents. On average, respondents indicated a moderately low perception score of 1.88 regarding the current state of BIM adoption in the industry. However, regarding BIM's contribution to project success, respondents reported a notably higher mean score of 3.49, suggesting a significant positive impact. Additionally, stakeholders were perceived to have a moderately influential role in the adoption and utilization of BIM in construction projects, with a mean score of 3.32. The data underscores a perceived gap between the current state of BIM adoption and its recognized benefits for project success, indicating potential opportunities for improvement and increased stakeholder engagement in promoting BIM integration within the Addis Ababa construction industry.

	N	Minimum	Maximum	Mean	Std. Deviation
Do you Agree BIM adoption is widespread and effectively implemented in the Addis Ababa construction industry?	105	1	3	1.86	.739
To what extent do you agree that BIM contributes to project success?	105	1	3	1.88	.768
Do you Agree that Stakeholders Doesn't have influence on the adoption and use of BIM in construction projects?	105	1	3	1.89	.764
Valid N (listwise)	105				

Table 11 BIM Adoption and Implementation, source; SPSS Output

The descriptive analysis of the data regarding perceptions of BIM adoption in the Addis Ababa construction industry (1-not adopted, 3-moderatetly adopted, 5-fully adopted) indicates a relatively low mean score of 1.86, with a standard deviation of 0.739. This suggests that respondents perceive the current state of BIM adoption in the construction industry of Addis Ababa to be at a relatively early stage. Furthermore, respondents view the contribution of BIM to project success highly, on the scale of 1-5 (1-high contribution, 3-moderate contribution, 5-low contribution), with a mean score of 1.88 and a standard deviation of 0.768. This implies that while there is recognition of BIM's potential to enhance project outcomes, its full impact may not yet be realized or widely acknowledged. Additionally, stakeholders' influence on the adoption and use of BIM in construction projects is perceived to be relatively high, on the scale of 1-5 (1-very high influence, 3-moderate influence, 5-very low influence), with a mean score of 1.89 and a standard deviation of 0.764. This suggests that stakeholders play a significant role in shaping the adoption and utilization of BIM within the construction industry of Addis Ababa, highlighting the importance of stakeholder engagement and collaboration in driving BIM initiatives.

4.5 The aggregate mean and standard deviation

	N	Minimum	Maximum	Mean	Std. Deviation
BIM ADOPTION AND IMPLEMENTATION	105	1	3	1.89	.684
ORGANIZATIONAL READINESS	105	1	3	1.83	.656
TECHNOLOGICAL INFRASTRUCTURE	105	1	4	1.99	.726
FINANCIAL CONSIDERATION	105	1	3	1.88	.684
CULTURAL ATTITUDE	105	1	3	1.85	.655
GOVERNMENT POLICY	105	1	3	1.88	.684
INDUSTRY ASSOCIATION	105	1	3	1.98	.720
Valid N (listwise)	105				

Table 12 Aggregate Mean and Standard Deviation, source; SPSS Output

4.6 Inferential Analysis

4.6.1 Correlation Analysis

In this section, a correlation analysis was performed to assess the relationships between BIM adoption and implementation, organizational readiness, technological infrastructure, financial considerations, cultural attitudes towards technology adoption, government policies, and industry associations. The analysis employed Pearson's Product Moment Correlation Coefficient (r), which ranges from -1 to +1 and indicates the strength and direction of linear associations based on sampled data. According to Cooper and Schindler (2014), the coefficient r estimates the population correlation. The strength of the associations was characterized using the module from LaMorte (2021).

4.7 Correlations

		BIM A&I	OR	TI	FC	CATTA	GP	IA
BIM A&I	Pearson Correlation	1	.456**	.370**	.461**	.247*	.247*	.376**
	Sig. (2-tailed)		.000	.000	.000	.011	.011	.000
	N	105	105	105	105	105	105	105
OR	Pearson Correlation	.456**	1	.187	.246*	.185	.246*	.160
	Sig. (2-tailed)	.000		.056	.011	.058	.011	.102
	N	105	105	105	105	105	105	105

TI	Pearson Correlation	.370**	.187	1	.076	.203*	.391**	.279**
	Sig. (2-tailed)	.000	.056		.441	.038	.000	.004
	N	105	105	105	105	105	105	105
FC	Pearson Correlation	.461**	.246*	.076	1	.154	-.106	.104
	Sig. (2-tailed)	.000	.011	.441		.116	.280	.289
	N	105	105	105	105	105	105	105
CATTA	Pearson Correlation	.247*	.185	.203*	.154	1	.164	.074
	Sig. (2-tailed)	.011	.058	.038	.116		.095	.454
	N	105	105	105	105	105	105	105
GP	Pearson Correlation	.247*	.246*	.391**	-.106	.164	1	.304**
	Sig. (2-tailed)	.011	.011	.000	.280	.095		.002
	N	105	105	105	105	105	105	105
IA	Pearson Correlation	.376**	.160	.279**	.104	.074	.304**	1
	Sig. (2-tailed)	.000	.102	.004	.289	.454	.002	
	N	105	105	105	105	105	105	105

Table 13 Correlations, source; SPSS Output

The correlation analysis reveals significant relationships between BIM adoption and several organizational factors. BIM adoption and implementation positively correlate with organization readiness ($r = .456$, $p < .01$), technological infrastructure ($r = .370$, $p < .01$), financial considerations ($r = .461$, $p < .01$), cultural attitudes towards technology adoption ($r = .247$, $p < .05$), government policies ($r = .247$, $p < .05$), and industry associations ($r = .376$, $p < .01$). These findings indicate that higher readiness, better technological infrastructure, greater financial investment, positive cultural attitudes, supportive government policies, and involvement in industry associations are associated with increased BIM adoption.

4.8 Regression Analysis

4.8.1 Assumption of Regression Analysis

Thornhill & Saunders (2009) state that in order to calculate a regression equation, it is necessary to confirm that the following assumptions are satisfied: multicollinearity, homoscedasticity, normality, and linearity.

Thus, in order to ensure the validity and reliability of the study, the researcher has verified the necessary presumptions that the data must satisfy. SPSS version 27 was used to test the hypotheses.

1. Normality Assumption

Before conducting regression analysis, it's crucial to examine the distribution of numerical variables (Thornhill & Saunders, 2009). A common method for assessing distribution is through histogram plotting. If the histogram shows clustering on the left side with a long tail on the right, the data are positively skewed. Conversely, if the clustering is on the right with a long tail on the left, the data are negatively skewed. Symmetrically distributed data exhibit equal frequency on both sides of the peak. A specific type of symmetric distribution, resembling a bell-shaped curve, is termed a normal distribution. Multiple regression assumes that variables follow normal distributions.

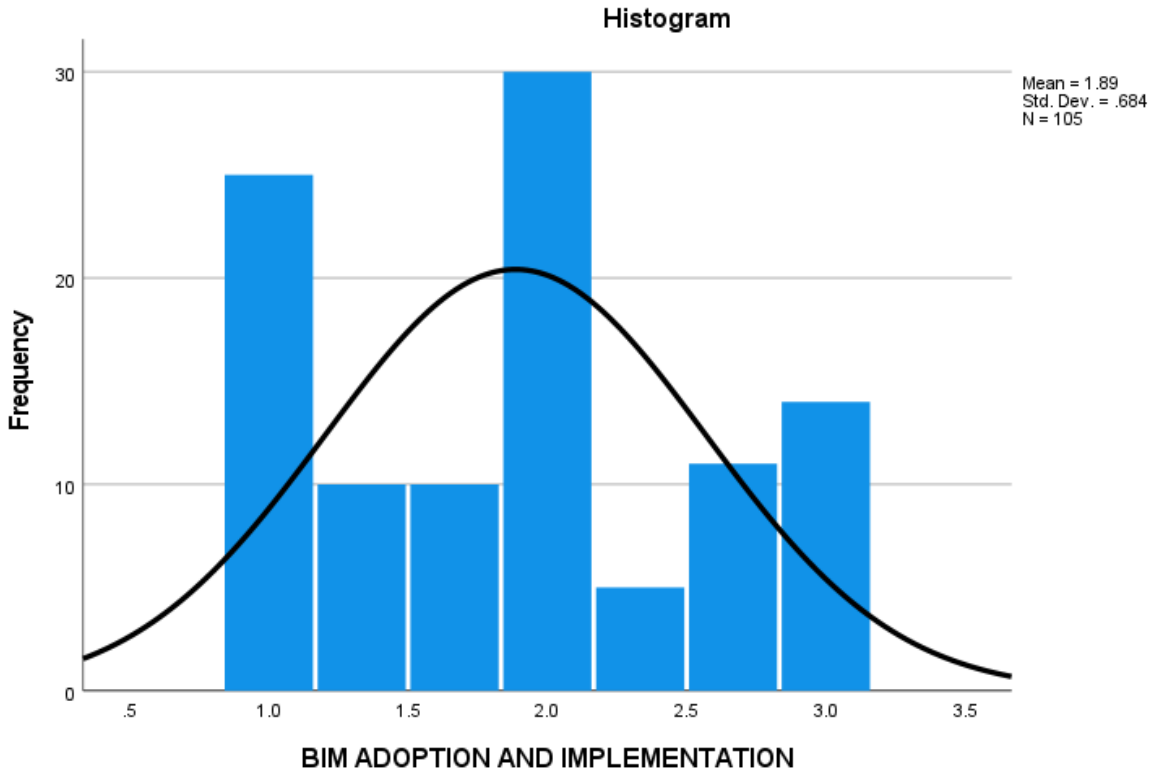

Figure 2 Histogram for Normality Test, source; SPSS Output

The above figure 2 shows that, the histogram is a bell-shaped curve. The distribution is moderately normal. Therefore, the data is good for the analysis.

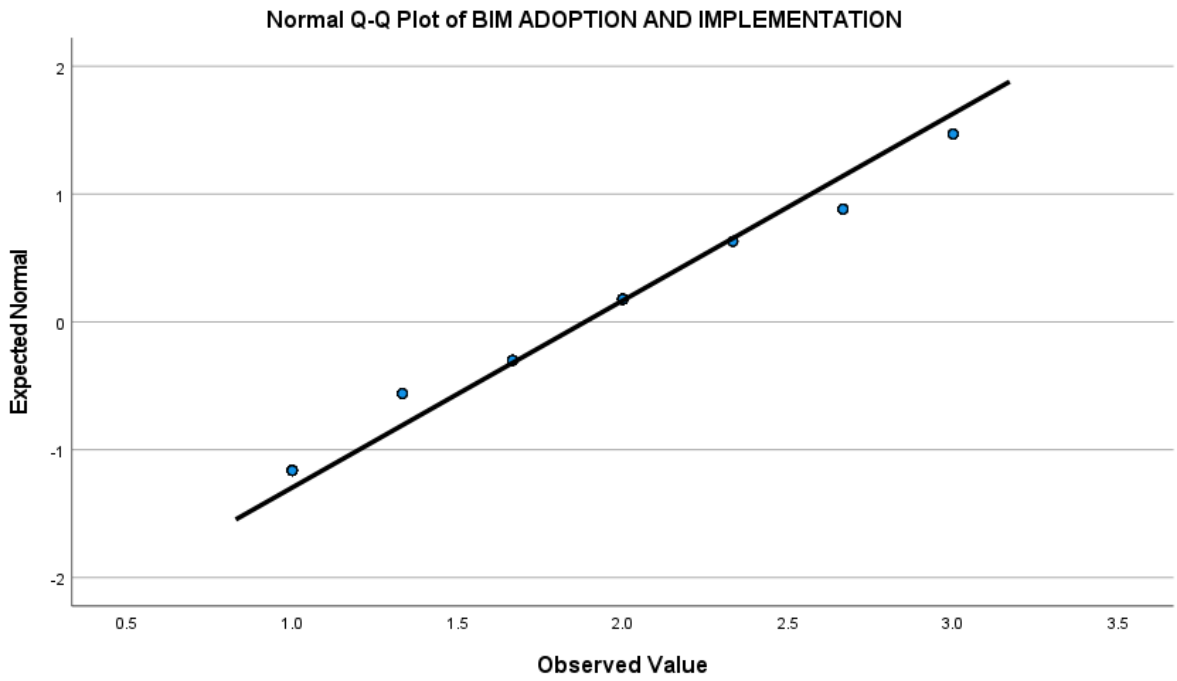

Figure 3 Normality Test Plot, source; SPSS Output

The above figure 3 shows that, the data appears to be normally distributed as it follows the diagonal line closely and does not appear to have a nonlinear pattern. Hence, it can be concluded that, the data is good for analysis.

2. Linearity Assumption

Thornhill & Saunders (2009) explain that the relationship between dependent and independent variables should be linear. Linearity indicates how changes in the dependent variable correspond to changes in the independent variables. This can be assessed through residual plots in SPSS software. Consequently, the linearity was examined by generating Normal Probability Plots to analyze the relationship between each independent variable and the dependent variable (BIM Adoption and Diffusion).

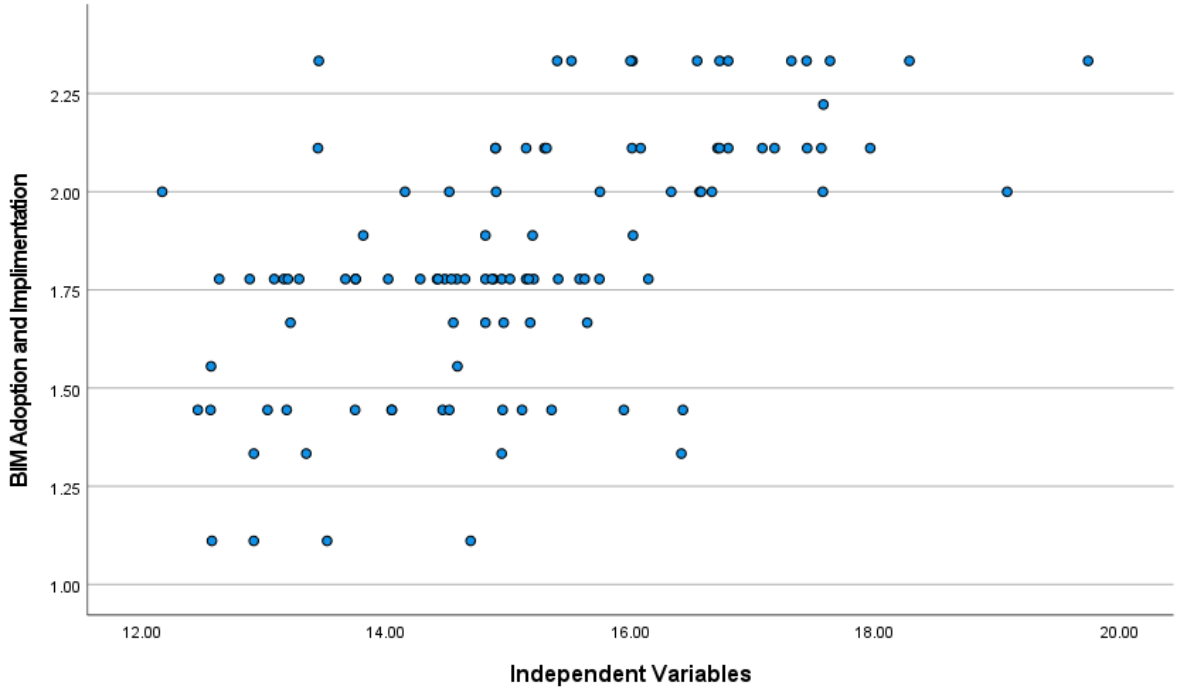

Figure 4 Linearity test, source SPSS Output

The above figure 4 shows that, there is a linear relationship between the independent variables and BIM Adoption and Implementation, because as shown on the figure as independent variables increases, BIM Adoption and Implementation increases as well.

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
BIM Adoption and Implementation * Organization Readiness	Between Groups	(Combined)	4.860	21	.231	3.363	.000
		Linearity	2.197	1	2.197	31.929	.000
		Deviation from Linearity	2.663	20	.133	1.935	.020
	Within Groups		5.711	83	.069		
	Total		10.571	104			
BIM Adoption and Implementation * Technological Infrastructure	Between Groups	(Combined)	3.230	20	.161	1.848	.028
		Linearity	1.448	1	1.448	16.573	.000
		Deviation from Linearity	1.781	19	.094	1.073	.393
	Within Groups		7.341	84	.087		
	Total		10.571	104			
		(Combined)	3.357	14	.240	2.992	.001

BIM Adoption and Implementation * Financial Considerations	Between Groups	Linearity	2.243	1	2.243	27.987	.000
		Deviation from Linearity	1.114	13	.086	1.069	.396
	Within Groups		7.214	90	.080		
	Total		10.571	104			
BIM Adoption and Implementation * Cultural Attitudes towards Technology Adoption	Between Groups	(Combined)	2.964	17	.174	1.994	.020
		Linearity	.647	1	.647	7.400	.008
		Deviation from Linearity	2.317	16	.145	1.656	.071
	Within Groups		7.607	87	.087		
	Total		10.571	104			
BIM Adoption and Implementation * Government Policies	Between Groups	(Combined)	2.557	19	.135	1.428	.136
		Linearity	.643	1	.643	6.816	.011
		Deviation from Linearity	1.915	18	.106	1.128	.341
	Within Groups		8.013	85	.094		
	Total		10.571	104			
BIM Adoption and Implementation * Industry Associations	Between Groups	(Combined)	3.338	26	.128	1.384	.138
		Linearity	1.498	1	1.498	16.151	.000
		Deviation from Linearity	1.840	25	.074	.794	.738
	Within Groups		7.233	78	.093		
	Total		10.571	104			

Table 14 Linearity Assumption Test, source; SPSS Output

The ANOVA analysis results reveal significant relationships between BIM adoption and implementation and several key factors. Organizational readiness showed a strong overall effect ($F(21, 83) = 3.363$, $p < .001$), with a significant linearity ($F(1, 83) = 31.929$, $p < .001$), and deviation from linearity also being significant ($F(20, 83) = 1.935$, $p = .020$). Technological infrastructure also demonstrated a significant overall effect ($F(20, 84) = 1.848$, $p = .028$) with significant linearity ($F(1, 84) = 16.573$, $p < .001$), though deviation from linearity was not significant ($F(19, 84) = 1.073$, $p = .393$).

Financial considerations had a significant effect on BIM adoption ($F(14, 90) = 2.992$, $p = .001$), with significant linearity ($F(1, 90) = 27.987$, $p < .001$), while deviation from linearity was not significant ($F(13, 90) = 1.069$, $p = .396$). Cultural attitudes towards technology adoption showed a significant relationship ($F(17, 87) = 1.994$, $p = .020$) and linearity ($F(1, 87) = 7.400$, $p = .008$), but deviation from linearity was not significant ($F(16, 87) = 1.656$, $p = .071$).

Government policies did not show a significant overall effect (F (19, 85) = 1.428, p = .136), though linearity was significant (F (1, 85) = 6.816, p = .011), and deviation from linearity was not significant (F (18, 85) = 1.128, p = .341). Lastly, industry associations also did not show a significant overall effect (F (26, 78) = 1.384, p = .138), though linearity was significant (F (1, 78) = 16.151, p < .001), and deviation from linearity was not significant (F (25, 78) = .794, p = .738). These results indicate that organizational readiness, technological infrastructure, financial considerations, and cultural attitudes significantly influence BIM adoption and implementation, while government policies and industry associations show mixed impacts.

3. Multicollinearity Assumption

Thornhill & Saunders (2009) note that when there is no correlation between two or more independent variables (known as collinearity or multicollinearity), it becomes challenging to isolate the individual effects of each variable. Linear regression assumes minimal or no multicollinearity in the data. To measure this, tolerance values and the variance inflation factor (VIF) are commonly used; a very small tolerance value (0.10 or below) or a high VIF value (10 or above) signifies high collinearity.

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	.120	.277		.433	.666		
	Organization Readiness	.214	.066	.254	3.239	.002	.844	1.185
	Technological Infrastructure	.150	.068	.179	2.208	.030	.789	1.267
	Financial Considerations	.198	.043	.359	4.655	.000	.873	1.146
	Cultural Attitudes towards Technology Adoption	.037	.042	.066	.876	.383	.912	1.097
	Government Policies	.052	.049	.090	1.062	.291	.722	1.386
	Industry Associations	.205	.080	.201	2.571	.012	.852	1.174

a. Dependent Variable: BIM Adoption and Implementation

Table 15 Collinearity Test, source; SPSS Output

Table 16 demonstrates that the vif values for organization readiness, technological infrastructure, financial considerations, cultural attitude towards technology adoption,

government policies and industry associations are all below 10, and the tolerance values for these Project independent variable Dimensions exceed 0.1. This suggests that there is no significant collinearity or multicollinearity issue.

4. Homoscedasticity Assumption

According to Thornhill & Saunders (2009), homoscedasticity refers to the uniformity of variances among data values for both dependent and independent variables, implying that errors are evenly distributed across the variables. Conversely, heteroscedasticity occurs when variances are unequal. To check for homoscedasticity, one can visually inspect a scatter plot of standardized residuals against the regression standardized predicted values. If the scatter plot displays patterns such as fan or butterfly shapes rather than an even distribution, it indicates a potential heteroscedasticity issue.

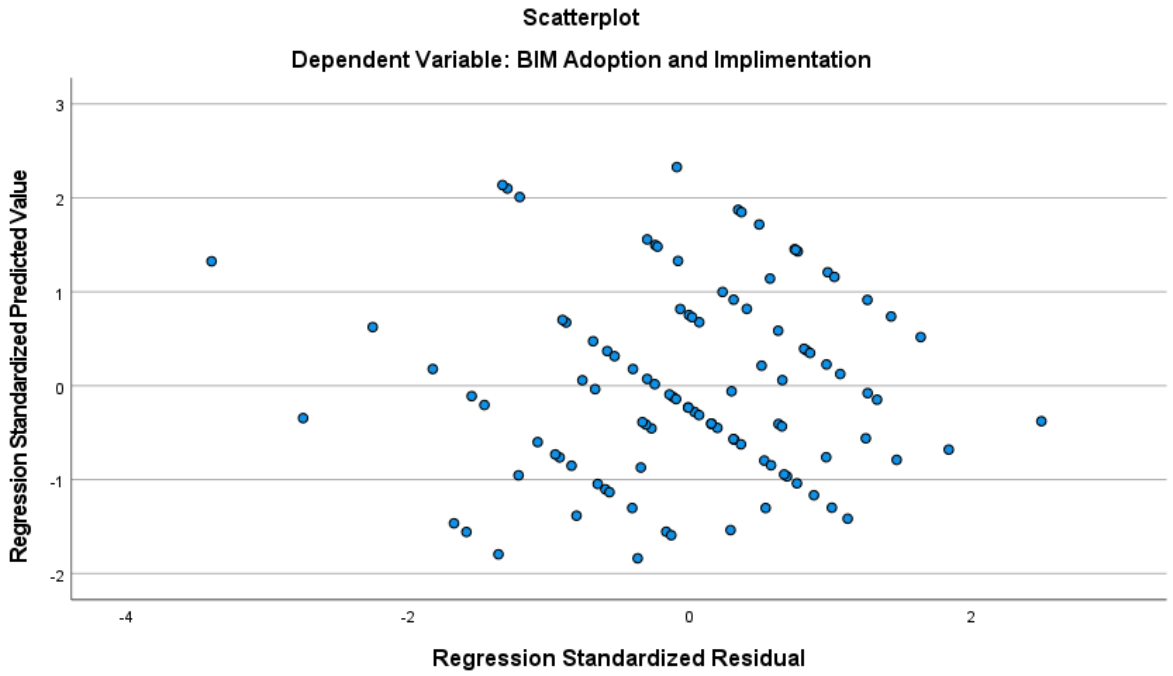

Figure 5 Homoscedasticity Test, source; SPSS Output

Figures 5 above demonstrates that the residual values were uniformly distributed without forming any discernible pattern. This observation suggests the absence of heteroscedasticity issues. Hence, based on the assessment of assumptions such as normality, linearity, multicollinearity, and homoscedasticity, it can be inferred that there are no notable data issues that would indicate a serious violation of the multiple regression assumptions.

4.9 Multiple Linear Regression Analysis

Multiple linear regression analysis was utilized to explore the influence of organization readiness, technological infrastructure, financial considerations, cultural attitudes towards technology adoption, government policies, and industry associations on BIM adoption in Addis Ababa. This approach facilitated the identification of significant factors within these components that affect BIM adoption and implementation in the context of Addis Ababa.

1. Model Summary

In the model summary, the coefficient R indicates both the direction and intensity of the correlation between independent variables and BIM adoption and implementation in Addis Ababa construction projects. R squared quantifies the proportion of the dependent variable that is explained by the independent variables, while adjusted R-squared accounts for the percentage of variance explained solely by those independent variables that genuinely impact the dependent variable.

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.704[a]	.495	.459	.23451	.495	13.603	7	97	.000

a. Predictors: (Constant), Project Success Metrix, Financial Considerations, Technological Infrastructure, Cultural Attitudes towards Technology Adoption, Industry Associations, Organization Readiness, Government Policies

b. Dependent Variable: BIM Adoption and Implementation

Table 16 Survey, source; SPSS Output

The multiple linear regression analysis reveals a substantial relationship between the predictors and the dependent variable, BIM adoption and implementation. The model explains approximately 49.5% of the variance in BIM adoption and implementation ($R^2 = .495$), with an adjusted R^2 of .459, indicating that the model accounts for a significant portion of the variability in the dependent variable after adjusting for the number of predictors. The standard error of the estimate is .23451, demonstrating the typical deviation of the observed values from the regression line. The F-change statistic is significant ($F(7, 97) = 13.603$, $p < .001$), confirming that the model significantly improves the prediction of BIM adoption and implementation beyond what would be

expected by chance. This suggests that factors such as financial considerations, technological infrastructure, cultural attitudes towards technology adoption, industry associations, organization readiness, and government policies collectively influence the adoption and implementation of BIM.

2. ANOVA Model Fit

The F-ratio in the ANOVA tests whether the above model is a good fit for the data and shows the significance of the variable.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.236	7	.748	13.603	.000[b]
	Residual	5.334	97	.055		
	Total	10.571	104			

a. Dependent Variable: BIM Adoption and Implementation

b. Predictors: (Constant), Project Success Metrix, Financial Considerations, Technological Infrastructure, Cultural Attitudes towards Technology Adoption, Industry Associations, Organization Readiness, Government Policies

Table 17 Survey, source; SPSS Output

The ANOVA analysis for the multiple linear regression model indicates that the overall model is statistically significant in predicting BIM adoption and implementation. The regression sum of squares is 5.236 with 7 degrees of freedom, leading to a mean square of .748. The residual sum of squares is 5.334 with 97 degrees of freedom, resulting in a mean square of .055. The F-statistic is 13.603, and the corresponding p-value is less than .001, indicating that the predictors financial considerations, technological infrastructure, cultural attitudes towards technology adoption, industry associations, organization readiness, and government policies—collectively have a significant impact on BIM adoption and implementation.

3. Model Coefficient

When all other independent variables are held constant, the unstandardized coefficient in a model coefficient shows how much the dependent variable changes with an independent variable, and the p-value reflects the statistical significance.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.120	.277		.433	.666		
	Organization Readiness	.214	.066	.254	3.239	.002	.844	1.185
	Technological Infrastructure	.150	.068	.179	2.208	.030	.789	1.267
	Financial Considerations	.198	.043	.359	4.655	.000	.873	1.146
	Cultural Attitudes towards Technology Adoption	.037	.042	.066	.876	.383	.912	1.097
	Government Policies	.052	.049	.090	1.062	.291	.722	1.386
	Industry Associations	.205	.080	.201	2.571	.012	.852	1.174

a. Dependent Variable: BIM Adoption and Implementation

Table 18 Survey, source; SPSS Output

The multiple linear regression analysis provides insight into the impact of various predictors on BIM adoption and implementation. The model indicates that organization readiness (B = .214, p = .002), technological infrastructure (B = .150, p = .030), financial considerations (B = .198, p < .001), and industry associations (B = .205, p = .012) are significant positive predictors of BIM adoption. This indicates that these four independent variables have a significant effect on BIM Adoption and Implementation because the p value is less than 0.05 and when others independent variables held constant for each independent variable, a unit change in each independent variable increases BIM Adoption and Implementation by 0.214, 0.150, 0.198 and 0.205 respectively. This suggests that better preparedness, stronger technological infrastructure, more financial investment, and active involvement in industry associations are associated with higher levels of BIM adoption and Implementation. Conversely, the project success metric (B = -.172, p = .039) shows a significant negative relationship, indicating that traditional project success factors might slightly hinder BIM adoption. Cultural attitudes towards technology adoption (B = .037, p = .383) and government policies (B = .052, p = .291) do not show significant effects.

From the above model coefficient, the following multiple regression model was determined.

$$\text{Performance (P)} = \beta 0 + \beta 1\text{OR} + \beta 2\text{TI} + \beta 3\text{FIC} + \beta 4\text{CATA} + \beta 5\text{GP} + \beta 6\text{IA} + \beta 7\text{PSM} + e$$

$$P = 0.120 + 0.214\text{OR} + 0.150\text{TI} + 0.198\text{FIC} + 0.037\text{CATA} + 0.052\text{GP} + 0.205\text{IA} - 0.172\text{PSM} + 0.277$$

Where: P= Performance
β0 = 0.120
OR = organization readiness
TI= Technological infrastructure
FIC= Financial consideration
CATA= Cultural Attitudes towards Technology Adoption
GP= Government policy
IA= Industry associations
e = 0.277 and
β1 – β7 = Coefficients of the independent variables

4.10 Hypothesis

In this study three hypotheses were proposed. To test the hypotheses we use **p** value, if p value is less than 0.05 then the hypotheses will be accepted.

Hypothesis	Coefficient (B)	p-value	Result
H1: There is a positive relationship between organizational readiness and BIM adoption level.	0.214	0.002	Supported
H2: Technological infrastructure positively influences BIM adoption level.	0.150	0.030	Supported
H3: Financial considerations positively affect BIM adoption level.	0.198	<0.001	Supported
H4: Cultural attitudes towards technology adoption impact BIM adoption level.	0.037	0.383	Not Supported
H5: Government policies and support positively influence BIM adoption level.	0.052	0.291	Not Supported
H6: Industry associations and knowledge-sharing platforms positively influence BIM adoption level.	0.205	0.012	Supported

Table 19 Survey, Source; own

-Supported Hypotheses: H1, H2, H3, H6
-Not Supported Hypotheses: H4, H5

The above table 19 shows the hypothesis, the corresponding coefficient, the p-value, and the result of the hypothesis test. The supported hypotheses indicate significant positive relationships, while the not supported hypotheses indicate either non-significant relationships or a significant but negative relationship in the case of H7.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 introduction

This chapter provides an overview of the summary, conclusion, and suggestions made in light of the literature study and the findings of chapter four. The inference drawn from the study's purpose.

5.2 Summary of findings

From the 115 questionnaires which were distributed to 115 employees in consulting offices, 109 were collected and again 105 (96.3%) were selected based on the quality of the response. The sample comprised 28.6% females and 71.4% males. The majority of respondents were aged between 26-35 years (70.5%), followed by 19.0% aged 36-45 years, 7.6% aged 18-25 years, 1.9% aged 46-55 years, and 1.0% aged 56-65 years. Regarding education, most participants held a first degree (74.3%), with 24.8% having a master's degree, and only 1.0% possessing a diploma. Experience levels varied, with 43.8% having 6-10 years of experience, 41.9% having 1-5 years, 10.5% over 10 years, and 3.8% with less than a year of experience. The professional disciplines were evenly distributed, each comprising 14.3% of the sample, including architects, BOQ surveyors, civil engineers, electrical engineers, project managers, sanitary engineers, and site supervisors.

The findings indicate that organizational readiness, technological infrastructure, financial investment, and engagement with industry associations are crucial for successful BIM adoption. Organizational readiness ($\beta = .254$, $p = .002$), technological infrastructure ($\beta = .179$, $p = .030$), financial considerations ($\beta = .359$, $p < .001$), and industry associations ($\beta = .201$, $p = .012$) positively influence BIM implementation. However, cultural attitudes and government policies did not show significant impacts. Overall, emphasizing training, resource allocation, and adaptive PM methodologies can enhance BIM implementation and contribute to improved project outcomes.

There is a strong correlation between the predictors and the dependent variable, BIM adoption and implementation, according to the multiple linear regression analysis. With an adjusted R^2 of.459, the model explains a considerable amount of the variability

in the dependent variable after correcting for the number of variables. Approximately 49.5% of the variation in BIM adoption and implementation is explained by the model (R^2 =.495). The estimate's standard error, which is.23451, shows how frequently the observed values deviate from the regression line. Beyond what would be predicted by chance, the model greatly improves the forecast of BIM acceptance and implementation, as indicated by the significant F-change statistic (F (7, 97) = 13.603, p <.001).

This implies that the adoption and use of BIM are influenced by a variety of variables, including financial considerations, industry associations, organizational preparation, technological infrastructure, cultural attitudes toward technology adoption, and government legislation.

5.3 Alignment with literature

The study's findings that organizational readiness, technological infrastructure, financial investment, and engagement with industry associations are crucial for successful BIM adoption are well-supported by existing literature. Dessalegn & Ayele (2018) highlighted that organizational readiness, encompassing leadership support, employee skills, and organizational culture, is critical for BIM adoption. Effective leadership is essential for championing BIM initiatives, securing resources, and fostering a culture of innovation and collaboration (Beyene et al., 2020). Similarly, technological infrastructure, including software compatibility, interoperability, and data standardization, is pivotal for BIM adoption. Bekele & Bekele (2019) identified these technological barriers as significant challenges in the Ethiopian context, and Azagegn et al. (2020) noted that limited access to BIM software and technical expertise can hinder adoption. Financial considerations, such as initial investment costs, licensing fees, and ROI calculations, significantly influence organizations' willingness to adopt BIM, with high upfront costs and perceived risks acting as major deterrents, particularly for SMEs (Fekadu & Hassen, 2018; Mengistu et al., 2019). Industry associations play a crucial role in BIM diffusion by fostering collaboration, knowledge exchange, and best practice sharing, with organizations like Building Smart International and associations such as the AIA and RICS providing necessary support for BIM adoption (Building Smart, n.d.; AIA, n.d.; RICS, n.d.).

Research gaps remain that future studies could address. Longitudinal studies tracking the evolution of BIM adoption over time and assessing the long-term impacts of interventions, such as training programs and policy changes, would provide valuable insights. A more detailed examination of government policies and their specific impacts on BIM adoption is needed to understand barriers to effective policy implementation and how to overcome them. Research focusing on different sectors within the construction industry could offer more nuanced insights, while comparative studies between regions with different levels of BIM adoption could help identify best practices. Additionally, evaluating the effectiveness of various training and education programs in improving BIM adoption and implementation, and investigating user experience and satisfaction with BIM tools and processes, can uncover practical challenges and areas for improvement, contributing to more user-friendly and effective BIM solutions. By addressing these gaps, future studies can provide a more comprehensive understanding of the factors influencing BIM adoption and offer targeted recommendations to enhance its implementation in the Ethiopian construction industry.

5.4 Conclusion

The findings from the multiple linear regression analysis shed light on the influential factors affecting Building Information Modeling (BIM) adoption and implementation. The model underscores the significance of organizational readiness, technological infrastructure, financial considerations, and industry associations as positive predictors of BIM adoption. These factors indicate that a well-prepared organization, robust technological framework, adequate financial investment, and active engagement in industry associations contribute to higher levels of BIM adoption and implementation.

This conclusion aligns with existing literature. For instance, Smith and Tardif (2009) emphasize the importance of organizational readiness in facilitating successful BIM implementation, highlighting its role in shaping attitudes and behaviors within an organization. Similarly, studies by Eastman et al. (2011) and Teicholz (2004) stress the pivotal role of technological infrastructure in enabling effective BIM utilization, emphasizing the need for reliable hardware and software support. furthermore,

financial considerations emerge as a significant factor, echoing the findings of Barlish and Sullivan (2012), who highlight the necessity of adequate financial resources to support BIM adoption initiatives. Active involvement in industry associations also proves crucial, corroborating insights from Azhar et al. (2011), who underscore the role of collaborative networks in promoting BIM diffusion across the industry. However, cultural attitudes towards technology adoption and government policies do not emerge as significant predictors in this analysis. While this might seem surprising, it aligns with studies such as that of Succar (2009), which suggests that cultural factors and governmental policies may not always directly influence BIM adoption outcomes.

In conclusion, this study underscores the multifaceted nature of BIM adoption and implementation, highlighting the importance of organizational readiness, technological infrastructure, financial considerations, and industry collaboration. By addressing these key factors, stakeholders can enhance their capacity for successful BIM implementation, thereby fostering innovation and efficiency within the construction industry.

5.5 Suggestion

Based on the research findings, future studies should explore the dynamics between traditional project management practices and BIM adoption. Investigating how these frameworks can be adapted or restructured to better support BIM adoption and implementation could provide valuable insights. Additionally, since cultural attitudes towards technology adoption and government policies did not emerge as significant predictors, further research might focus on understanding the underlying reasons for this and identifying conditions under which these factors might become more influential. Such studies could help in developing more comprehensive strategies for enhancing BIM adoption across different organizational and regulatory environments. To promote widespread BIM adoption in Addis Ababa, several strategic initiatives should be undertaken. Enhancing organizational readiness is essential, involving leadership training to champion BIM initiatives and comprehensive change management programs to ease the transition. Investing in technological infrastructure by upgrading software and hardware and providing robust IT support is crucial. Financial support through government grants, subsidies, and proper budgeting can

mitigate initial adoption costs. Promoting industry collaboration through knowledge-sharing platforms and partnerships, and integrating BIM with existing project management frameworks, will foster a collaborative environment. Employee skills can be enhanced through extensive BIM training programs and continuous professional development. Addressing cultural attitudes by promoting a culture of innovation and highlighting BIM success stories will shift perceptions positively. Leveraging government policies to create supportive regulations and implementing BIM in public sector projects can set a powerful example. Starting with small-scale pilot projects to demonstrate BIM's benefits and sharing successful outcomes will build confidence across the industry. By adopting these strategies, Addis Ababa can enhance BIM diffusion, leading to improved efficiency, collaboration, and innovation in the construction sector.

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APPENDIX; Questionnaire

Dear Participants, Selam.

I am Fuad Mohammed, I am writing a Masters Graduation paper on the research study titled "Fostering Project Success & Building Information Modeling (BIM): Harnessing BIM to converge project success factors, Adoption and Diffusion in Addis Ababa." I am excited to explore the integration of Building Information Modeling (BIM) in the construction sector of Addis Ababa and how it influences project success factors, adoption, and diffusion within our local context.

As someone deeply involved in the construction industry of Addis Ababa, your insights are invaluable. By participating in this questionnaire, you will help shed light on the current state of BIM integration, identify key success factors, uncover adoption barriers, and reveal diffusion mechanisms specific to our region.

Your participation is voluntary, and all responses will be treated with confidentiality. Your input will play a vital role in shaping the future of project management practices in Addis Ababa's construction sector.

Thank you for taking the time to share your valuable insights.

Best regards,

Fuad Mohammed

Please indicate your appropriate choice among the options by ticking the options

SECTION 1: BASIC DEMOGRAPHIC DATA

1.1 Gender: Male ☐ Female ☐

1.2. Age: 18-25 ☐ 26-35 ☐ 36-45 ☐ 46-55 ☐ 56-65 ☐ >65 ☐

1.3 Level of education:
Certificate ☐ Diploma ☐ First Degree ☐ Master's degree ☐ PhD ☐

SECTION 2: BACKGROUND INFORMATION

2.1 How long have you worked in the Construction Industry?
Less than a year ☐ 1-5 years ☐ 6-10 years ☐ over 10 years ☐

2.2 What is your Discipline?
Architect ☐ Civil Engineer ☐ Electrical Engineer ☐ Sanitary Engineer ☐
Project Manager ☐ BOQ Surveyor ☐ Site Supervisor ☐

2.3 Have you worked on projects that implemented BIM? If yes, please specify?
YES ☐ NO ☐
If yes specify _____

SECTION 3: PROJECT MANAGEMENT

3.1 What project management methodologies are you familiar with?
Waterfall ☐ Agile ☐ Scrum ☐ Strategic ☐ None ☐

3.2 How do you define a successful construction project?

☐ On-time completion within budget
☐ Meeting quality standards and specifications
☐ Fulfilling client requirements and expectations
☐ Minimal safety incidents and adherence to regulations
☐ Effective communication and collaboration among stakeholders
☐ All of the above

3.3 What are the key factors that contribute to the success of a construction project in your experience?

☐ Effective project planning and management
☐ Skilled and experienced workforce
☐ Clear communication and collaboration among team members
☐ Adequate budget and resource allocation
☐ Adherence to safety regulations and protocols
☐ Timely decision-making and problem-solving
☐ Proper risk management and mitigation strategies
☐ Regular monitoring and evaluation of progress
☐ Client satisfaction and meeting expectations
☐ All of the above

3.4. In your opinion, how does BIM affect the project management process in construction?

☐ Enhances Coordination
☐ Enhances Communication
☐ Improves visualization
☐ Improves Clash detection
☐ All

SECTION 4: BIM ADOPTION AND IMPLIMENTATION

4.1 Do you Agree BIM adoption is widespread and effectively implemented in the Addis Ababa construction industry?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

4.2 To what extent do you agree that BIM contributes to project success?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

4.3 Do you Agree that Stakeholders Doesn’t have influence on the adoption and use of BIM in construction projects?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

SECTION 5: BIM ADOPTION AND IMPLIMENTATION IN YOUR ORGANAIZATION

5.1 Organizational Readiness

a. Do you agree your organization is prepared to adopt new technologies like BIM?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

b. To what extent do you agree that your organization has the necessary resources to support BIM implementation?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

c. Are employees in your organization not willing to undergo training for BIM adoption?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

5.2 Technological Infrastructure

a. Adequacy of your organization's current technological infrastructure is enough to support BIM implementation.

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

b. How do you Agree that, it’s easy for your organization to integrate BIM software with existing systems?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

c. Do you agree that technical limitations don’t hinder BIM adoption in your organization?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

5.3 Financial Considerations

a. Your organization is willing to allocate financial investment for BIM implementation?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

b. Budget constraints doesn't impact BIM adoption in your organization?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

c. BIM implementation is not cost-effective compared to traditional project management methods.

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

5.4 Cultural Attitudes towards Technology Adoption

a. Do you agree Employees in your organization are open to adopting new technologies like BIM?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

b. Do you agree cultural beliefs and attitudes influence BIM adoption in your organization?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

c. Is there some level of resistance to change regarding BIM implementation among employees?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

5.5 Government Policies

a. Do you find government policies supportive in promoting BIM adoption within the construction sector?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

b. Do regulatory frameworks facilitate or hinder BIM implementation in your region?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

c. Are the government guidelines regarding BIM adoption clear and consistent?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

5.6 Industry Associations

a. Is your organization involved with industry associations that promote BIM adoption?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

b. Does industry networks and collaborations facilitate BIM implementation extensively?

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

c. Does industry associations provide support and resources for BIM adoption is effectively.

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

SECTION 6: ADDITIONAL COMMENTS

15. Please provide any additional comments or insights you have regarding project management, BIM, and construction Projects in Addis Ababa

_____
_____
_____
_____
_____